STAFFER
EUROPEAN RAIL SKILLS ALLIANCE

Implementation of VET at EQF levels 6 to 8

ANNEXES TO DELIVERABLE D6.6

Co-funded by the Erasmus+ Programme of the European Union

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ANNEX I - QUESTIONNAIRS FOR THE EVALUATION OF PILOT VETS AND TRAINING PROGRAMMES

I.1 Student questionnaire

Student Survey

The STAFFER project (Skill Training Alliance for the Future European Rail System) is developing educational programmes to provide learners with the future skills and competencies required in the railway sector. The strategy is to identify current and new skill requirements in the railway sector. Work Package 6 of the STAFFER project is related to the implementation of training programmes and work-based internships. As a student, your programme has been chosen to be a pilot course in order to conduct a survey on existing and new training programmes related to the railway sector. Your feedback is highly valuable. Thank you for your help. (More information about STAFFER is available at https://www.railstaffer.eu/).

Course: **Date:**

Course Content

▶ Was your existing knowledge sufficient to understand the topics covered in the course?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Were the objectives of the course clear?

No, not at all				Yes, absolutely	Not applicable

☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Do you think the objectives of the course have been achieved?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

Teaching and study material

▶ Do you think the lessons were sufficient for understanding the course topics?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

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▶ Do you think the teaching methods used made it easy to understand the course concepts?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Do you think the study material was sufficient for understanding the course concepts?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

Professional relevance

▶ Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

Support – Environment

▶ Was the information provided about the course clear and comprehensive?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Could you please specify any areas where you believe improvements could be made to enhance the course?

Overall Evaluation

▶ Did this course assist you in improving your technical skills?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐

1	2	3	4	5	
☑ Add a comment					

▶ Did the shared experiences contribute to the development of your knowledge?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

▶ What was the most valuable aspect of the course?

▶ Overall, how satisfied are you with the course you completed?

Not satisfied				Extremely satisfied	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

Recommendation

▶ Would you recommend this course to your friends and family?

No, not at all									Yes, absolutely	
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7	8	9	10

☑ Add a comment

I.2 Teacher questionnaire

Teachers Survey

The STAFFER project (Skill Training Alliance for the Future European Rail System) is developing educational programs to help prepare workers for the future needs of railway sector employers. The strategy is to identify current and new skill requirements in the railway sector. Work Package 6 of the STAFFER project is related to the implementation of training programs and work-based internships. You have participated in one of these programs and it would help us very much if you could complete this short survey. Your feedback on some issues relating to skills and competencies is highly valuable. Thank you for your help. (More information about STAFFER is available at https://www.railstaffer.eu/).

LAST NAME, First name:

Training Program: **Date:**

► Number of participants in the course.

► Are transversal skills explicitly taught?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

► Are transversal skills assessed?

Yes	No
☐	☐

☑ Add a comment

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▶ Are digital skills explicitly taught?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

▶ Are digital skills separately assessed?

Not at all satisfied				Completely satisfied	Not Applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

▶ Does the course teach railway related professional skills?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

▶ Does the course prepare students for future professional roles within the railway sector?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Are realistic simulations used to give experience of real work situations?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Are there in the course work-related learning activities?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Have those activities been communicated to the learners?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Optional: please specify which are the work-related activities within the course?

▶ Do you think that the program/module could result in an improvement in the students' performance in the railway sector?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

▶ Does the course actively support students in reflection and review of their accomplishments throughout the program/module?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

I.3 In-Company Supervisor questionnaire

Supervisor Survey

The STAFFER project (Skill Training Alliance for the Future European Rail System) is developing educational programmes to provide learners with the future skills and competencies required in the railway sector. The strategy is to identify current and new skill requirements in the railway sector. Work Package 6 of the STAFFER project is related to the implementation of training programmes and work-based internships. You have hosted in your company a learner who participated in one of these programmes and it would help us very much if you could complete this short survey. Your feedback is highly valuable. Thank you for your help. (More information about STAFFER is available at https://www.railstaffer.eu/).

LAST NAME, First name:

Company: **Date:**

Your experience with our Institution

▶ Are you satisfied with acquired knowledge on railway topics by the learner/trainee?

No, not at all Yes, absolutely

☐ ☐ ☐ ☐ ☐ ☐

1 2 3 4 5 Not applicable

☑ Add a comment

▶ Are you satisfied with acquired skills* by the learner/trainee?

No, not at all Yes, absolutely

☐ ☐ ☐ ☐ ☐ ☐

1 2 3 4 5 Not applicable

☑ Add a comment

** A particular ability developed through training and experience and that is useful in a job.*

▶ Has the support provided by the training institution team met your needs as a supervisor?

No, not at all Yes, absolutely

☐ ☐ ☐ ☐ ☐ ☐

1 2 3 4 5 Not applicable

☑ Add a comment

▶ Did the training programme, your learner completed, prepare them for their current responsibilities in your organisation?

No, not at all Yes, absolutely

☐ ☐ ☐ ☐ ☐ ☐

1 2 3 4 5 Not applicable

☑ Add a comment

▶ Has your learner's performance improved due to the programme?

No, not at all Yes, absolutely

☐ ☐ ☐ ☐ ☐ ☐

1 2 3 4 5 Not applicable

☑ Add a comment

▶ As a contribution to the continuous improvement of the training programme, what would you consider skills to be developed to meet the current needs of the job?

▶ In your opinion, are there any specific topics that should be introduced in the course? If so, which ones?

Recommendation

▶ Would you recommend your learner programme to others?

No, not at all									Yes, absolutely	
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7	8	9	10

☑ Add a comment

I.4 Organiser short-term questionnaire

Evaluation form for Organisers

The STAFFER project (Skill Training Alliance for the Future European Rail System) is developing educational programmes to provide learners with the future skills and competencies required in the railway sector. The strategy is to identify current and new skill requirements in the railway sector. Work Package 6 of the STAFFER project is related to the implementation of training programmes and work-based internships. You have organised in your institution one of these pilot courses/programmes and it would help us very much if you could complete this short survey. Your feedback is highly valuable. Thank you for your help. (More information about STAFFER is available at https://www.railstaffer.eu/).

LAST NAME, First name:

Pilot Course/Programme: **Date:**

▶ Number of participants in the course.

▶ Number of participants having successfully completed the course.

▶ Does your institution actively apply internal quality assurance systems?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Is the implemented pilot programme accredited?

No	In process	Yes	Not applicable
☐	☐	☐	☐

☑ Add a comment

▶ Are students able to select specific modules or focus areas to customise their course content according to their preferences and perceived requirements?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

▶ Does the information provided to students about the programme contain data on employment and career opportunities?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	

☑ Add a comment

► Do students have the opportunity to visit local employers?

Yes	No	Not applicable
☐	☐	☐
☑ Add a comment		

► Do students have the opportunity to travel and visit foreign employers?

Yes	No	Not applicable
☐	☐	☐
☑ Add a comment		

► Do students have the opportunity for virtual visits of foreign employers?

Yes	No	Not applicable
☐	☐	☐
☑ Add a comment		

► Are students regularly provided with information about available employment opportunities, such as through annual job fairs or similar activities?

Yes	No	Not applicable
☐	☐	☐
☑ Add a comment		

► Are there any online resources related to employability available for students?

Yes	No	Not applicable
☐	☐	☐

If yes, please list this of resources:

☐ Data base

☐ Website

☐ Intranet

☐ Social channel

☐ Others (please specify):

► Does the educational staff know who actually employs their graduates?

Yes	No	Not Applicable
☐	☐	☐

☑ Add a comment

► Are professional career possibilities and profiles available to students?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

► Is there explicit guidance within the programme to encourage students to connect with the office responsible of careers services?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Does the information provided about the programme contain data on employment and career opportunities?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

▶ Are there any admission tests or assessment that could be usefully shared with employers in case of placement?

No, not at all				Yes, absolutely	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

▶ Are students explicitly instructed in management skills?

Yes	No	Not applicable
☐	☐	☐
☑ Add a comment		

▶ Do employers review your programme and provide feedback on its content?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Do you know strengths and weaknesses of your graduates as perceived by employers?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Do you review and update your programme based on employer feedback regularly?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Do you use any other mechanisms to review and update your programme based on railway sector innovation and railway labour market training needs?

Yes	No	Not applicable
☐	☐	☐

If yes, please list these mechanisms:

▶ Do you have active communication with major employers of your students?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Do employers visit your institution and present their employment opportunities?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Do employers attend student project presentations?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Are foreign employment placements possible and encouraged for students?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ What strategies have been employed to enhance access to the programme?

▶ Are teachers and trainers have been engaged in additional training?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

I.5 Organiser long-term questionnaire

Long-term Survey Form for Organisers

The STAFFER project (Skill Training Alliance for the Future European Rail System) is developing educational programmes to provide learners with the future skills and competencies required in the railway sector. The strategy is to identify current and new skill requirements in the railway sector. Work Package 6 of the STAFFER project is related to the implementation of training programmes and work-based internships. You have organised in your institution one of these programmes and it would help us very much if you could complete this short survey. Your feedback is highly valuable. Thank you for your help. (More information about STAFFER is available at https://www.railstaffer.eu/).

LAST NAME, First name:

Programme: **Date:**

► Please list the name and the type of companies / institutions where your graduates are working one year after graduation.

► Please list the occupations or roles your graduates perform in their professional work.

►Please give an overall satisfaction rate regarding the skills and competencies acquired by the learners through the programme.

Completely unsatisfied				Very satisfied	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

► From a global point of view, how satisfied are employers with the skills and competencies of students who have completed your programme?

Completely unsatisfied				Very satisfied	Not applicable
☐	☐	☐	☐	☐	☐
1	2	3	4	5	
☑ Add a comment					

► Do you have mechanisms in place to identify training needs in the labour market?

Yes	No	Not applicable
☐	☐	☐
If yes, please list these mechanisms:		

☑ Add a comment

▶ Does the information provided about the programme contain data on employment and career opportunities?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

▶ Are there any admission tests or assessment that could be usefully shared with employers in case of placement?

Yes	No	Not applicable
☐	☐	☐

☑ Add a comment

ANNEX II - DESCRIPTION OF THE TRAINING PROGRAMMES

II.1 AUTh

II.1.1 Civil Engineering Diploma

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**Aristotle University of Thessaloniki**
Faculty/Department	**Faculty of Engineering/ School of Civil Engineering**
Training Program Title	**Diploma (Integrated Master) in Civil Engineering**
Indicate if it is a new training program or an existing one to be adapted	**Existing program**
Contact Name/Function/Mail/Phone	**Christos Pyrgidis/ Professor/ pyrgidis@civil.auth.gr/ 0030-2310-995795**
Degree Type	University course taught as part of the Civil Engineering Diploma (Integrated Undergraduate and Postgraduate Degree)
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	Aristotle University of Thessaloniki (AUTh)
Training address	AUTh campus
EQF Level	7
Usual entry age	21 plus
Entry requirements / Prerequisites	Typically taught to civil engineering students as an elective course or a compulsory course for the students that follow the Transport and Project Management specialization. Also available to visiting ERASMUS and other students.
Potential progression for learners after graduation	Post graduate or doctoral studies
Type of VET programme (initial/continuous/	Continuous

apprenticeship)	
Status of learners (student/apprentice/staff)	Student
Expected learners' numbers	80
Assessment of learning outcomes	Exams at the end of the semester. Optional project to be undertaken and completed before the exams.
Diplomas/Certificates provided	Part of Degree (4 ECTS)
	OBJECTIVES
Overarching goals/visions	The "Railway Infrastructure" course covers all three components of a railway system: the track, the rolling stock and the exploitation. It focuses on the interurban railway systems (high speed and conventional speed) and mainly on design and construction issues. Its objective is to provide students with the necessary knowledge in order to comprehend the main principles in designing, constructing and operating railway systems but also to enable them to face the railway projects they will come across.
Targeted public	Civil engineering students
Potential jobs	Various posts in railway engineering companies.
Selection method	The course is available to all students enrolled in the civil engineering diploma program at AUTh. For visiting students, the selection process is based on the program through which they will be attending the course.
Learning objectives and outcomes, challenges and expected impacts	Basic knowledge in railway engineering General Competences • Apply knowledge in practice • Make decisions • Work autonomously • Work in an interdisciplinary team • Design and manage projects
Others	
	MEANS / MODALITIES

Human and material resources (pedagogical team, workshops, laboratory, etc.)	The available human resources include the teaching professor, supporting staff, and visiting lecturers. Educational Material includes: • Notes • Slide presentations • Video lectures • Textbook
Training program (curriculum, contents, general and specific objectives of each course, etc.)	The course covers the following thematic items: • The railway technique and potentials (The railway as a transport system; Railway historical evolution) • Railway traction (traction elements , traction systems) • Wheel – rail interaction (traffic loads, wheel-rail contact surface study, forces exerted on the track) • Track panel (rails, sleepers, fastenings, switches and crossings) • Track bed and substructure (track bed, substructure, track bed / subgrade system) • Track alignment (track alignment geometry, track defects) • Track mechanical behavior (vertical behavior, lateral behavior) • Civil engineering works in railway systems (tunnels, bridges, etc.) • Track installations (signaling, electrification, level crossings) • Rolling stock • Rolling stock behavior on the track (axles/bogies behavior, vehicle’s derailment) • High speed trains (Problems and solutions) • Technical and commercial exploitation of railway systems • Urban (metro, tramway) and interurban railway systems • Track maintenance • The railway systems in Greece The required coursework is structured as follows: • Lectures – ECTS 2.9 • Visits – ECTS 0.3 • Projects – ECTS 0.7

	• Exams – ECTS 0.1		
Training program (curriculum, contents, general and specific objectives of each course, etc.) (continued)		**Lecture titles**	**Lecture Contents**
	1	• Introduction to the Railway Engineering course • Railways as a transport system	• Course contents • Teaching and assessment methods • Teaching material overview • Fundamentals and functionalities of the system • Wheel/rail system • Trends in and evolution of the railway sector • Railways in Greece and worldwide
	2	• Railway track alignment • Description of optional course project	• Track horizontal and vertical alignment • Exercises
	3	• Railway traction	• Power vehicles • Traction elements • Traction systems • Exercises
	4	• Wheel/rail interaction • Traffic loads	• Geometry of the wheel/rail contact • Creep phenomena • Forces acting on the track • Exercises
	5	• Railway track superstructure • Track configurations	• Rails • Sleepers • Fastenings • Track bed • • Turnouts • Switches and Crossings • Crossovers
	6	• Substructure • Track bed-substructure failures • Railways and the environment	• Dimensioning of ballast and sub ballast layers • Exercises • Railway operation under special weather conditions and natural phenomena
	7	• Railway track behavior	• Vertical track behavior • Lateral track behavior • Longitudinal track behavior • Exercises
	8	• Railway trailer vehicles • Track installations	• Main parts and types of rolling stock • Signaling • Electrification
	9	• Rolling stock behavior on track	• Dynamic rolling stock behavior in curves and on straight paths • Derailment • Exercises
	10	• Laying, rehabilitation, and maintenance of track	• Educational visit

	11	• Railway civil engineering structures • Trends and Innovations in the railway sector	• Tunnels • Bridges • Grade-separated crossings • Fencing • Embankments and cuttings • Drainage systems • Trends • Innovations
	12	• High and very high-speed railways	• Definition and distinction between conventional, high, and very high speeds. • Issues at high speeds • Specifications of high-speed lines and rolling stock • Tilting trains
	13	• Organization and management of railway freight transport	• Railway freight fundamentals
Indicate the selected programme according to STAFFER findings	Rail transport engineering		
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☐ Global new energies & technologies ☒ Formal methods for system design & verification ☐ Web development ☐ Communication ☐ Safety, dependability, security ☒ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒		
Duration and type of work-based internships (if compulsory)			
Companies that offer internships (please indicate if there are STAFFER partners among them)			
Teaching language	Greek		
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Full time. Taught in person. Physical presence is not required. Teaching material available via e-learning platform.		
Assessment methods and regulations	Student Assessment methods • Written Exam with Multiple Choice Questions (Formative, Summative)		

	• Written Exam with Short Answer Questions (Formative, Summative) • Written Assignment (Formative, Summative) • Written Exam with Problem Solving (Formative, Summative)
Qualification of teachers and trainers	Teaching Supervisor is a permanent staff member of AUTh (current supervisor holds the rank of Professor). Visiting lectures typically hold an engineering degree and are high ranking staff of railway related companies.
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	Survey of students' opinions at the end of the course analyzed by teaching and administrative staff.
Results indicators	1. Number of students enrolled 2. Percentage of enrolled students who pass the course 3. Student satisfaction survey results
Expected results	
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	
	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2023/2024
Duration of the programme	One semester
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://qa.auth.gr/el/class/1/600193096/M1

II.1.2 Railway PhD Course

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**Aristotle University of Thessaloniki**
Faculty/Department	**Faculty of Engineering/ School of Civil Engineering**
Training Program Title	**Postgraduate program leading to Doctorate Degree**
Indicate if it is a new training program or an existing one to be adapted	**Existing program**
Contact Name/Function/Mail/Phone	**Christos Pyrgidis/ Professor/ pyrgidis@civil.auth.gr/ 0030-2310-995795**
Degree Type	Doctorate Degree
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	Aristotle University of Thessaloniki (AUTh)
Training address	AUTh Campus
EQF Level	8
Usual entry age	23 plus
Entry requirements / Prerequisites	Typically requires the candidate to hold an undergraduate and postgraduate degree or an integrated master (as per l.4485/2017). Under special circumstances the requirement for a postgraduate degree may be waived (described in detail in Governmental Gazette Issue 2174/2018)
Potential progression for learners after graduation	Post-doctoral studies
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student
Expected learners numbers	Maximum of 8 Per Supervisor
Assessment of learning outcomes	Exams at the end of compulsory and elective modules.

	Oral and written presentation of progress to advisory committee (three supervisors) twice a year. Yearly progress report Public thesis defense in front of seven-person committee.
Diplomas/Certificates provided	Doctorate Degree
	OBJECTIVES
Overarching goals/visions	The subject of postgraduate studies at the Doctorate level is the coordinated organization and development of specialized knowledge as well as the production of new knowledge and technologies in the subject and the research directions of civil engineering. The main objective of these studies is the development of the research areas related to the technological, economic and social development of the country with emphasis on those that concern high priority sectors in Greece and internationally.
Targeted public	(Recent engineering) master's graduates
Potential jobs	Railway companies/ Research Institutes/ Academia
Selection method	Candidates submit applications at specified dates. Applications include the topic of the proposed thesis and the name of the proposed supervisor. Applications are accompanied by a detailed CV. The department/school assembly nominates three people supervisory committees based on the topics. Each supervisory committee examines the applications and the candidates are chosen based on: • Their undergraduate degree grade. • Their postgraduate degree grade. • Their grade in undergraduate and postgraduate courses/modules that are relevant to the proposed topic. • Grade of undergraduate and postgraduate dissertations. • Publications (e.g. articles in journals). • Work experience relevant to the proposed topic. • Any additional information deemed relevant from the candidate’s CV. • Two letters of recommendation • Interview • Language skills (minimum required is one additional EU language at B2 level)

	The findings/choices of the supervisory committees are given to the department/school assembly that validates them.
Learning objectives and outcomes, challenges and expected impacts	
Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	Access to civil engineering school facilities
Training program (curriculum, contents, general and specific objectives of each course, etc.)	Two compulsory and two elective modules. Compulsory modules are on: Research methodologies Computer skills Elective modules are chosen based on the topic of the thesis. Independent study.
Indicate the selected programme according to STAFFER findings	Rail transport engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☐ Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☐ Safety, dependability, security ☒ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	
Companies that offer internships (please indicate if there are STAFFER partners among them)	
Teaching language	Greek or English

Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Full or part time. Physical presence is not always required.
Assessment methods and regulations	After the completion of the thesis the candidate submits it to the three-person supervisory committee. After the committee gives its approval the candidate defends their thesis publicly in front of a seven-person supervisory committee.
Qualification of teachers and trainers	Members of the supervisory committee must hold at least the rank of assistant professor (or equivalent in the case of researchers).
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	
Results indicators	4. Number of students enrolled 5. Percentage of enrolled students who graduate
Expected results	
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Funding options may be available through scholarships. Examples may be found in: https://www.iky.gr/en/ https://www.elidek.gr/
	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2023/2024
Duration of the programme	Minimum duration of three years (four if candidate does not hold a postgraduate degree) Maximum duration of 9 years
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://www.civil.auth.gr/en/postg-en/ppltd-en.html

II.2 CESI

II.2.1 Bachelor en sciences et en ingénierie spécialité BTP (BIM) en apprentissage

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**CESI Ecole d'Ingénieurs**
Faculty/Department	**BTP**
Training Program Title	Bachelor en sciences et en ingénierie spécialité BTP (BIM) en apprentissage
Indicate if it is a new training program or an existing one to be adapted	**Adapted Existing Program**
Contact Name/Function/Mail/Phone	**Valerie POUPARDIN (STAFFER)** **Lyna AIT MOKHTAR (STAFFER)** **Norbert SAHAKIAN** **Candidate Relations Department** **0 800 054 568**
Degree Type	Bachelor (Bac +3)
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	Ministry of Labour (Titre RNCP) CTI (Commission des titres d'ingénieur)
Training address	93 Boulevard de Seine, 92000 Nanterre
EQF Level	EQF 6
Usual entry age	Post Bac
Entry requirements / Prerequisites	Baccalauréat

CESI ÉCOLE D'INGÉNIEURS

Potential progression for learners after graduation	Possibility for a Master's Degree
Type of VET programme (initial/continuous/ apprenticeship)	Apprenticeship
Status of learners (student/apprentice/staff)	Apprentices
Expected learners numbers	25
Assessment of learning outcomes	To complete the program, the learners should pass all the examination in the school-based part, the company based part.
Diplomas/Certificates provided	Bachelor
	OBJECTIVES
Overarching goals/visions	The BIM oriented Bachelor will be a training program dedicated to the understanding and mastery of technical aspects of BIM usage in the construction field. The students will learn to : Analyze, formalize, coordinate, organize and manage the modeling of the BIM project Manage communication around the project Participate in the digital and energy transition within your company This Bachelor in Science and Engineering prepares the student for his future missions in business through a framework adapted to the acquisition of knowledge and essential professional skills. To support them as best as possible in taking control of their future profession, CESI has put in place a veritable arsenal of tools for success:

	- A personalized follow-up thanks to individual and collective meetings scheduled throughout the course. - The school's pedagogy makes it possible to acquire the essential professional notions, whether technical or human. - Collaborative work to develop teamwork. - Integration within the dynamics of the engineering school through the rich and diverse community life. The apprentice status also offers the candidate the advantage of benefiting from rapid professional experience and comparing their learning in the company. Considered as a full-fledged employee, he will integrate into the company's culture and develop his professional ease to be quickly operational. This BIM Bachelor will allow the students to work on the maintenance of new and existing train stations, rail buildings and maintenance canters.
Targeted public	Highschool Students Graduates
Potential jobs	BIM Coordinator BIM modeler
Selection method	The method of recruitment is on application file, technical and motivation test during individual interviews prior to recruitment.
Learning objectives and outcomes, challenges and expected impacts	In the 1st year, the student will be able to participate in BIM projects integrating scientific aspects. In the 2nd year, the student will be able to integrate aspects around the envelope of the building which will make it possible to optimize the building by taking into account sustainable development. In the 3rd year, TheY will be able to optimize the site and suggest changes.

Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	**Pedagogical team** (*teachers, tutors, pedagogical engineers and Professionals)* **Material resources:** classrooms equipped with videoconferencing devices and personal computer equipment available to students. Fablab. BIM oriented classrooms
Training program (curriculum, contents, general and specific objectives of each course, etc.)	PROGRAM : **Analyze, formalize, coordinate, organize and manage the modeling of the BIM project** Manage communication around the project Participate in the digital transition within your company Master project management, agile methods, collaborative development Acquire soft-skills to work in a team **Coordinate the action of the project manager during a BIM project** Identify and implement the various BIM tools Choose the most suitable solution(s) and transcribe the functional specifications into a design file **Organize and manage the modeling of the BIM project** Define a BIM project management method Break down the project and define the resources needed for the project Identify and measure project management risks Monitor the project Closing the project and ensuring its sustainability **Manage and guarantee the formalization of BIM data** Technical support for a team Accompany the change induced by the projects Follow the project budget

	Assess the quality of your projects **Support the company's BIM strategy in its digital developments** Appropriate the changes generated by digital and digital developments Supporting the digital and digital transition of your company **International internships** To complete his career, the apprentice will carry out a 4-week mobility abroad.
Indicate the selected programme according to STAFFER findings	Railway systems engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☒ Living language ☒ Big Data & Artificial Intelligence ☐ Transportation systems ☐ Reliability, maintenance & life cycle management ☒ Learning skills ☒ Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☒ Safety, dependability, security ☐ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	3 years
Companies that offer internships (please indicate if there are STAFFER partners among them)	Companies that are involved in construction or Railway
Teaching language	French

Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face to face
Assessment methods and regulations	The evaluation system is based on continuous assessment. To advance to the next year, students must: - validate all their teaching units, - obtain all ECTS credits
Qualification of teachers and trainers	Researchers, professors, professionals, engineers and high-level technicians.
	PARTNERSHIP
Partners Name/Address	l'ENSA PLV, l'école nationale supérieure d'architecture de Paris la Villette.
	TRAINING EVALUATION
Evaluation Modalities	Surveys done for students and company tutors as well.
Results indicators	Success rate, Employability rate and Student Satisfaction
Expected results	
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	In the case of the apprenticeship, the company will pay the registration fees.
	PROVISIONAL TIMETABLE
Implementation school year	2024
Duration of the programme	3 Year
	DISSEMINATION

Supports (flyer, website, social media, etc.)	https://www.cesi.fr/formation/bachelor-en-sciences-et-en-ingenierie-specialite-btp-bim-en-apprentissage-2301850/#anchor-4

II.2.2 Bachelor en sciences et ingénierie spécialité maintenance & data apprentissage

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**CESI Ecole d'Ingénieurs**
Faculty/Department	**INDUSTRIE**
Training Program Title	1. Bachelor en sciences et ingénierie spécialité maintenance & data apprentissage
Indicate if it is a new training program or an existing one to be	**Adapted Existing Program**
Contact Name/Function/Mail/Phone	**Valerie POUPARDIN (STAFFER)** **Lyna AIT MOKHTAR (STAFFER)** **Djamila KITOUS** **Candidate Relations Department** **0 800 054 568**
Degree Type	Bachelor
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	Ministry of Labour (Titre RNCP) CTI (Commission des titres d'ingénieur)
Training address	CESI PARIS, 93 Boulevard de Seine, 92000 Nanterre
EQF Level	EQF 6

Usual entry age	Post Bac
Entry requirements / Prerequisites	Baccalauréat
Potential progression for learners after graduation	Possibility for a Master's Degree
Type of VET programme (initial/continuous/ apprenticeship)	Apprenticeship
Status of learners (student/apprentice/staff)	Apprentices
Expected learners numbers	24
Assessment of learning outcomes	To complete the programme, the learners should pass all the examination in the school-based part, the company based part.
Diplomas/Certificates provided	Bachelor
	OBJECTIVES
Overarching goals/visions	The Bachelor of Science and Engineering in maintenance and data course trains students in predictive maintenance. They will be able to set up monitoring tools in order to anticipate maintenance needs, which will allow companies to make their industrial processes more reliable. Artificial Intelligence in Maintenance is an excellent means of analysis which aims to support digital change and optimize the company to meet the challenges of tomorrow. At the end of the training, the

	graduates will have all the necessary background to become an expert in his field thanks to his sense of analysis and his strength of proposal to identify the best solutions while optimizing the maintenance. The training and skills obtained during this program will be applied to the maintenance of railing stock.
Targeted public	Highschool Students Graduates
Potential jobs	Project manager in predictive maintenance Automation maintenance technician industrial maintenance technician Robotics maintenance technician
Selection method	The method of recruitment is on application file, technical and motivation test during individual interviews prior to recruitment
Learning objectives and outcomes, challenges and expected impacts	In the 1st year, the student will be able to participate in maintenance projects integrating scientific aspects. In the 2nd year, the student will be able to integrate sensors that will allow the company to visualize its results and thus analyze the data. In the 3rd year, they will be able to optimize maintenance and suggest changes.
Others	
	MEANS / MODALITIES

Human and material resources (pedagogical team, workshops, laboratory, etc.)	**Pedagogical team** *(teachers, tutors, pedagogical engineers and Professionals)* **Material resources:** classrooms equipped with videoconferencing devices and personal computer equipment available to students. Fablab.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	PROGRAM **Analyze and find solutions to a maintenance problem** Translate the company's strategy into industrial objectives for its scope of activity Write and/or participate in the drafting of the specifications Participate in the construction of the solution **Organize and manage a predictive maintenance project** Define the project management method best suited to the chosen solution Break down the maintenance project into sub-projects, actions and tasks and assess the necessary workload Identify and measure the risks related to the management of a predictive maintenance project Monitor the project Closing the project and ensuring its sustainability **Manage and adapt the production process** Follow the evolution of data and tools to guarantee the effectiveness of the predictive maintenance solution Manage the company's orientations in terms of maintenance 4.0

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	Manage the predictive maintenance project and support change Animate the human aspects of the predictive maintenance project in connection with the company's digital transition Accompany the change induced by the predictive maintenance project Evaluate the performance of the predictive maintenance project and contribute to the ethical framework of the project **Optimize business performance through the use of predictive maintenance** Model the "upstream" process that will be associated with predictive maintenance to meet the expectations of stakeholders Synthesize the information collected Analyze the feasibility and profitability of the predictive maintenance project **International internships** To complete his course, the student will carry out a 4-week mobility abroad.			
Indicate the selected programme according to STAFFER findings	Railway systems engineering			
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐	Norms, standards & certification ☐	Smart cities & Internet of Things (IoT) ☐	Living language ☐

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	Big Data & Artificial Intelligence ☒ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☒ Global new energies & technologies ☒ Formal methods for system design & verification ☐ Web development ☐ Communication ☒ Safety, dependability, security ☒ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	3 year
Companies that offer internships (please indicate if there are STAFFER partners among them)	Companies that are involved in construction or Railway
Teaching language	French
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face to face
Assessment methods and regulations	The evaluation system is based on continuous assessment. To advance to the next year, students must: - validate all their teaching units, - obtain all ECTS credits
Qualification of teachers and trainers	Researchers, professors, engineers, professionals and high-level technicians.

	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	Surveys done for students and company tutors as well.
Results indicators	Success rate, Employability rate and Student Satisfaction
Expected results	
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	In the case of the apprenticeship, the company will pay the registration fees.
	PROVISIONAL TIMETABLE
Implementation school year	2024
Duration of the programme	3 Year
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://www.cesi.fr/formation/bachelor-en-sciences-et-ingenierie-specialite-maintenance-data-apprentissage-2301856/

II.2.3 Mastère Spécialisé ® Management de Projets de Construction (MS®), Option BIM

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**CESI Ecole d'Ingénieurs**
Faculty/Department	**BTP**
Training Program Title	Mastère Spécialisé ® Management de Projets de Construction (MS®), Option BIM
Indicate if it is a new training program or an existing one to be adapted	**Adapted Existing Program**
Contact Name/Function/Mail/Phone	**Valerie POUPARDIN** **Boubakar SECK** **Candidate Relations Department : 0 800 054 568** **0 800 054 568**
Degree Type	MS® (Bac +6)
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	Accrédité by the CGE (Conférence des Grandes Ecoles) label MS® Ministry of Labour : Mastère Spécialisé® enregistré au RNCP au niveau 7.
Training address	93 Boulevard de Seine, 92000 Nanterre
EQF Level	EQF 7
Usual entry age	Adult aged after a Master's degree

Entry requirements / Prerequisites	- Candidate holding a bac +5 (engineer, M2, title certifying RNCP level 7) or equivalent M1 with 3 years of professional experience
Potential progression for learners after graduation	
Type of VET programme (initial/continuous/ apprenticeship)	Apprenticeship and initial
Status of learners (student/apprentice/staff)	Apprentices and students
Expected learners numbers	100
Assessment of learning outcomes	To complete the programme, the learners should pass all the examination in the school-based part, the company based part.
Diplomas/Certificates provided	Mastère Spécialisé ® and RNCP title Level 7
	OBJECTIVES
Overarching goals/visions	The Specialized Master® Construction Project Manager prepares the student to manage multidisciplinary construction, renovation and rehabilitation projects of different scales and natures (buildings, public works, urban-scale projects, rail transport, urban and mobility projects). ...) over their entire life cycle, in France or abroad. With increasingly demanding and complex projects, the construction project manager ensures the acceptance of projects from a technical, technological, economic, legal and regulatory point of view by integrating the challenges of current and future transitions in the sector. (BIM and digital model, new technologies, environment, energy, development of the industrialization of construction processes...).

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	BIM is now a major challenge in project management for greater control and optimization. This training should ultimately enable work-study students to manage all types of construction projects over the entire life cycle of the project (design, execution, operation, etc.) using the digital model and BIM. It helps to train project managers capable of understanding changes in the organization of the company as well as developing a project management strategy adapted to the integration and development of this activity.
Targeted public	Students continuing their studies Company employees Job seekers Resuming studies Retraining
Potential jobs	Construction project leader or director Program Manager Head of studies Works manager, works coordination and scheduling manager BIM project manager or manager BIM and digital model manager BIM Project Manager
Selection method	The method of recruitment is on application file, technical and motivation test during individual interviews prior to recruitment
Learning objectives and outcomes, challenges and expected impacts	Manage construction projects over the entire life cycle using BIM and digital modeling Know how to implement and support the BIM approach in an organization Develop a project management strategy in BIM
Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	**Pedagogical team** *(teachers, tutors, pedagogical engineers and Professionals)*

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	Material resources : classrooms equipped with videoconferencing devices and personal computer equipment available to students. Fablab. BIM Classes.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	PROGRAM : **project management** Project management Culture project **Construction and BIM project management** Innovations and new approaches in construction project management **Management of people in transitions** Team management Change management **Strategic and economic management of projects and companies** Financial analysis Financial viability of a project Indicators and dashboards Application job **Legal and construction law** Responsibilities, Warranties and Insurance Law and financial arrangement of contracts (in France and abroad) Urban planning and land use planning Normative context of BIM in France and abroad **BIM project management** BIM project management in-depth BIM Project – Buildings BIM project – infrastructure BIM project – Urban development **BIM environment, tools and interoperability** BIM tools, interoperability and its challenges Information system, choice and software strategy

	Exchange formats, Construction of IFC objects Information system and data flow Intellectual and industrial property Management of the digital model and its data **BIM strategies and development** BIM at the urban scale BLM (Building Lifecycle Management) BIM and asset management BIM in an organization: integration, changes, management **Methodologies and professional tools** Group dynamic Innovation approach Professional written and oral Structuring of the professional project **Mission and professional thesis** The mission in a company, lasting 6 months full-time equivalent, is evaluated by the company tutor at the end of the course, and is the subject of the drafting of a mid-term strategic vision report, presented orally and assessed during the visit to the company. As part of this mission, the master's student carries out a professional thesis project which makes it possible to identify and then explore in depth a business subject, chosen by the master's student and his business tutor. The methodology deployed must make it possible to arrive at the implementation of an innovative solution for the company. The professional thesis is presented in writing and defended orally
Indicate the selected programme according to STAFFER findings	Railway systems engineering
Indicate the subjects that you intend to implement or modify for the declared	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☒ Living language ☒

fields/trends/skillsets according to STAFFER findings	Big Data & Artificial Intelligence ☐ Transportation systems ☐ Reliability, maintenance & life cycle management ☒ Learning skills ☒ Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☒ Safety, dependability, security ☐ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	1 year
Companies that offer internships (please indicate if there are STAFFER partners among them)	Companies that are involved in construction or Railway
Teaching language	French
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face to face and Remote (35h remote)
Assessment methods and regulations	Follow the courses and validate the Teaching Units - Carry out a mission in a company for a minimum duration of 6 months full-time equivalent and validate it - Realize a professional thesis and validate it The MS® allows to acquire 75 ECTS credits
Qualification of teachers and trainers	Researchers, professors, and engineers and high-level technicians.
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	Surveys done for students and company tutors as well.
Results indicators	Success rate, Employability rate and Student Satisfaction

Expected results	We are expecting the same or better results than our last survey : 92% exam pass rate in 2020 6 months after graduation, 90% of 2020 graduates from this training are in employment 100% of 2020 graduates are satisfied with their training
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	In the case of the apprenticeship, the company will pay the registration fees.
	PROVISIONAL TIMETABLE
Implementation school year	2023-2024
Duration of the programme	1 Year
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://www.cesi.fr/formation/mastere-specialise-management-de-projets-de-construction-bim-1602302/

II.2.4 Mastère Spécialisé ® Management de Projets de Construction (MS®), Option Transports Ferroviaires, Urbains et Nouvelles Mobilités

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**CESI Ecole d'Ingénieurs**
Faculty/Department	**BTP**
Training Program Title	Mastère Spécialisé ® Management de Projets de Construction (MS®), Option Transports Ferroviaires, Urbains et Nouvelles Mobilités
Indicate if it is a new training program or an existing one to be adapted	**Adapted Existing Program**
Contact Name/Function/Mail/Phone	**Valerie POUPARDIN** **Candidate Relations Department : 0 800 054 568** **0 800 054 568**
Degree Type	MS® (Bac +6)
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	Accrédité by the CGE (Conférence des Grandes Ecoles) label MS® Ministry of Labour : Mastère Spécialisé® enregistré au RNCP au niveau 7.
Training address	93 Boulevard de Seine, 92000 Nanterre
EQF Level	EQF 7
Usual entry age	Adult aged after a Master's degree

Entry requirements / Prerequisites	- Candidate holding a bac +5 (engineer, M2, title certifying RNCP level 7) or equivalent M1 with 3 years of professional experience
Potential progression for learners after graduation	
Type of VET programme (initial/continuous/ apprenticeship)	Apprenticeship and initial
Status of learners (student/apprentice/staff)	Apprentices and Students
Expected learners numbers	20
Assessment of learning outcomes	To complete the programme, the learners should pass all the examination in the school-based part, the company based part.
Diplomas/Certificates provided	Mastère Spécialisé ® and RNCP title Level 7
	OBJECTIVES
Overarching goals/visions	The Specialized Master® Construction Project Manager prepares the student to manage multidisciplinary construction, renovation and rehabilitation projects of different scales and natures (buildings, public works, urban-scale projects, rail transport, urban and mobility projects). ...) over their entire life cycle, in France or abroad. With increasingly demanding and complex projects, the construction project manager ensures the acceptance of projects from a technical, technological, economic, legal and regulatory point of view by integrating the challenges of current and future transitions in the sector. (BIM and digital model, new technologies, environment, energy, development of the industrialization of construction processes...). With the climate change we are experiencing mobility is an essential brick in the reduction of greenhouse gases in our cities. This training allows you to manage all types

	of rail or urban transport projects, integrating the specificities of urban, rail and guided transport (metro, tram-train, tramway, BHNS, cable transport, etc.) and new uses and services in terms of smart and sustainable mobility (multi-modality, real-time information systems, carpooling, car-sharing, self-service bicycles, etc.). It also makes it possible to train project managers capable of piloting a transport project from study to completion, in France and abroad, by mastering the interfaces between the different disciplines and taking into account the operation and maintenance from the design stage. This option responds to the growing challenges of mobility and urban transport in the cities of today and tomorrow.
Targeted public	Students continuing their studies Company employees Job seekers Resuming studies Retraining
Potential jobs	Construction project leader or director Program Manager Head of studies Works manager, works coordination and scheduling manager Head or director of rail or urban transport projects Railway or urban works supervisor Railway work scheduling officer or manager Rail/urban studies and projects manager Rail or urban transport project manager/manager Railway/urban studies officer/manager Business manager Project management assistant in the project phase Railway works supervisor Railway works scheduling manager
Selection method	The method of recruitment is on application file, technical and motivation test during individual interviews prior to recruitment

Learning objectives and outcomes, challenges and expected impacts	Manage rail, urban and sustainable mobility transport projects Conduct work on rail and urban transport projects (infrastructure, equipment, etc.) Ensure the mission of scheduling, planning and coordination (OPC) of railway, urban or mobility works Design a multi-modal exchange hub Ensure the commercial development and the improvement of the commercial efficiency process (gain of strategic offers) Optimize the management of the rolling stock fleet and its maintenance Manage the organization and operational management of operations
Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	**Pedagogical team** *(teachers, tutors, pedagogical engineers and Professionals)* **Material resources:** classrooms equipped with videoconferencing devices and personal computer equipment available to students. Fablab.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	PROGRAM **project management** Project management Culture project **Construction and BIM project management** Innovations and new approaches in project management construction **Management of people in transitions** Team management Change management **Strategic and economic management of projects and companies**

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	Financial analysis Financial viability of a project Indicators and dashboards Financial and extra-financial performance **Legal and construction law** Responsibilities, Warranties and Insurance Law and financial arrangement of contracts (in France and international) Urban planning and land use planning Normative context of BIM in France and abroad **Issues and organization of rail, urban and** **innovative motilities** Rail and urban transport in France and Europe Environmental issues Economic issues and estimation of the profitability of a project Types of transport systems, their operations and maintenance Railway safety **Railway infrastructure design** BIM and Design of railway / urban infrastructures Choice of Civil Engineering and infrastructure Track sizing and design Railway works: Works of art, Hydraulic works/in earth, tunnels Pathology and rehabilitation of infrastructure and railway facilities Railway equipment design General concepts of railway equipment Signaling and safe train control system Energy and Catenaries Telecommunications - Operation support systems (EAS) -

	Ticketing - operational safety Rolling stock **Sustainable development and innovative mobilities** BIM and Rail / Urban Transport Land use planning around an urban project Innovative mobility and intelligent transport systems Sustainable mobility management **Methodologies and professional tools** Group dynamic Innovation approach Professional written and oral Structuring of the professional project **Mission and professional thesis** The mission in a company, lasting 6 months equivalent time full, is assessed by the company tutor at the end of the course, and is the subject of the drafting of a mid-term strategic vision report, presented orally and assessed during the visit to the company. As part of this mission, the master's student leads a professional thesis project that identifies and then to explore in depth a business topic, chosen by the student master's degree and his company tutor. The methodology deployed should lead to the implementation of a solution Innovative for the company. The professional thesis is presented in writing and defended orally
Indicate the selected programme according to STAFFER findings	Railway systems engineering
Indicate the subjects that you intend to implement or modify for the declared	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☒ Smart cities & Internet of Things (IoT) ☒ Living language ☒

fields/trends/skillsets according to STAFFER findings	Big Data & Artificial Intelligence ☐ · Transportation systems ☒ · Reliability, maintenance & life cycle management ☒ · Learning skills ☒ · Global new energies & technologies ☒ · Formal methods for system design & verification ☐ · Web development ☐ · Communication ☒ · Safety, dependability, security ☒ · Networking & ICT technologies ☐ · Virtual reality ☐ · Soft skills ☒
Duration and type of work-based internships (if compulsory)	1 year
Companies that offer internships (please indicate if there are STAFFER partners among them)	Companies that are involved in construction or Railway
Teaching language	French
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face to face and Remote (35h remote)
Assessment methods and regulations	Follow the courses and validate the Teaching Units - Carry out a mission in a company for a minimum duration of 6 months full-time equivalent and validate it - Realize a professional thesis and validate it The MS® allows to acquire 75 ECTS credits
Qualification of teachers and trainers	Researchers, professors, and engineers and high-level technicians.
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	Surveys done for students and company tutors as well.
Results indicators	Success rate, Employability rate and Student Satisfaction

Expected results	We are expecting the same or better results than our last survey : 92% exam pass rate in 2020 6 months after graduation, 90% of 2020 graduates from this training are in employment 100% of 2020 graduates are satisfied with their training
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	In the case of the apprenticeship, the company will pay the registration fees.
	PROVISIONAL TIMETABLE
Implementation school year	2023-2024
Duration of the programme	1 Year
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://www.cesi.fr/formation/mastere-specialise-management-de-projets-de-construction-transports-urbains-1479842/

II.3 CTU

II.3.1 Transportation Systems and Technology

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	Czech Technical University in Prague
Faculty/Department	Departments of Mechanics and Materials
Training Program Title	Transportation Systems and Technology
Indicate if it is a new training program or an existing one to be adapted	Existing training program
Contact Name/Function/Mail/Phone	Ondrej Jirousek STAFFER contact person.
Degree Type	Master diploma
Certification (Yes/No/In Process, type, etc.)	YES
Organism of Certification	Czech Technical University in Prague
Training address	Konviktska 20, CZ10000, Prague, Czech Republic
EQF Level	EQF Level 7
Usual entry age	Adult aged 18 and above

Entry requirements / Prerequisites	All applicants shall submit an officially certified copy of their previous successfully completed studies according to the type of study programme. The condition of master's degree study program is the completion of a university degree of at least bachelor type. All applicants shall submit a certified copy of the diploma and the Diploma Supplement or other confirmation containing a list of completed subjects and achieved study average. These documents do not have to be submitted by applicants who have completed a bachelor's degree program at the Czech Technical University in Prague, Faculty of Transportation Sciences. The applicants who completed previous studies abroad will submit a validated Bachelor's Diploma – called nostrification (except for those who have completed their education in the Slovak Republic).
Potential progression for learners after graduation	Possible to continue in any related field, under certain conditions.
Type of VET programme (initial/continuous/ apprenticeship)	Initial
Status of learners (student/apprentice/staff)	Students in initial training, employees or job seekers, or work-study students
Expected learners numbers	200
Assessment of learning outcomes	To complete the programme, the learners must pass all examination in the school-based part, the practical work tests, and the professional committee examination.

Diplomas/Certificates provided	Master diploma in Transportation Systems and Technology
	OBJECTIVES
Overarching goals/visions	Intelligent Transport Systems (IS) is a quickly evolving area facing a lack of qualified professionals. Why are these systems important? Intelligent Transport Systems integrate information and telecommunication technologies with transport engineering in order to achieve better transport systems efficiency, lower travel times, higher safety and security, reduction of environmental impacts, increase in passenger comfort. The study field Intelligent transport systems (IS) is a part of a Master´s Degree Programme called Technology in Transportation and Telecommunications and enlarges the spectrum of transportation education. The Faculty of Transportation Sciences is well recognized for its Intelligent Transport Systems education. It possesses vehicle simulators and has research laboratories specializing in ITS related problems (e. g. Laboratory of Telematics, Joint Laboratory of System Reliability and Laboratory of Traffic Control and Modelling). Last but not least, the Faculty of Transportation Sciences closely cooperates with the Intelligent Transport Systems and Services of the Czech Republic Association, with the Academy of Sciences of the Czech Republic and with many organizations in the private sector. During the study students gain knowledge in the following areas: Transportation Systems, Automated Data Acquisition and Processing, Intelligent Transport Systems Management Skills, Mathematical Tools, Traffic Modelling and Simulation, Telecommunication, Specialization in Intelligent Transport Systems (design, control, evaluation, ...), GIS, Positioning, Navigation and Identification Systems,

	Complex Systems, Human Environmental Impacts, Safety and Sustainability. Study is organized as project oriented enabling team work on transport projects under the supervision of experienced specialists. In this study field there is the possibility of study in cooperation with Swedish university - the Intelligent Transport Systems study field is offered either as a single degree program at the Czech Technical University in Prague or as a joint-degrees study field combined with partner university in Linköping (Linköpings Universitet), Sweden offering students the possibility to obtain diploma also from the foreign university.
Targeted public	People with a bachelor level, public in activity, retraining of job seekers
Potential jobs	Managers, planners, leaders
Selection method	Interview, checking off previous education level, and written examination
Learning objectives and outcomes, challenges and expected impacts	The goal of the course is to train engineers in railway area who are potentially interesting for companies supporting the study programme and can invest on them after a period of reciprocal knowledge and professional integration, as well as for other companies beyond them. Close collaboration with companies supporting the study programme that can contribute to the definition of the contents of the modules, collaborate with the selection of participants and to teaching activities, host technical visits and internships and issue scholarships for students is essential to achieve this goal.

Others

A collaboration with the commercial sector, governments and public organizations, foreign universities, foreign partners.

MEANS / MODALITIES

Human and material resources (pedagogical team, workshops, laboratory, etc.)

Pedagogical team, Testing Laboratory of Faculty of Transportation Sciences (the laboratory established a management system in accordance with the Czech technical standard ČSN ISO/IEC 17025:2005 and it was accredited by the Czech Accreditation Institute, o. p. s. under No. 1048.3.), Mobile laboratory for transport analysis

Training program (curriculum, contents, general and specific objectives of each course, etc.)

1st semester – study programme IS (EN)

Course	Code	hrs/w	Credits
ITS Mathematical tools	11MAY	2 + 2	4
Traffic Flow Theory	12TDP	2 + 1	3
Electronic systems in modern vehicles	16ESDP	2 + 1	3
Modern techniques of safety control	20MZZ	2 + 1	3
Vehicles within ITS	16SAID	2 + 2	4
Geographical, information, localization and navigation systems	20GINS	3 + 3	6
Telematic systems and their design	20CH	3 + 2	6
Technology and Security of Sensor Networks			
Master project 1 for study program IS	XN1S	0 + 4	5

1st semester – study programme IS (EN)

(study plan at Linkoping university)

Course	Code	hrs/w	Credits
Optimization	TNK053	1,5+4,5	6
Geographical Information Systems for Transportation	TNK055	3 + 3	6
Traffic Safety Management	TNK091	2+1+3	6

Positioning Systems	TNK106	2 + 4	6
Transport and Logistics Systems	TNK112	2+2+2	6

2nd semester – study programme IS (EN)

Course	Code	hrs/w	Credits
C-ITS Systems	14OTHER	3 + 3	6
Microsimulation Models	14ME	0 + 3	3
Simulation and HMI	16SHMI	2 + 1	3
ITS-R	20ITSR	2 + 1	4
Programming and modelling	14PAM	2 + 2	4
Data processing	14PD	2 + 4	6
Computer Aided Project Management	14PPRP	0 + 2	2
Safety and reliability of ITS Systems	20BITS	2 + 1	3

2nd semester – study programme IS (EN)

(study plan at Linkoping university)

Course	Code	hrs/w	Credits
Logistics Networks and Transport	TNK099	1+2+3	6
Smart Cities	TNK115	2+2+2	6
Logistics Resource Planning	TNK100	1 + 5	6
Mobile Communication and Networks	TNK110	1+2+3	6
Internet of Things	TNK116	2 + 4	6
Traffic Theory and Simulation	TNK119	3 + 3	6
Transport Demand Forecasting	TNK118	2 + 4	6

3rd semester – study programme IS (EN)

Course	Code	hrs/w	Credits
Mathematical Methods for Data Analysis	11MMAD	3 + 3	6
Quality and reliability in area of transportation means and systems	16KSD	2 + 1	3
Computer aided railway traffic control	20PRZP	2 + 1	3
Telematics in Public Transport	20TVHD3	2 + 1	3
Application of ITS in Urban Engineering	20AIMI	3 + 3	6
Quiet System engineering	20SYIN	4 + 2	6
Evaluation and Economics of ITS	20HEY	2 + 1	3

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3rd semester – study programme IS (EN)

(study plan at Linkoping university)

Course	Code	hrs/w	Credits
Project Management	TEI091	3 + 3	6
Planning of Public Transportation and Railway Traffic	TNK098	2 + 4	6
Analysis of Communication and Transport Systems	TNK103	6	6
Data Analytics for Smart Cities	TNK117	2+2+2	6
Traffic State Estimation, Prediction and Control	TNK120	3 + 3	6

4th semester

Course	Code	hrs/w	Credits
Master Thesis for study programme IS	XNDS	0 + 16	16
Master project 4 for study programme IS	XN4S	0 + 8	10
Training course for study programme IS	XPXS	0 + 4	4

Indicate the selected programme according to STAFFER findings	Rail traffic/operations engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☒ Living language ☒ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☐ Learning skills ☒ Global new energies & technologies ☒ Formal methods for system design & verification ☐ Web development ☐ Communication ☐

	Safety, dependability, security ☐ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	3-6 months
Companies that offer internships (please indicate if there are STAFFER partners among them)	Companies that are involved in inteligent transport systems
Teaching language	English
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Attendance education
Assessment methods and regulations	Evaluations by scenario and knowledge checks
Qualification of teachers and trainers	Researchers, professors, and high-level technicians.
	PARTNERSHIP
Partners Name/Address	Linköpings Universitet Linköping University SE-581 83 Linköping, Sweden Telephone: +46 13 281000, Monday-Friday 8.00-16.30
	TRAINING EVALUATION

Evaluation Modalities	Mid-term and end satisfaction surveys, analyzed in development advice at the end of training, to identify areas for improvement
Results indicators	Success rate, continuation rate
Expected results	60% success of registered students, 30% continuation of studies for graduates
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Depending on the status of the students. In the case of the apprenticeship, the company will pay the registration fees.
	PROVISIONAL TIMETABLE
Implementation school year	2023-2024
Duration of the programme	Two years
	DISSEMINATION
Supports (flyer, website, social media, etc.)	To be created (flyer, presentation of the battery school, job center, website)

II.4 ESTACA

II.4.1 Transport engineering / Operation and Maintenance (specialization)

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	École Supérieure des Techniques Aéronautiques et de Construction Automobile (ESTACA)
Faculty/Department	Railway pathway (Filière Ferrovaire)
Training Program Title	Operation and Maintenance (specialization)
Indicate if it is a new training program or an existing one to be	Existing, in continuous adaptation
Contact Name/Function/Mail/Phone	Philippe Guibert Training Director philippe.guibert@estaca.fr +33176521116
Degree Type	Engineering degree
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	ESTACA
Training address	Saint-Quentin-en-Yvelines, Laval, Bordeaux
EQF Level	7
Usual entry age	Individuals who have reached the age of 18 or older

Entry requirements / Prerequisites	BAC (+ 1 / 2) staggered start, preparatory classes, universities, international students
Potential progression for learners after graduation	Advanced master's degree, PhD, MBA ...
Type of VET programme (initial/continuous/ apprenticeship)	Initial training, apprenticeship, block release training, lifelong learning
Status of learners (student/apprentice/staff)	Students undergoing initial training, employees, job seekers and apprentices.
Expected learners numbers	30 - 70
Assessment of learning outcomes	Progress reports, supervised tests and exams ...
Diplomas/Certificates provided	Engineering degree, Railways (*Diplôme d'Ingénieur ESTACA, spécialisation Ferroviaire*)
	OBJECTIVES
Overarching goals/visions	This text is taken from the training brochure: Innovation is at the heart of railway industry professions, aiming for ever-energy-efficient transport systems. It encompasses the development of freight transportation, autonomous trains, integration of new energy sources, advancements in urban transport systems, predictive maintenance engineering, big data utilization, and more. Collective mobility profoundly impacts daily life and lies at the core of ecological transition challenges. Engineers are in high demand from manufacturers, transport companies, and local communities to spearhead the

	design of urban cable cars, tramways, and the cutting-edge hyperloop systems of the future. The reputation of French expertise in this field is widely recognized and gaining global prominence. ESTACA stands as one of the few schools in France offering a specialized education focused on railway. It represents one of the fields facing the most significant shortage of engineers today, with promising prospects for the future.
Targeted public	All French or foreign students holding a general Baccalaureate or an equivalent qualification can join the railway training programme of ESTACA. Eager to diversify student profiles, ESTACA offers various levels of admission based on the candidate's background (see below).
Potential jobs	**Railway Design Engineer**: Design and develop new railway vehicles, as well as the associated systems and equipment. **Railway Maintenance Engineer**: Ensure preventive and corrective maintenance of trains and railway infrastructure to ensure their proper functioning and safety. **Railway Signaling and Automation Engineer**: Work on automated signaling and control systems to enhance railway safety and efficiency. **Urban Transportation Engineer**: Contribute to the development and improvement of urban public transportation systems, such as trams and metros. **Railway Energy Engineer**: Work on energy efficiency solutions and the implementation of new energy sources for railway transportation.

	Logistics and Supply Chain Engineer: Manage logistics and supply of materials and equipment necessary for the operation of railway networks. **Railway Safety and Security Engineer:** Implement safety and security devices to protect passengers, staff, and assets during railway travel. **Research and Development Engineer:** Participate in research projects to drive innovation in the railway field, encompassing technologies, materials, and systems.
Selection method	**Baccalaureate BAC:** to join ESTACA, candidates have to apply through the Parcoursup platform and then go through the selection process of the Concours Avenir: • **Parcoursup** is a web portal managed by the French Ministries of Education and Higher Education, Research, and Innovation. It handles undergraduate admissions to French universities and other higher education institutions for high school diploma holders. • **Concours Avenir** (Established in 2009) is one of the first joint entrance exams enabling access to post-baccalaureate engineering schools in France. **BAC+1 deferred admission:** to join ESTACA, candidates must apply through the **AvenirPlus procedure,** which is a fully online and specifically tailored for students who have already obtained the Baccalaureate and are interested in joining the platform's affiliated schools in the 2nd, 3rd, or 4th year (based on their current academic track).

	Preparatory classes, universities (BAC+2/3...): Selection is based on application via **AvenirPlus**. The jury ranks applications based on: • Results achieved in previous academic years, particularly in scientific subjects and English. • Teacher's assessments. • Results from exams and competitions. • Motivations expressed during the interview.
Learning objectives and outcomes, challenges and expected impacts	The railway training program is designed to equip students with the necessary knowledge and skills to excel in various roles within the railway industry. Some of the **key learning objectives and outcomes** include: • In-depth understanding of railway systems and technologies. • Proficiency in the design and development of railway vehicles and infrastructure. • Ability to analyze and solve complex problems in the railway domain. • Knowledge of safety standards and regulations related to railway operations. • Expertise in railway signaling and control systems. • Familiarity with energy-efficient and sustainable practices in railway operations. • Project management skills for handling railway-related projects.

	• Competence in maintenance and optimization of railway systems. • Strong communication and teamwork abilities for effective collaboration within the industry. The railway training program at ESTACA faces **various challenges,** including: • Keeping up with technological advancements in the rapidly evolving railway industry. • Addressing sustainability and environmental concerns in railway operations. • Meeting the demand for skilled professionals in the railway sector. • Adapting to changes in regulations and safety standards. • Integrating emerging technologies like automation and digitalization into railway systems. • Balancing theoretical knowledge with practical experience. The railway training program at ESTACA aims to make a **positive impact** on various levels: • Meeting the industry's demand for skilled and competent railway professionals. • Contributing to the development of innovative and sustainable solutions in the railway sector. • Enhancing safety and efficiency in railway operations through well-trained engineers. • Fostering collaboration between students and industry stakeholders.

	• Strengthening the railway workforce with competent project managers and leaders. • Advancing research and development in the railway domain.
Others	**Over 400 hours of training** delivered by active engineers (among others) from ALSTOM, SNCF, HITACHI RAIL, EGIS RAIL, DB, IDF Mobilités, and more. **At least 4 application projects completed during the curriculum**, such as new high-speed night train, concept for a mixed passenger/freight TER (regional train), regeneration of a self-driving railcar with new energy sources, study of freight tramway solutions for urban zone supply. **12 months of mandatory internships**, for example: • Execution internship during 1st or 2nd year at SNCF: technical maintenance for railway equipment in the brake domain. • Student engineer internship during the 4th year at Deutsche Bahn Schenker Rail GmbH: European freight wagon maintenance project. • End-of-studies internship during the 5th year at Egis Rail: implementation of operating systems and equipment for the Montpellier tramway. **Visits to test centers**, study centers, and maintenance sites accompanied by conferences. **SNCF Group Partnership**: a pre-graduate program for 3rd and 4th-year students and two research and teaching chairs.
	MEANS / MODALITIES

Human and material resources (pedagogical team, workshops, laboratory, etc.)	The human and material resources involved in railway training at ESTACA include: **Faculty and Instructors**: ESTACA would have a team of experienced professors and industry professionals specialized in railway engineering and related disciplines. These experts would be responsible for designing and delivering the training courses. **Curriculum and course materials**: The school developed a comprehensive curriculum covering various aspects of railway engineering, including track design, signaling systems, rolling stock, safety regulations, maintenance, and more. Course materials, textbooks, and digital resources would be provided to students for study and reference. **Laboratories**: ESTACA'Lab (the research laboratory of ESTACA) is equipped with the several infrastructures and tools to conduct practical training and experiments related to railway systems such as , green rolling-stock, testing equipment, simulation tools, and software for modeling and analysis. **Training facilities**: ESTACA has several have specialized training facilities, as part of its collaborations with industrial partners, including mock railway tracks, signaling systems, and rolling stock, to offer hands-on training and real-world experience. **Industry partnerships**: ESTACA collaborates with railway companies and industry partners to provide students with internships, industrial visits,

	and practical projects that expose them to real-life railway engineering challenges and solutions. • **Research & Development:** ESTACA engages in continuous research and development projects focused on railway technology, which enhances the training content and grants students access to the latest advancements in the field. • **Support staff:** ESTACA employs administrative and technical staff to manage logistics, support students, and maintain the facilities required for the railway training programme.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	**Distribution of training clusters as a percentage of the total number of hours.** **Preparatory Cycle:** **First Year (total hours = 734):** • Scientific cluster (73% of total hours, 47 ETCS) • Transport engineering cluster (5% of total hours, 3 ETCS) • Human sciences and engineering culture cluster (13% of total hours, 11 ETCS) • Professional experience cluster (9% of total hours, 1 ETCS): Industrial internship (4 weeks) **Second Year** (total hours = 757): • Scientific cluster (73% of total hours, 44 ETCS) • Transport engineering cluster (6% of total hours, 4 ETCS)

	• Human sciences and engineering culture cluster (12% of total hours, 14 ETCS) • Professional experience cluster (9% of total hours, 1 ETCS): Company discovery internship (4 weeks) **Engineering Cycle:** **Third Year** (total hours = 775): • Scientific cluster (51% of total hours, 37 ETCS) • Transport engineering cluster (14% of total hours, 14 ETCS) • Human sciences and engineering culture cluster (18% of total hours, 12 ETCS) • Professional Experience cluster (17% of total hours, 1 ETCS): Company Internship (optional, 4 weeks) **Fourth Year** (total hours = 1185): • Scientific cluster (25% of total hours, 24 ETCS) • Transport engineering cluster (28% of total hours, 20 ETCS) • Human sciences and engineering culture cluster (16% of total hours, 12 ETCS) • Professional experience cluster (31% of total hours, 3 ETCS): Engineering Student Internship (4 months) **Fifth Year** (total hours = 1152): • Transport engineering cluster with one project and supervision (50% of total hours, 30 ETCS)

	• Professional experience cluster (50% of total hours): Final internship (6 months) **Details of the training clusters:** All details are available in the website of ESTACA: https://www.estaca.fr/formations/ingenieur/ferroviaire-transports-guides/ Here are the training programme details of the fourth and the fifth years (EQF 6 and 7): **Fourth Year:** *Scientific cluster:* Finite Elements Method (35hrs) • Variational formulation and meshing • Structure discretization • The various families of finite elements in structure calculation • Calculation of elementary matrices, assembly, and calculation of the solution to a static problem Continuum Mechanics (25hrs) • General hypotheses of continuum mechanics • Theory of elasticity, viscoelasticity, and thermoelasticity • Introduction to damage, rupture, and fatigue • Elastic problem-solving methods Structural Dynamics (25hrs) • Introduction to dynamic and acoustic phenomena • Theoretical and experimental modal analysis

	• Linear acoustics, acoustic modes, and acoustic impedance Energy Conversion and Transfer (20hrs) • Mass and energy balances in open systems • Conversion of thermochemical energy into heat energy • Conversion of thermochemical energy into mechanical-electrical energy Hydraulic Systems (15hrs) • Architecture design of hydraulic systems • Modeling of head loss • Power dimensioning • Introduction to networks and components Multi-physical Modeling (25hrs) • Coupling of mechanical, electrical, thermal, and hydraulic models • Multi-physical modeling tools Architecture and Communication (20hrs) • Basic concepts of software architectures • Task scheduling • Synchronization and inter-task communication Real-time Command (10hrs) • Control of discrete-time systems • Introduction to sequential systems • Real-time prototyping Modeling and Control of Electrical Actuators (20hrs)

	• Inverse model • Modeling control of asynchronous and synchronous machines Experimental Practical Work (20hrs) *Transport engineering cluster:* Railway Infrastructure (35hrs) • Railway Civil Engineering: maintenance and design of infrastructure • Interfaces between Infrastructure and Rolling Stock Geometry Vehicle-Track Interactions (32hrs) • Braking • Dynamics of railway vehicles • Current collection and pantograph-catenary interface • Train System Architecture Railway Safety and Signaling Installations (21hrs) • Signaling and safety – ATP/ERTMS • Signal cabins, interlocking systems • CBTC (Communication-Based Train Control) Power Supply (12hrs) • Principles and technology of electrical power supply • Traction return installations Project Management (25hrs) • Preliminary studies

	• Operator specifications Design of Railway Network in Dense Areas (9hrs) Systems Engineering (16hrs) • Operability • General design New Line Design Project (50hrs) *Human sciences and engineering culture cluster:* Reliability and Safety (24hrs) • Basic principles of reliability • Methods and tools for analyzing complex systems (fault trees, FMEA…) • Project Management, Economics, and Business Strategy (28hrs) • Serious game BECOM-ING (Business, Éthique, Communication Organisation, Management, INsertion pro et INnovation, Gestion, 31hrs) • Development of professional project objectives • Role-playing job interviews • Mastering public speaking for impactful self-presentation • Effective digital communication skills • Proficiency in organizing and actively participating in meetings • Enhancing cybersecurity awareness within the company

	• Nurturing team management capabilities • Fostering a sense of corporate social responsibility • Encouraging active involvement in school activities Industrial communication and technical English (36hrs) Foreign language 2, optional (36hrs) **Fifth Year** *Transport engineering cluster:* Option 2: Operation and Maintenance (275hrs) • Contract management • Management of railway operation safety • Connected trains • Passenger information system • Maintenance theory and decision support • Engineering of railway network maintenance • Maintenance of rolling stock • Elements of operation and maintenance • Railway Operation Project (capacity optimization)
Indicate the selected programme according to STAFFER findings	Option 2 (Operation and Maintenance): Rail traffic/operations engineering
Indicate the subjects that you intend to implement or modify for the declared	Cybersecurity & Internet of Things (IoT) X Norms, standards & certification X Smart cities & Internet of Things (IoT) ☐

fields/trends/skillsets according to STAFFER findings				Living language ☐
	Big Data & Artificial Intelligence X	Transportation systems ☐	Reliability, maintenance & life cycle management ☐	Learning skills ☐
	Global new energies & technologies X	Formal methods for system design & verification ☐	Web development ☐	Communication X
	Safety, dependability, security ☐	Networking & ICT technologies ☐	Virtual reality ☐	Soft skills X
Duration and type of work-based internships (if compulsory)	4-6 months			
Companies that offer internships (please indicate if there are STAFFER partners among them)	SNCF, ALSTOM			
Teaching language	French, English			

Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face-to-face, hybrid
Assessment methods and regulations	Continuous assessments and final exams.
Qualification of teachers and trainers	Lecturers, researchers, engineers and high-level technicians.
	PARTNERSHIP
Partners Name/Address	SNCF, ALSTOM, AnsaldoSTS, RATP, SYSTRA, IKOS ...
	TRAINING EVALUATION
Evaluation Modalities	Conducted midway and at the conclusion of the training, satisfaction surveys are carefully analyzed to provide developmental feedback and pinpoint areas that require improvement.
Results indicators	Business proximity, professional integration, international collaborations, research ...
Expected results	The *Usine Nouvelle* indicators are available in https://www.usinenouvelle.com/article/estaca.N313826
	FUNDING
Free of charge	☐

Type, modalities (estimated budget, contributions, fees, charges, etc.)	The tuition fees for the academic year 2023-2024 amount to €9,365 (excluding the contribution to the Student Union). Numerous possibilities exist to finance studies at ESTACA for each student based on their situation. *ESTACA Scholarships* In an effort to assist students, the school allocates a significant portion of the apprenticeship tax paid by companies to students. *Social Criteria Scholarships from CNOUS/CROUS* Designed for students with limited family resources, these scholarships must be applied for between January 15th and May 31st at the CROUS of the current educational institution. More information can be found at www.cnous.fr. *Local Authority Support* Regions, departments, or cities provide financial aid to schools for students originating from their territories. Any student who is tax-domiciled in Mayenne and chooses to join ESTACA Campus Ouest can obtain additional financial aid in addition to social criteria scholarships. Territoires aux Grandes Écoles: A scholarship of €6,000 per year for the first two years of higher education. Applications for terminal students go through partner schools. Selection is based on academic results, social criteria, and the student's project. For 2021, five departments are involved, and candidates must originate from one of these departments to apply. *Mobility Passport* The Mobility Passport provides students from overseas territories (DOM TOM) with a round-trip ticket per

	academic year for pursuing studies in mainland France for courses not available in their home department or interzone. Students wishing to pursue an engineering program at ESTACA may benefit from this scholarship. *New Government Financial Aid* The Merit Aid complements social criteria scholarships. It is awarded to students who obtain a "mention très bien" in the Baccalaureate or an excellent Bachelor's degree. The amount is €1,800 per year. Information is available at www.cnous.fr. *Specific Aid* This provides quick, personalized financial assistance to students facing difficulties. Emergency aid can take two forms: either a one-time assistance for students experiencing temporary severe difficulties, or an annual aid for students facing persistent challenges. To apply for aid, you must obtain an assistance request form from your CROUS. More information is available at Service Public. *Eiffel Excellence Scholarships* Scholarships may be awarded to foreign students. For more information: Campus France Eiffel Scholarship. *Mobility Scholarships* Various aid programs are available to help finance studying abroad as part of the education. Reserved for scholarship students, mobility scholarships can be granted for a duration of 3 to 9 months during a university stay. When planning your departure, ESTACA's International Department will provide you with all the information on other possible aids, such as Leonardo scholarships, Zellidja travel grants, etc.

	Loans Student loans are consumer credits granted to finance your studies. They can be subject to deferred repayment, allowing you to start repaying once you have graduated and entered the workforce. ESTACA has agreements with certain banks that offer attractive conditions for school students. Contact details for these banks' representatives can be found below. However, all banks may offer attractive interest rates for engineering students.
	PROVISIONAL TIMETABLE
Implementation school year	2023-2024
Duration of the programme	5, 4 or 3 years ...
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://www.estaca.fr/formations/ingenieur/ferroviaire-transports-guides/

II.4.2 Transport engineering / System Design (specialization)

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	École Supérieure des Techniques Aéronautiques et de Construction Automobile (ESTACA)
Faculty/Department	Railway pathway (Filière Ferrovaire)
Training Program Title	System Design (specialization)
Indicate if it is a new training program or an existing one to be adapted	Existing, in continuous adaptation
Contact Name/Function/Mail/Phone	Philippe Guibert Training Director philippe.guibert@estaca.fr +33176521116 Marc Cisais Head of the railway department, ESTACA Equipment and Maintenance Manager, SNCF SUD AZUR marc.ciais@estaca.fr
Degree Type	Engineering degree
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	ESTACA
Training address	Saint-Quentin-en-Yvelines, Laval, Bordeaux
EQF Level	7
Usual entry age	Individuals who have reached the age of 18 or older
Entry requirements / Prerequisites	BAC (+ 1 / 2) staggered start, preparatory classes, universities, international students
Potential progression for learners after graduation	Advanced master's degree, PhD, MBA ...
Type of VET programme (initial/continuous/ apprenticeship)	Initial training, apprenticeship, block release training, lifelong learning
Status of learners (student/apprentice/staff)	Students undergoing initial training, employees, job seekers and apprentices.

Expected learners numbers	30 - 70
Assessment of learning outcomes	Progress reports, supervised tests and exams …
Diplomas/Certificates provided	Engineering degree, Railways (*Diplôme d'Ingénieur ESTACA, spécialisation Ferroviaire*)
	OBJECTIVES (from
Overarching goals/visions	This text is taken from the training brochure: Innovation is at the heart of railway industry professions, aiming for ever-energy-efficient transport systems. It encompasses the development of freight transportation, autonomous trains, integration of new energy sources, advancements in urban transport systems, predictive maintenance engineering, big data utilization, and more. Collective mobility profoundly impacts daily life and lies at the core of ecological transition challenges. Engineers are in high demand from manufacturers, transport companies, and local communities to spearhead the design of urban cable cars, tramways, and the cutting-edge hyperloop systems of the future. The reputation of French expertise in this field is widely recognized and gaining global prominence. ESTACA stands as one of the few schools in France offering a specialized education focused on railway. It represents one of the fields facing the most significant shortage of engineers today, with promising prospects for the future.
Targeted public	All French or foreign students holding a general Baccalaureate or an equivalent qualification can join the railway training programme of ESTACA. Eager to diversify student profiles, ESTACA offers various levels of admission based on the candidate's background (see below).
Potential jobs	**Railway Design Engineer**: Design and develop new railway vehicles, as well as the associated systems and equipment. **Railway Maintenance Engineer**: Ensure preventive and corrective maintenance of trains and railway infrastructure to ensure their proper functioning and safety. • **Railway Signaling and Automation Engineer**: Work on automated signaling and control systems to enhance railway safety and efficiency.

	Urban Transportation Engineer: Contribute to the development and improvement of urban public transportation systems, such as trams and metros **Railway Energy Engineer:** Work on energy efficiency solutions and the implementation of new energy sources for railway transportation. **Logistics and Supply Chain Engineer:** Manage logistics and supply of materials and equipment necessary for the operation of railway networks. **Railway Safety and Security Engineer:** Implement safety and security devices to protect passengers, staff, and assets during railway travel. **Research and Development Engineer:** Participate in research projects to drive innovation in the railway field, encompassing technologies, materials, and systems.
Selection method	**Baccalaureate BAC:** to join ESTACA, candidates have to apply through the Parcoursup platform and then go through the selection process of the Concours Avenir: • **Parcoursup** is a web portal managed by the French Ministries of Education and Higher Education, Research, and Innovation. It handles undergraduate admissions to French universities and other higher education institutions for high school diploma holders. • **Concours Avenir** (Established in 2009) is one of the first joint entrance exams enabling access to post-baccalaureate engineering schools in France. **BAC+1 deferred admission:** to join ESTACA, candidates must apply through the **AvenirPlus procedure**, which is a fully online and specifically tailored for students who have already obtained the Baccalaureate and are interested in joining the platform's affiliated schools in the 2nd, 3rd, or 4th year (based on their current academic track). **Preparatory classes, universities (BAC+2/3...):** Selection is based on application via **AvenirPlus**. The jury ranks applications based on: • Results achieved in previous academic years, particularly in scientific subjects and English. • Teacher's assessments. • Results from exams and competitions. • Motivations expressed during the interview.

Learning objectives and outcomes, challenges and expected impacts	The railway training program is designed to equip students with the necessary knowledge and skills to excel in various roles within the railway industry. Some of the **key learning objectives and outcomes** include: • In-depth understanding of railway systems and technologies. • Proficiency in the design and development of railway vehicles and infrastructure. • Ability to analyze and solve complex problems in the railway domain. • Knowledge of safety standards and regulations related to railway operations. • Expertise in railway signaling and control systems. • Familiarity with energy-efficient and sustainable practices in railway operations. • Project management skills for handling railway-related projects. • Competence in maintenance and optimization of railway systems. • Strong communication and teamwork abilities for effective collaboration within the industry. The railway training program at ESTACA faces **various challenges,** including: • Keeping up with technological advancements in the rapidly evolving railway industry. • Addressing sustainability and environmental concerns in railway operations. • Meeting the demand for skilled professionals in the railway sector. • Adapting to changes in regulations and safety standards. • Integrating emerging technologies like automation and digitalization into railway systems. • Balancing theoretical knowledge with practical experience. The railway training program at ESTACA aims to make a **positive impact** on various levels: • Meeting the industry's demand for skilled and competent railway professionals. • Contributing to the development of innovative and sustainable solutions in the railway sector. • Enhancing safety and efficiency in railway operations through well-trained engineers.

	• Fostering collaboration between students and industry stakeholders. • Strengthening the railway workforce with competent project managers and leaders. • Advancing research and development in the railway domain.
Others	**Over 400 hours of training** delivered by active engineers (among others) from ALSTOM, SNCF, HITACHI RAIL, EGIS RAIL, DB, IDF Mobilités, and more. **At least 4 application projects completed during the curriculum**, such as new high-speed night train, concept for a mixed passenger/freight TER (regional train), regeneration of a self-driving railcar with new energy sources, study of freight tramway solutions for urban zone supply. **12 months of mandatory internships**, for example: • Execution internship during 1st or 2nd year at SNCF: technical maintenance for railway equipment in the brake domain. • Student engineer internship during the 4th year at Deutsche Bahn Schenker Rail GmbH: European freight wagon maintenance project. • End-of-studies internship during the 5th year at Egis Rail: implementation of operating systems and equipment for the Montpellier tramway. **Visits to test centers**, study centers, and maintenance sites accompanied by conferences. **SNCF Group Partnership**: a pre-graduate program for 3rd and 4th-year students and two research and teaching chairs.
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	The human and material resources involved in railway training at ESTACA include: • **Faculty and Instructors**: ESTACA would have a team of experienced professors and industry professionals specialized in railway engineering and related disciplines. These experts would be responsible for designing and delivering the training courses. • **Curriculum and course materials**: The school developed a comprehensive curriculum covering various aspects of railway engineering, including track design, signaling systems, rolling stock, safety regulations, maintenance, and more. Course materials, textbooks, and digital

	resources would be provided to students for study and reference. • **Laboratories**: ESTACA'Lab (the research laboratory of ESTACA) is equipped with the several infrastructures and tools to conduct practical training and experiments related to railway systems such as , green rolling-stock, testing equipment, simulation tools, and software for modeling and analysis. • **Training facilities**: ESTACA has several have specialized training facilities, as part of its collaborations with industrial partners, including mock railway tracks, signaling systems, and rolling stock, to offer hands-on training and real-world experience. • **Industry partnerships**: ESTACA collaborates with railway companies and industry partners to provide students with internships, industrial visits, and practical projects that expose them to real-life railway engineering challenges and solutions. • **Research & Development**: ESTACA engages in continuous research and development projects focused on railway technology, which enhances the training content and grants students access to the latest advancements in the field. • **Support staff**: ESTACA employs administrative and technical staff to manage logistics, support students, and maintain the facilities required for the railway training programme.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	**Distribution of training clusters as a percentage of the total number of hours.** **Preparatory Cycle**: **First Year (total hours = 734):** • Scientific cluster (73% of total hours, 47 ETCS) • Transport engineering cluster (5% of total hours, 3 ETCS) • Human sciences and engineering culture cluster (13% of total hours, 11 ETCS) • Professional experience cluster (9% of total hours, 1 ETCS): Industrial internship (4 weeks) **Second Year** (total hours = 757): • Scientific cluster (73% of total hours, 44 ETCS) • Transport engineering cluster (6% of total hours, 4 ETCS) • Human sciences and engineering culture cluster (12% of total hours, 14 ETCS)

	• Professional experience cluster (9% of total hours, 1 ETCS): Company discovery internship (4 weeks) **Engineering Cycle:** **Third Year** (total hours = 775): • Scientific cluster (51% of total hours, 37 ETCS) • Transport engineering cluster (14% of total hours, 14 ETCS) • Human sciences and engineering culture cluster (18% of total hours, 12 ETCS) • Professional Experience cluster (17% of total hours, 1 ETCS): Company Internship (optional, 4 weeks) **Fourth Year** (total hours = 1185): • Scientific cluster (25% of total hours, 24 ETCS) • Transport engineering cluster (28% of total hours, 20 ETCS) • Human sciences and engineering culture cluster (16% of total hours, 12 ETCS) • Professional experience cluster (31% of total hours, 3 ETCS): Engineering Student Internship (4 months) **Fifth Year** (total hours = 1152): • Transport engineering cluster with one project and supervision (50% of total hours, 30 ETCS) • Professional experience cluster (50% of total hours): Final internship (6 months) **Details of the training clusters :** All details are available in the website of ESTACA: https://www.estaca.fr/formations/ingenieur/ferroviaire-transports-guides/ Here are the training programme details of the fourth and the fifth years (EQF 6 and 7): **Fourth Year:** *Scientific cluster:* Finite Elements Method (35hrs) • Variational formulation and meshing • Structure discretization • The various families of finite elements in structure calculation

	• Calculation of elementary matrices, assembly, and calculation of the solution to a static problem Continuum Mechanics (25hrs) • General hypotheses of continuum mechanics • Theory of elasticity, viscoelasticity, and thermoelasticity • Introduction to damage, rupture, and fatigue • Elastic problem-solving methods Structural Dynamics (25hrs) • Introduction to dynamic and acoustic phenomena • Theoretical and experimental modal analysis • Linear acoustics, acoustic modes, and acoustic impedance Energy Conversion and Transfer (20hrs) • Mass and energy balances in open systems • Conversion of thermochemical energy into heat energy • Conversion of thermochemical energy into mechanical-electrical energy Hydraulic Systems (15hrs) • Architecture design of hydraulic systems • Modeling of head loss • Power dimensioning • Introduction to networks and components Multi-physical Modeling (25hrs) • Coupling of mechanical, electrical, thermal, and hydraulic models • Multi-physical modeling tools Architecture and Communication (20hrs) • Basic concepts of software architectures • Task scheduling • Synchronization and inter-task communication Real-time Command (10hrs) • Control of discrete-time systems • Introduction to sequential systems • Real-time prototyping Modeling and Control of Electrical Actuators (20hrs) • Inverse model • Modeling control of asynchronous and synchronous machines Experimental Practical Work (20hrs) *Transport engineering cluster:* Railway Infrastructure (35hrs) • Railway Civil Engineering: maintenance and design of infrastructure

	• Interfaces between Infrastructure and Rolling Stock Geometry Vehicle-Track Interactions (32hrs) • Braking • Dynamics of railway vehicles • Current collection and pantograph-catenary interface • Train System Architecture Railway Safety and Signaling Installations (21hrs) • Signaling and safety – ATP/ERTMS • Signal cabins, interlocking systems • CBTC (Communication-Based Train Control) Power Supply (12hrs) • Principles and technology of electrical power supply • Traction return installations Project Management (25hrs) • Preliminary studies • Operator specifications Design of Railway Network in Dense Areas (9hrs) Systems Engineering (16hrs) • Operability • General design New Line Design Project (50hrs) *Human sciences and engineering culture cluster:* Reliability and Safety (24hrs) • Basic principles of reliability • Methods and tools for analyzing complex systems (fault trees, FMEA…) • Project Management, Economics, and Business Strategy (28hrs) • Serious game BECOM-ING (Business, Éthique, Communication Organisation, Management, INsertion pro et INnovation, Gestion, 31hrs) • Development of professional project objectives • Role-playing job interviews • Mastering public speaking for impactful self-presentation • Effective digital communication skills • Proficiency in organizing and actively participating in meetings • Enhancing cybersecurity awareness within the company • Nurturing team management capabilities • Fostering a sense of corporate social responsibility

	• Encouraging active involvement in school activities Industrial communication and technical English (36hrs) Foreign language 2, optional (36hrs) **Fifth Year** *Transport engineering cluster:* Option 1: Systems Design (275hrs) • Design and dimensioning of the body structures • Elements of electric propulsion systems • Elements of mechanical and hydraulic transmissions • Design and dimensioning of bearing components • Aerodynamics • Acoustics • Electromagnetic compatibility
Indicate the selected programme according to STAFFER findings	Option 1 (System Design): Railway systems engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) X Norms, standards & certification X Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence X Transportation systems ☐ Reliability, maintenance & life cycle management ☐ Learning skills ☐ Global new energies & technologies X Formal methods for system design & verification ☐ Web development ☐ Communication X Safety, dependability, security ☐ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills X
Duration and type of work-based internships (if compulsory)	4-6 months
Companies that offer internships (please indicate if there are STAFFER partners among them)	SNCF, ALSTOM

Teaching language	French, English
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face-to-face, hybrid
Assessment methods and regulations	Continuous assessments and final exams.
Qualification of teachers and trainers	Lecturers, researchers, engineers and high-level technicians.
	PARTNERSHIP
Partners Name/Address	SNCF, ALSTOM, AnsaldoSTS, RATP, SYSTRA, IKOS ...
	TRAINING EVALUATION
Evaluation Modalities	Conducted midway and at the conclusion of the training, satisfaction surveys are carefully analyzed to provide developmental feedback and pinpoint areas that require improvement.
Results indicators	Business proximity, professional integration, international collaborations, research ...
Expected results	The *Usine Nouvelle* indicators are available in https://www.usinenouvelle.com/article/estaca.N313826
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	The tuition fees for the academic year 2023-2024 amount to €9,365 (excluding the contribution to the Student Union). Numerous possibilities exist to finance studies at ESTACA for each student based on their situation. *ESTACA Scholarships* In an effort to assist students, the school allocates a significant portion of the apprenticeship tax paid by companies to students. *Social Criteria Scholarships from CNOUS/CROUS* Designed for students with limited family resources, these scholarships must be applied for between January 15th and May 31st at the CROUS of the current educational institution. More information can be found at www.cnous.fr. *Local Authority Support* Regions, departments, or cities provide financial aid to schools for students originating from their territories. Any student who is tax-domiciled in Mayenne and chooses to join ESTACA Campus Ouest can obtain additional financial aid in addition to social criteria

	scholarships. Territoires aux Grandes Écoles: A scholarship of €6,000 per year for the first two years of higher education. Applications for terminal students go through partner schools. Selection is based on academic results, social criteria, and the student's project. For 2021, five departments are involved, and candidates must originate from one of these departments to apply. *Mobility Passport* The Mobility Passport provides students from overseas territories (DOM TOM) with a round-trip ticket per academic year for pursuing studies in mainland France for courses not available in their home department or interzone. Students wishing to pursue an engineering program at ESTACA may benefit from this scholarship. *New Government Financial Aid* The Merit Aid complements social criteria scholarships. It is awarded to students who obtain a "mention très bien" in the Baccalaureate or an excellent Bachelor's degree. The amount is €1,800 per year. Information is available at www.cnous.fr. *Specific Aid* This provides quick, personalized financial assistance to students facing difficulties. Emergency aid can take two forms: either a one-time assistance for students experiencing temporary severe difficulties, or an annual aid for students facing persistent challenges. To apply for aid, you must obtain an assistance request form from your CROUS. More information is available at Service Public. *Eiffel Excellence Scholarships* Scholarships may be awarded to foreign students. For more information: Campus France Eiffel Scholarship. *Mobility Scholarships* Various aid programs are available to help finance studying abroad as part of the education. Reserved for scholarship students, mobility scholarships can be granted for a duration of 3 to 9 months during a university stay. When planning your departure, ESTACA's International Department will provide you with all the information on other possible aids, such as Leonardo scholarships, Zellidja travel grants, etc. *Loans* Student loans are consumer credits granted to finance your studies. They can be subject to deferred

	repayment, allowing you to start repaying once you have graduated and entered the workforce. ESTACA has agreements with certain banks that offer attractive conditions for school students. Contact details for these banks' representatives can be found below. However, all banks may offer attractive interest rates for engineering students.
	PROVISIONAL TIMETABLE
Implementation school year	2023-2024
Duration of the programme	5, 4 or 3 years ...
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://www.estaca.fr/formations/ingenieur/ferroviaire-transports-guides/

SGH

II.5 SGH

II.5.1 Postgraduate course in "Organization of Extra-Urban Public Transport"

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**SGH Warsaw School of Economics**
Faculty/Department	**Institute of Infrastructure, Transport and Logistics**
Training Program Title	**Organization of Extra-Urban Public Transport**
Indicate if it is a new training program or an existing one to be adapted	**new**
Contact Name/Function/Mail/Phone	**Michał Wolański / Resarcher and Lecturer / michal.wolanski@sgh.waw.pl**
Degree Type	**Postgraduate course**
Certification (Yes/No/In Process, type, etc.)	YES
Organism of Certification	Approval by the Senate of the Warsaw School of Economics dated November 29, 2023
Training address	Al. Niepodległości 162, 02-554 Warszawa
EQF Level	7
Usual entry age	25
Entry requirements / Prerequisites	Bachelor's or Engineer's degree
Potential progression for learners after graduation	[See potential jobs]
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student/Staff
Expected learners numbers	30 for the first cohort + 20 for the second cohort

Co-funded by the Erasmus+ Programme of the European Union

<table>
<tr><td>Assessment of learning outcomes</td><td>Verification of learning outcomes in postgraduate studies:
Final exams.
Defense of the final thesis.
Written exams: theory and practice of management (covering thematic blocks 9-11), organization of public transport (covering thematic blocks 2-8).
Method of documenting learning outcomes in postgraduate studies:
Exam papers.
Exam protocols.
Final theses.
Protocol from the defense of the final thesis.</td></tr>
<tr><td>Diplomas/Certificates provided</td><td>-</td></tr>
<tr><td></td><td>OBJECTIVES</td></tr>
<tr><td>Overarching goals/visions</td><td>Objective of postgraduate studies:
The main objective of the studies is to build a managerial staff for public transport (other than urban communication) – in particular, the staff of organizers of interprovincial, provincial, county, municipal, and county-municipal passenger transport.</td></tr>
<tr><td>Targeted public</td><td>Professionals and co-financed by employees</td></tr>
<tr><td>Potential jobs</td><td>Management staff for public transport companies</td></tr>
<tr><td>Selection method</td><td>-</td></tr>
<tr><td>Learning objectives and outcomes, challenges and expected impacts</td><td>Specific objectives of the studies include:
providing knowledge and developing skills related to management sciences (e.g., project management, marketing management, team management), essential for managing both project and permanent teams organizing public transport; providing specialist knowledge necessary for contracting operators, obtaining financing within the framework of the Bus Transport Development Fund (FRPA) as well as investment grants.

As a result, the staff trained under the study program will be able to create and develop attractive public transport systems for passengers outside cities, thus contributing to: combating transportation exclusion, social inclusion, and promoting low-emission and energy-efficient public transport.

<table><tr><td>No.</td><td>Description</td><td>PRK Code</td></tr><tr><td>W1</td><td>Elements of management theory relevant to the organization of public transport systems (PTZ) –</td><td>P7S_WK
P7S_WG</td></tr></table></td></tr>
</table>

	particularly in the areas of marketing management, project management, and leadership.	
W2	Principles of organizing PTZ networks.	P7S_WK P7S_WG
W3	Legal basis for the activities of PTZ organizers.	P7S_WK P7S_WG
W4	Methods and sources of PTZ financing along with their implications for transport organization and enterprises.	P7S_WK P7S_WG

Skills – the graduate can:

No.	Description	PRK Code
U1	Launch PTZ in a municipality, county, or province.	P7S_UW P7S_UK P7S_UO
U2	Prepare and conduct the procedure for selecting a PTZ operator.	P7S_UW P7S_UK P7S_UO
U3	Lead the process of obtaining external financing to co-finance the PTZ system.	P7S_UW P7S_UK P7S_UO
U4	Manage a PTZ system, especially by shaping the PTZ offer according to marketing management principles.	P7S_UW P7S_UK P7S_UO

Social Competences – the graduate is ready to:

No.	Description	PRK Code
K1	Be a leader or member of a team managing the PTZ system.	P7S_KK P7S_KO P7S_KR
K2	Cooperate with the operator to	P7S_KK P7S_KO P7S_KR

<table>
<tr><td></td><td>
<table>
<tr><td></td><td>efficiently organize PTZ.</td><td></td></tr>
<tr><td>K3</td><td>Recognize and consider the needs of different PTZ stakeholders.</td><td>P7S_KK P7S_KO P7S_KR</td></tr>
</table>
</td></tr>
<tr><td>Others</td><td>-</td></tr>
<tr><td></td><td>MEANS / MODALITIES</td></tr>
<tr><td>Human and material resources (pedagogical team, workshops, laboratory, etc.)</td><td></td></tr>
<tr><td>Training program (curriculum, contents, general and specific objectives of each course, etc.)</td><td>
Program of postgraduate studies:
<table>
<tr><td>No.</td><td>Subject / Thematic block</td><td>Practical Hours</td><td>Theoretical Hours</td><td>ECTS Points</td></tr>
<tr><td>1</td><td>Inaugural lecture</td><td>0</td><td>2</td><td>0</td></tr>
<tr><td>2</td><td>Legal conditions for PTZ operation</td><td>12</td><td>12</td><td>5</td></tr>
<tr><td>3</td><td>Bus transport technology and market</td><td>4</td><td>4</td><td>1.5</td></tr>
<tr><td>4</td><td>Railway transport technology and market</td><td>8</td><td>8</td><td>3</td></tr>
<tr><td>5</td><td>Management of a transport company's finances</td><td>8</td><td>4</td><td>2.5</td></tr>
<tr><td>6</td><td>Sources of PTZ financing</td><td>4</td><td>4</td><td>1.5</td></tr>
<tr><td>7</td><td>PTZ infrastructure</td><td>4</td><td>4</td><td>1.5</td></tr>
<tr><td>8</td><td>Network planning and organization of transport</td><td>16</td><td>12</td><td>5.5</td></tr>
<tr><td>9</td><td>Negotiation training</td><td>12</td><td>4</td><td>3.5</td></tr>
<tr><td>10</td><td>Project and team management</td><td>19</td><td>5</td><td>5</td></tr>
<tr><td>11</td><td>Marketing management</td><td>6</td><td>4</td><td>2</td></tr>
<tr><td>12</td><td>Seminar</td><td>4</td><td>0</td><td>1</td></tr>
</table>
</td></tr>
</table>

	Total hours: 162 (including: practical: 100, theoretical: 62) **Total ECTS points: 32**
Indicate the selected programme according to STAFFER findings	Rail transport engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☐ Learning skills ☐ Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☒ Safety, dependability, security ☐ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	Not applicable
Companies that offer internships (please indicate if there are STAFFER partners among them)	Not applicable
Teaching language	Polish
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	• Face to face (workshops) • Hybrid (lectures)
Assessment methods and regulations	• Final exams. • Defense of the final thesis. • Written exams: theory and practice of management (covering thematic blocks 9-11), organization of public transport (covering thematic blocks 2-8).
Qualification of teachers and trainers	Researchers and professors of the Warsaw School of Economics
	PARTNERSHIP

SGH

Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	Survey of students' opinions at the end of the course analysed by teaching committee to identify areas for improvement.
Results indicators	Satisfaction rate, recommendation rate
Expected results	
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Not applicable
	PROVISIONAL TIMETABLE
Implementation school year	2023/2024 – 2024/2025
Duration of the programme	Two semesters
	DISSEMINATION
Supports (flyer, website, social media, etc.)	SGH Website and Social Media dissemination will be done after approval of the course

SGH

II.5.2 Postgraduate course in "Railway Manager"

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**SGH Warsaw School of Economics**
Faculty/Department	**Institute of Infrastructure, Transport and Logistics**
Training Program Title	**Railway Manager**
Indicate if it is a new training program or an existing one to be adapted	**new**
Contact Name/Function/Mail/Phone	**Michał Wolański / Resarcher and Lecturer / michal.wolanski@sgh.waw.pl**
Degree Type	**Postgraduate course**
Certification (Yes/No/In Process, type, etc.)	YES
Organism of Certification	Approval by the Senate of the Warsaw School of Economics dated July 3, 2024
Training address	Al. Niepodległości 162, 02-554 Warszawa
EQF Level	7
Usual entry age	25
Entry requirements / Prerequisites	Bachelor's or Engineer's degree
Potential progression for learners after graduation	[See potential jobs]
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student/Staff
Expected learners numbers	20
Assessment of learning outcomes	**Verification of learning outcomes in postgraduate studies:**

<table>
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- Final exams.
- Defense of the final thesis.
- Written exams: theory and practice of management (covering thematic blocks 9-11), organization of public transport (covering thematic blocks 2-8).

Method of documenting learning outcomes in postgraduate studies:

- Exam papers.
- Exam protocols.
- Final theses.
- Protocol from the defense of the final thesis.
</td></tr>
<tr><td>**Diplomas/Certificates provided**</td><td>-</td></tr>
<tr><td></td><td>**OBJECTIVES**</td></tr>
<tr><td>**Overarching goals/visions**</td><td>**Objective of postgraduate studies:**
The studies are aimed at the current and future management staff of companies in the railway sector – including employees of operators, infrastructure managers, regulators, and suppliers. The main objective of the studies is to build a management staff for railways that will comprehensively understand the economic, technical, and legal conditions of railway companies' operations and actively use modern management tools. A strong emphasis will be placed on understanding the entire spectrum of railway activities (passenger carriers, freight carriers, infrastructure), which will facilitate mutual understanding among employees of various departments and enable so-called "horizontal promotions." Another important aspect of the studies is shaping ethical attitudes in business and developing personal and social competencies.</td></tr>
<tr><td>**Targeted public**</td><td>Professionals and co-financed by employees</td></tr>
<tr><td>**Potential jobs**</td><td>Management staff for railways companies</td></tr>
<tr><td>**Selection method**</td><td>-</td></tr>
<tr><td>**Learning objectives and outcomes, challenges and expected impacts**</td><td>

Specific objectives of the studies include:
shaping managerial knowledge and skills (especially for individuals with technical and legal education); providing the legal basis and regulatory framework for the organization of railways; supplementing technical knowledge (familiarizing with modern technologies and current solutions – also useful for individuals with technical education).

Learning outcomes for postgraduate studies:

<table>
<tr><td>No.</td><td>Description</td><td>PRK Code</td></tr>
<tr><td>W1</td><td>Selected management science theories, particularly in strategic</td><td>P7S_WK
P7S_WG</td></tr>
</table>
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		management, team management, project management, and managerial accounting.	
	W2	Selected economic theories regarding the organization and operation of rail transport.	P7S_WK P7S_WG
	W3	Principles of logistics and mobility systems operation and the role of railways in these systems.	P7S_WK P7S_WG
	W4	Legal and regulatory basis for the operation of railways in the European Union and Poland.	P7S_WK P7S_WG

Skills – the graduate can:

No.	Description	PRK Code
U1	Participate in the creation of a railway company's strategy.	P7S_UW P7S_UK P7S_UO
U2	Participate in managing a passenger or freight carrier's product, identifying customer needs, co-creating attractive offers to meet them, and determining the costs of satisfying those needs.	P7S_UW P7S_UK P7S_UO
U3	Use the data resources available to the railway company and interpret them in line with the latest achievements in management science.	P7S_UW P7S_UK P7S_UO
U4	Carry out assigned tasks with an understanding of technical possibilities, the efficiency of	P7S_UW P7S_UK P7S_UO

SGH

	<table><tr><td></td><td>typical solutions, and in compliance with railway market regulations, understanding the conditions under which they were created.</td><td></td></tr><tr><td>U5</td><td>Critically evaluate solutions used in other railway companies and creatively implement them.</td><td>P7S_UU</td></tr></table> **Social competences – the graduate is ready to:** <table><tr><td>No.</td><td>Description</td><td>PRK Code</td></tr><tr><td>K1</td><td>Consciously and empathetically, but also critically, collaborate with employees from other departments and divisions of the railway company and other railway companies.</td><td>P7S_KK P7S_KO P7S_KR</td></tr><tr><td>K2</td><td>Manage a team and consciously participate in team work (project team or permanent organizational unit), understanding the diversity of character and competencies of other participants in the project or team members, but also critically addressing inappropriate actions.</td><td>P7S_KK P7S_KO P7S_KR</td></tr><tr><td>K3</td><td>Adapt well to other roles in the railway sector - in case of horizontal or vertical promotion or when changing jobs.</td><td>P7S_KK P7S_KO P7S_KR</td></tr></table>
Others	-
	MEANS / MODALITIES

Human and material resources (pedagogical team, workshops, laboratory, etc.)	
Training program (curriculum, contents, general and specific objectives of each course, etc.)	**Program of postgraduate studies:**

No.	Subject / Thematic block	Practical Hours	Theoretical Hours	ECTS Points
1	Inaugural lecture	0	2	0
2	Digital transformation	2	2	0.5
3	Strategic and marketing management	16	8	5
4	Project, team, and change management	22	10	7
5	Communication, negotiation, and presentation training	20	4	5
6	Managerial accounting	4	4	1.5
7	Economic regulations of rail transport in Poland	4	4	1.5
8	Organization and marketing of passenger transport	8	8	3
9	Organization and marketing of freight transport	8	8	3
10	Management and regulations concerning railway infrastructure	8	8	3
11	EU funds in rail transport	4	4	1.5
12	Seminar	4	0	1

Total hours: 162 (including: practical: 100, theoretical: 62)

Total ECTS points: 32

SGH

Indicate the selected programme according to STAFFER findings	Rail transport engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☐ Learning skills ☐ Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☒ Safety, dependability, security ☐ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	Not applicable
Companies that offer internships (please indicate if there are STAFFER partners among them)	Not applicable
Teaching language	Polish
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	• Face to face (workshops) • Hybrid (lectures)
Assessment methods and regulations	• Final exams. • Defense of the final thesis. • Written exams: theory and practice of management (covering thematic blocks 9-11), organization of public transport (covering thematic blocks 2-8).
Qualification of teachers and trainers	Researchers and professors of the Warsaw School of Economics
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION

Evaluation Modalities	Survey of students' opinions at the end of the course analysed by teaching committee to identify areas for improvement.
Results indicators	Satisfaction rate, recommendation rate
Expected results	
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Not applicable
	PROVISIONAL TIMETABLE
Implementation school year	2024/2025
Duration of the programme	Two semesters
	DISSEMINATION
Supports (flyer, website, social media, etc.)	SGH Website and Social Media dissemination will be done after approval of the course

II.5.3 Sustainable Mobility Management

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**SGH Warsaw School of Economics**
Faculty/Department	**Institute of Infrastructure, Transport and Logistics**
Training Program Title	**Sustainable Mobility Management**
Indicate if it is a new training program or an existing one to be adapted	**new**
Contact Name/Function/Mail/Phone	**Michał Wolański / Resarcher and Lecturer / michal.wolanski@sgh.waw.pl**
Degree Type	Master or Bachelor
Certification (Yes/No/In Process, type, etc.)	YES
Organism of Certification	National Acreditation Agency The course requires approval by SGH Programme Comission – the earlier start will be academic year 2024/2025
Training address	Al. Niepodległości 162, 02-554 Warszawa
EQF Level	6 if Bachelor 7 if Master – to be agreed
Usual entry age	20 years if Bachelor 23 years if Master
Entry requirements / Prerequisites	Bachelor degree – if Master
Potential progression for learners after graduation	[See potential jobs]
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student
Expected learners numbers	20

Assessment of learning outcomes	Exams Esseay Presentation
Diplomas/Certificates provided	-
	OBJECTIVES
Overarching goals/visions	Rail transport engeeners usually have strong focus on engeeniring subjects. This is complimented by soft skills. The aim of the Introduction to Mobility and Logistics Management course is to present transport systems, supply chain managment, logistics and mobility form a Macroeconomics and managerial perspective – taking into account digital transformation of business models.
Targeted public	Exchange students
Potential jobs	Possible career both as economists / managers knowing modern mobility and logistics as well as engineers having wide approach.
Selection method	Exchange students selected to SGH basing on the exchange agreements (Erasmus etc.). Students selected to SGH Master / Bachelor courses (according to SGH rules, every student has access to all courses).
Learning objectives and outcomes, challenges and expected impacts	• The graduate should know current approach to mobility and supply chain management, taking into account climate and digital transformation issues. • The graduate should know transport – land use interactions. • The graduate should be able to adapt strategic business models of railway companies to the digital economy. • The graduate should be able to assess transport infrastructure investment using Cost Benefit Analysis.
Others	-
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	The subject will be lead by the Institute of Infrastructure, Transport and Mobility of the Warsaw School of Economics. The course team will be lead by dr Michał Wolański. The course will be partially led in computer laboratories.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	This program is an equivalent to 3 ECTS and contains 30 hours. This includes: • Sustainable mobility – lecture (2h) • Digital transformation of business models – lecture (2h) • Mobility as a service – lecture (2h) • Deregulation and liberalization of railway market – lecture (2h) • Supply chain management – lecture (2h)

	• Last mile logistics – lecture (2h) • Transport infrastructure investment assessment – lecture (2h) • Transport infrastructure investment assessment – workshop (4h) • Digital transformation of passenger rail business models – workshops (6h) • Digital transformation of freight rail business models – workshops (6h) Students arriving for a student exchange to SGH can also choose out of a wide range of communication and soft skills courses, offered at the SGH.
Indicate the selected programme according to STAFFER findings	Rail transport engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ · Norms, standards & certification ☐ · Smart cities & Internet of Things (IoT) ☐ · Living language ☐ Big Data & Artificial Intelligence ☐ · Transportation systems ☒ · Reliability, maintenance & life cycle management ☐ · Learning skills ☐ Global new energies & technologies ☐ · Formal methods for system design & verification ☐ · Web development ☐ · Communication ☐ Safety, dependability, security ☐ · Networking & ICT technologies ☐ · Virtual reality ☐ · Soft skills ☐
Duration and type of work-based internships (if compulsory)	Not applicable
Companies that offer internships (please indicate if there are STAFFER partners among them)	Not applicable
Teaching language	English
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	• Face to face (workshops) • Hybrid (lectures)

Co-funded by the Erasmus+ Programme of the European Union

Assessment methods and regulations	• Digital transformation case study presentations (step by step) • Excel task (CBA) • Final exam
Qualification of teachers and trainers	Researchers and professors of the Warsaw School of Economics
	PARTNERSHIP
Partners Name/Address	SGH has official partnership agreement with the Polish Railway of Office Regulation (Warsaw, Poland). SGH has also official partnerships with such companies as Accenture, DB Schenker, Deloitte, EY, ING, AT Kearney, KPMG, MasterCard, McKinsey & Company, Microsoft, P&G, PWC, Samsung, Santander, SAS (Warsaw, Poland branches). SGH has other contractual realations (makes dedicated research or studies) for PKP Intercity and PKP Polskie Linie Kolejowe (Warsaw, Poland).
	TRAINING EVALUATION
Evaluation Modalities	Survey of students' opinions at the end of the course analysed by teaching committee to identify areas for improvement.
Results indicators	Satisfaction rate, recommendation rate
Expected results	• Satisfaction rate – 4,75/5 • Recommendation rate – 85% top 2 boxes
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Not applicable
	PROVISIONAL TIMETABLE
Implementation school year	2024/2025
Duration of the programme	One semester
	DISSEMINATION
Supports (flyer, website, social media, etc.)	SGH Website and Social Media dissemination will be done after approval of the course

TECHNISCHE UNIVERSITÄT DRESDEN

II.6 TUD

II.6.1 Diplomstudiengang Verkehrsingenieurwesen (Transport Engineering)

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**Technische Universität Dresden (TU Dresden)**
Faculty/Department	**Faculty of Transport Sciences "Friedrich List"**
Training Program Title	**Diplomstudiengang Verkehrsingenieurwesen (Transport Engineering)**
Indicate if it is a new training program or an existing one to be adapted	**Existing one to be adapted**
Contact Name/Function/Mail/Phone	**Richard Kayser** **Scientifc Associate / Richard.kayser@tu-dresden.de** **0049-(0351)-463-36737**
Degree Type	Diploma (Equivalent to Master)
Certification (Yes/No/In Process, type, etc.)	The programme is accredited by the university
Organism of Certification	Requires approval from the faculty and the university
Training address	Hettnerstraße 1-3 01069 Dresden
EQF Level	6 and 7
Usual entry age	17 to 19 (after secondary school)
Entry requirements / Prerequisites	Secondary School diploma, German A1 language requirement
Potential progression for learners after graduation	Either career or PhD study
Type of VET programme (initial/continuous/ apprenticeship)	Initial and continuous
Status of learners (student/apprentice/staff)	Student
Expected learners numbers	40-50

Assessment of learning outcomes	Protocols of practical lessons and exams at the end of the semester for each module.
Diplomas/Certificates provided	University Diploma certificate and an academic title of Dipl.-Ing.
	OBJECTIVES
Overarching goals/visions	The goal of the provide an interdisciplinary approach to transport sciences and have to opportunity study transport sciences over several years. After their fundamental study of four semesters "Grundstudium" the students have the opportunity to select from five different study tracks and continue to their specialized study "Hauptstudium". Two of these tracks are primarily targeted at railways. The students of the other tracks have the opportunity to study in the courses of railways as part of their elective courses. Specialization Railway Systems The railroad systems field of study includes planning, dimensioning, design and construction of railroad systems in the area of conflict between customer requirements, environment and railroad system dependencies; development and planning of complex railroad safety, guidance and control systems; process-oriented consideration of railroad operations and their interdependencies with infrastructure, operating resources and personnel deployment; supply, operational and resource planning. Specialization Electric Transport Systems The Electrical Transportation Systems field of study includes planning, design, layout, and operational management of electrical transportation systems, electrical vehicles, and power supply systems, including their maintenance. Specialization Transport systems technology and logistics The field of study Transport System Theory and Logistics includes system theoretical and logistical methods for mapping and evaluating transport systems and their processes; transport planning, transport law and transport economics of transport systems; operational planning and management of transport systems, focused on railroads and public transport as well as air transport; requirements for the means of transport. Specialization Transport telematics The traffic telematics field of study includes methods of transportation process automation, traffic safety engineering, and to traffic communication systems; planning, evaluation, and operation of operational and traffic control systems, traffic

	control and traffic safety systems, and traffic communication systems.
Targeted public	Secondary school graduates
Potential jobs	Students gain knowledge about several fields of railway engineering including research, planning and operation of railway systems including vehicles, infrastructure and networks.
Selection method	Students need to have a secondary school diploma or equivalent university entrance qualification
Learning objectives and outcomes, challenges and expected impacts	The objective of the programme is to provide students with the knowledge to work in a wide variety of fields of railway engineering. While there are no official partnerships with other universities or institutions, students have the possibility to get internships at companies. Together with the collaboration of different companies, students will be able to work in variety of fields including railway suppliers, operators, consulting, engineering and network companies.
Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	A committee of professors and program coordinators prepares the general program. The program consists of a mixture of class lectures, practical laboratory lessons and visits to companies.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	Equivalent to 60 ECTS per year, the entire study is equivalent to 300 ECTS. The fundamental study in the first four semesters has a total of 120 points, the specialized study a total of 180 points. A full translated list of all railway related courses will be provided.
Indicate the selected programme according to STAFFER findings	Rail transport engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☒ Smart cities & Internet of Things (IoT) ☐ Living language ☒ Learning skills ☒ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle

	management ☒ Global new energies & technologies ☒ · Formal methods for system design & verification ☐ · Web development ☐ · Communication ☐ Safety, dependability, security ☒ · Networking & ICT technologies ☒ · Virtual reality ☒ · Soft skills ☒
Duration and type of work-based internships (if compulsory)	The work based internships last 12 weeks
Companies that offer internships (please indicate if there are STAFFER partners among them)	• Siemens (Staffer Partner) • VEM Sachsenwerk • Institut für Bahntechnik • Deutsche Bahn (DB Netz AG, DB Energie) (Staffer Partner) • Alstom (Staffer Partner) • PROBST & CONSORTEN • Deutsche Gesellschaft für Internationale Zusammenarbeit • PTV Transport Consult GmbH • CE cideon engineering GmbH & Co. KG • SPNV Nord, Koblenz • Schüßler-Plan • Dresdner Verkehrsbetriebe (DVB) • S-Bahn Berlin • Berliner Verkehrsbetriebe (BVG) • Public offices Berlin • Ministry of Transport and Digital Infrastructure (Transport Ministry) *(Based on the most recent postings on the faculty website)*
Teaching language	German
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Full time and Part-time with face-to-face lessons. For some modules videos of lectures exist and are made available to students as part of exam preparation
Assessment methods and regulations	Exams are a mix of oral and written. Some oral exams are used as prerequisites for future exams. Practical lessons are a mix of oral and written exams. The practical lessons typically start with an oral exam, which serve

	as a prerequisite for the practical lesson. This is to ensure that the students have enough knowledge about the test equipment and the experiments. If this requirement is not met, the students may not participate in the lesson. The students then have to write protocol detailing the theoretical background, the test itself, the methodology, the results and a discussion.
Qualification of teachers and trainers	The modules are the responsibility of the individual coordinators, typically professors. The professors either teach the modules themselves or a teacher is identified on their behalf. These can be members of the faculty but also non-members who hold lectures at the faculty.
	PARTNERSHIP
Partners Name/Address	The program formally has no partnership agreements with other universities or institutions.
	TRAINING EVALUATION
Evaluation Modalities	The programme is evaluated every 5 years by the Center of Quality Analysis of TU Dresden (Zentrum für Qualitätsanalyse, ZOA). The analysis uses current study documents, university specific statistical indicators, a standardized online questionnaire for students, an evaluation of individual courses, a standardized questionnaire for teachers, a standardized questionnaire for alumni and work from the study programme coordinator. Quality criteria are rated on a scale from A to E (A = Quality criteria completely met, E = Quality criteria not met, the programme must be adapted). A total of 66 quality criteria are used based on the Sächsische Studienakkreditierungsverordnung (SächsStudAkkVO, engl.: Saxonian Study Accreditation Regulation) and six quality control criteria set forth by the universities. These criteria include: Qualification goals and the degree level , a coherent study program concept and adequate implementation, a subject-related and content related design of the study program, study success of students, gender equality and compensation for disadvantages and finally cooperation with other universities, companies and other institutions. Students are asked to evaluate the courses every two years. Sometimes students can also evaluate courses every year, depending on the initiative of the responsible teachers.
Results indicators	A complete List of indicators will be attached to this document.
Expected results	The nine formal quality criteria set forth by the SächsStudAkkVO must all be met, in order to qualify the programme for accreditation. If the criteria of the university are not met, a process for addressing these issues must be started in the relevant organizational bodies.

	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	The students pay a semester fee of 300,30 EUR.
	PROVISIONAL TIMETABLE
Implementation school year	2023/2024
Duration of the programme	Five years
	DISSEMINATION
Supports (flyer, website, social media, etc.)	• Advertisement on study program search engines • Own Website: https://tu-dresden.de/bu/verkehr/studium/studienangebot/dipl_viw • Promotion through the student marketing team of the university • Social media presence through university social media team • Promotional video through regional TV

II.7 UASFHE

II.7.1 European Railway Systems (M.Sc.) (further education program)

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	Universtity of Applied Sciences FH Erfurt
Faculty/Department	Faculty of Business, Logistics and Transport/ Department of Traffic and Transportation
Training Program Title	European Railway Systems (M.Sc.) (further education program)
Indicate if it is a new training program or an existing one to be adapted	Existing program to be adapted and/or to add new partners
Contact Name/Function/Mail/Phone	Michael Lehmann / Prof. of Railways in an international Context / michael.lehmann@fh-erfurt.de / +49 361 6700-6573
Degree Type	Further education Master program /Joint Degree (tri-national DE-AT-CH)
Certification (Yes/No/In Process, type, etc.)	The program is accredited by the german accreditation council (and accreditation agency ACQUIN), to be reaccredited
Organism of Certification	The accreditation process requires approval of an accreditation agency and the accreditation council
Training address	Altonaer Str. 25, 99085 Erfurt (Germany)
EQF Level	7
Usual entry age	25 and above
Entry requirements / Prerequisites	1) Bachelor's degree or master craftsman's examination or state-certified technician/state-certified business economist AND 2) at least 2 years of occupational experience
Potential progression for learners after graduation	individual, e.g. PhD, MBA, etc.
Type of VET programme (initial/continuous/ apprenticeship)	continuous, part-time

Status of learners (student/apprentice/staff)	student/staff
Expected learners numbers	15-30
Assessment of learning outcomes	Exams at the of modules, project reports/term papers, master thesis
Diplomas/Certificates provided	Masters Degree (M.Sc.)
	OBJECTIVES
Overarching goals/visions	The aim is to create an academic, railway-specific offer for employees of companies in the railway and transport sector or of public authorities, which meets the objectives of personnel retention and personnel development. The aim is to qualify future management personnel in the railway sector. The transport and railway sector should thus be supported in ensuring that the demand for future management personnel can be met. Therefor the program is designed to give a systemic and interdisciplinary perspective of the european railway system(s). It includes (i.e. infrastructure, rolling stock, interoperabilty,...) as well as economic and legal basics and the interlocking of railway and environment.
Targeted public	Bachelor graduates (engineers, industrial engineers, etc.), state certified technicians/business economists, craftsmen, staff of traffic and transportation companies
Potential jobs	Management positions: team or group leaders ; technical positions: specialists/experts
Selection method	Interviews with candidates, orientation on grade of last degree
Learning objectives and outcomes, challenges and expected impacts	The Aim of the Program is the deepening and linking of knowledge of the overall railway system and of the subsystem of Cross-Border-Railways. Graduates should know the political and technical frame conditions of the European Railway System and be able to independently identify challenges in CBR and develop solutions. An additional objective of the program is the creation/generation of a network of specialists for the European Railway System.
Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	A teaching committee is responsible to develop the general program of the course and to designate the teaching coordinators of each module. There is a collaboration with a laboratory (railway operating field) (technical school Gotha.) and the curricula includes a field trip and several meetings with experts from the sector.
Training program (curriculum, contents, general and specific	2 year/ 4 semester degree program with 120 ECTS, 24 ECTS each semester. Qualified work experience is a prerequisite for the recognition of 24 ECTS and the entire study model. The part-time

<table>
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<td>objectives of each course, etc.)</td>
<td>program includes classroom and self-study phases (67 classroom days).
<table>
<tr><th>Title of Module</th><th>Semester</th><th>ECTS</th></tr>
<tr><td>M0 occupational experience</td><td>0</td><td>24</td></tr>
<tr><td>Module P1 – Project</td><td>1</td><td>6</td></tr>
<tr><td>M1.1: Infrastructure management I</td><td>1</td><td>6</td></tr>
<tr><td>M1.2: Operational management and planning I</td><td>1</td><td>6</td></tr>
<tr><td>M1.3: Railway as part of the overall system</td><td>1</td><td>6</td></tr>
<tr><td>Module P2 – Project</td><td>2</td><td>6</td></tr>
<tr><td>M2.1: Infrastructure management II</td><td>2</td><td>6</td></tr>
<tr><td>M2.2: Operational management and planning II</td><td>2</td><td>6</td></tr>
<tr><td>M2.3: Practical Project – international strategies</td><td>2</td><td>6</td></tr>
<tr><td>Module P3 – Project</td><td>3</td><td>6</td></tr>
<tr><td>M3.1: Railway and Environment</td><td>3</td><td>6</td></tr>
<tr><td>M3.2: European Transport Policy</td><td>3</td><td>6</td></tr>
<tr><td>M3.3: Rolling Stock and Interoperability</td><td>3</td><td>6</td></tr>
<tr><td>M4.1: Field Trip</td><td>4</td><td>5</td></tr>
<tr><td>M4.2: Master's Thesis</td><td>4</td><td>19</td></tr>
</table>
</td>
</tr>
<tr>
<td>Indicate the selected programme according to STAFFER findings</td>
<td>Railway systems engineering</td>
</tr>
<tr>
<td>Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings</td>
<td>
<table>
<tr><td>Cybersecurity & Internet of Things (IoT) ☐</td><td>Norms, standards & certification ☒</td><td>Smart cities & Internet of Things (IoT) ☐</td><td>Living language ☒</td></tr>
<tr><td>Big Data & Artificial Intelligence ☐</td><td>Transportation systems ☒</td><td>Reliability, maintenance & life cycle management ☒</td><td>Learning skills ☒</td></tr>
<tr><td>Global new energies & technologies ☐</td><td>Formal methods for system design & verification ☒</td><td>Web development ☐</td><td>Communication ☒</td></tr>
<tr><td>Safety, dependability, security ☒</td><td>Networking & ICT technologies ☐</td><td>Virtual reality ☐</td><td>Soft skills ☒</td></tr>
</table>
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</table>

Duration and type of work-based internships (if compulsory)	This is a part-time further education program, so usually the participants work full-time in parallel.
Companies that offer internships (please indicate if there are STAFFER partners among them)	see above
Teaching language	primarily in german, in the future in part in english
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	part-time, classroom and distance learning (67 classroom days)
Assessment methods and regulations	• Written exams at the end of the modules • Project reports/ term papers (projects), in some cases as group works • Master thesis including a master thesis defense in form of colloquium
Qualification of teachers and trainers	Each University decides, which teachers are teaching the courses/lectures. In some cases, there are experts/managers involved in specific teaching units.
	PARTNERSHIP
Partners Name/Address	• University of Applied Sciences FH St. Pölten (Joint Degree) / Campus-Platz 1, A-3100 St. Pölten (Austria) • University of Applied Sciences ZHAW Zürich / ZHAW School of Engineering, Technikumstrasse 9, 8401 Winterthur (Switzerland)
	TRAINING EVALUATION
Evaluation Modalities	student surveys for each module as well as the whole program
Results indicators	
Expected results	
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	The tuition fee is €19,600. Usually the companies pay the fees.
	PROVISIONAL TIMETABLE
Implementation school year	6th year/cohort starts in Acadademic Year 2023/24

Duration of the programme	2 years / 4 semesters (starts every 2 years)
	DISSEMINATION
Supports (flyer, website, social media, etc.)	• https://www.fh-erfurt.de/fakultaeten-und-fachrichtungen/wirtschaft-logistik-verkehr/verkehrs-und-transportwesen/weiterbildungsmaster-europaeische-bahnsysteme (german) • https://www.fh-erfurt.de/fileadmin/Dokumente/ZFW/Flyer/Flyer_Master_Bahn_23.pdf (german)

II.8 UASSP

II.8.1 Innovation and the European Railway Mindset

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**St Pölten University of Applied Sciences**
Faculty/Department	**Railway Technology and Mobility**
Training Program Title	**Innovation and the European Railway Mindset**
Indicate if it is a new training program or an existing one to be adapted	**New**
Contact Name/Function/Mail/Phone	**Andrew Nash, Senior Researcher, andrew.nash@fhstp.ac.at, +43 676 933 0483**
Degree Type	BS and MS
Certification (Yes/No/In Process, type, etc.)	FHSTP BS and MS programs are certified, this will be an additional course.
Organism of Certification	Accredited by required institutions.
Training address	
EQF Level	6+/-
Usual entry age	18
Entry requirements / Prerequisites	For this course, none.
Potential progression for learners after graduation	Course could be part of normal BS, MS program.
Type of VET programme (initial/continuous/ apprenticeship)	Course can be used in any of these programs.
Status of learners (student/apprentice/staff)	Course can be used by any of these learner types.
Expected learners numbers	Many: course will be placed online for use by other institutions and individuals.
Assessment of learning outcomes	Survey at end of course. Continuing monitoring via social network of course attendees.
Diplomas/Certificates provided	This is one course, therefore NA.

	OBJECTIVES
Overarching goals/visions	Introduce the concept of a "European" railway system to replace outdated national concepts. Introduce ideas for revitalising railway service in Europe.
Targeted public	Workers, students, general public.
Potential jobs	All railway workers, public policy and governments.
Selection method	Course will be online, anyone can attend.
Learning objectives and outcomes, challenges and expected impacts	Introduce the concept of "European" railway system. Encourage students to think about creating a more attractive and efficient railway system that serves today's needs (e.g., climate change) and is a viable business.
Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	The course will be developed by a core team and placed on the internet. It will consist of video lectures, a website with course information (readings, glossary, etc.), a syllabus for using the internet materials in physical classes, and a social network for students and interested persons to share ideas and improve the course.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	An outline of the course is forthcoming, otherwise we believe these questions have been described above. Please ask if you need more information here.
Indicate the selected programme according to STAFFER findings	Choose an item.
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☐ Smart cities & Internet of Things (IoT) ☒ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☐ Global new energies & technologies ☒ Formal methods for system design & verification ☐ Web development ☐ Communication ☒ Safety, dependability, security ☒ Networking & ICT technologies ☒ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	Not applicable.
Companies that offer internships (please indicate STAFFER partners among them)	

Teaching language	English.
Teaching and learning forms (e.g. PT, dual, distance)	Students can take the course independently or as part of a physical class. All options possible.
Assessment methods and regulations	For independent students there will be no assessment or regulations. For students who “take” the course as part of another class, the assessment will be included in the regular assessment for that class.
Qualification of teachers and trainers	Any teacher will be free to use or not use the class.
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	Online surveys will be used to evaluate the course and suggest improvements.
Results indicators	Understanding of concepts, interest in subject, energy transmitted.
Expected results	Revitalisation of the European railway sector.
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Donations of money and time from industry, suppliers government, and educational institutions.
	PROVISIONAL TIMETABLE
Implementation school year	Fall 2024
Duration of the programme	We expect the program to last for many years with updates and improvements to the online resources.
	DISSEMINATION
Dissemination Support	Internet, word of mouth, conferences.

II.8.2 Rail Vehicle Technology

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	**St Pölten University of Applied Sciences**
Faculty/Department	**Railway Technology and Mobility**
Training Program Title	**Rail Vehicle Technology**
Indicate if it is a new training program or an existing one to be adapted	**New**
Contact Name/Function/Mail/Phone	**Frank Michelberger / Head of Department / frank.michelberger@fhstp.ac.at / +43 676 847 228**
Degree Type	Bachelor of Science in Engineering (BSc)
Certification (Yes/No/In Process, type, etc.)	In Process
Organism of Certification	AQ Austria
Training address	Campus-Platz 1 , A-3100 St. Pölten
EQF Level	6
Usual entry age	
Entry requirements / Prerequisites	• General university entrance qualification • Relevant professional qualification plus additional examinations
Potential progression for learners after graduation	Master of Science in Rail Technology and Management of Railway Systems
Type of VET programme (initial/continuous/ apprenticeship)	Initial
Status of learners (student/apprentice/staff)	Student
Expected learners numbers	20
Assessment of learning outcomes	
Diplomas/Certificates provided	Bachelor's degree
	OBJECTIVES

Overarching goals/visions	Shape the future of mobility: Innovative mobility solutions are becoming increasingly important in order to meet the growing demands of climate protection, sustainability and urbanization. Students can start their academic studies to develop the rail vehicles of the future. This will secure them a sought-after position in a forward-looking field.
Targeted public	
Potential jobs	Diverse career opportunities in rail vehicle technology. Professional fields of activity: • Technical planning and design: Development and modernization of rail vehicles including the implementation of new technologies and digital solutions. • Approval procedures: Implementation and coordination of international approval procedures for rail vehicles. • Fleet management: Planning of scope, composition, and deployment of rail vehicle fleets. • Maintenance management: Responsibility for the maintenance and repair of rail vehicles. • Project management: Planning, coordination and monitoring of projects, including communication with stakeholders. • Innovation and sustainability management: Management of projects in the area of innovation and sustainability strategies for rail vehicle technology.
Selection method	
Learning objectives and outcomes, challenges and expected impacts	In the Bachelor's degree course in Rail Vehicle Technology, students will acquire comprehensive skills that will prepare you for the demands of the industry. The programme will cover all essential aspects: • Planning and construction of rail vehicles: Learn the basics and advanced techniques for developing modern rail vehicles. • Approval and standards: Understand the legal requirements and standards necessary for the approval of rail vehicles. • Operation and maintenance: Gain insights into the operation and maintenance of rail vehicles to optimize their service life. • Upgrade and recycling: Learn how to upgrade existing vehicles and recycle them sustainably. The course places particular emphasis on the following areas:

	• Passenger transport: Work on innovative solutions for local public transport as well as for local and long-distance transport. • Freight transportation: Develop technologies and systems that make freight transportation more efficient and sustainable.
Others	
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	
Training program (curriculum, contents, general and specific objectives of each course, etc.)	
Indicate the selected programme according to STAFFER findings	Railway systems engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☒ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☐ Global new energies & technologies ☒ Formal methods for system design & verification ☐ Web development ☐ Communication ☐ Safety, dependability, security ☒ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☐
Duration and type of work-based internships (if compulsory)	In total 30 ECTS, divided into 4 semesters (dual projects)
Companies that offer internships (please indicate if there are STAFFER partners among them)	
Teaching language	German

Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Part-time/dual
Assessment methods and regulations	
Qualification of teachers and trainers	
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	
Results indicators	
Expected results	
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Tuition Fees/Semester: EUR 363.36 (for students from third countries: EUR 1,500) + student union fee
	PROVISIONAL TIMETABLE
Implementation school year	Winter semester 2025
Duration of the programme	6 semesters
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://www.fhstp.ac.at/en/study-programmes/rail-technology-mobility/rail-vehicle-technology

UNIVERSITY OF BELGRADE

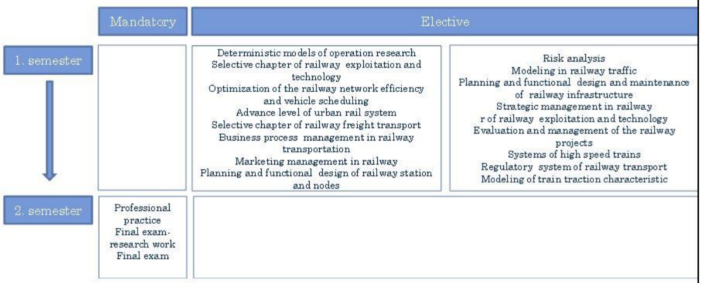
II.9 UB

II.9.1 Master of Science in "Traffic Engineering"

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	University of Belgrade (UB)
Faculty/Department	Faculty of Transport and Traffic Engineering - Department of Railway transport
Training Program Title	Master education study programme: *Traffic Engineering*
Indicate if it is a new training program or an existing one to be adapted	Existing education program to be adapted
Contact Name/Function/Mail/Phone	Mirjana Bugarinović, associate professor, mirab@sf.bg.ac.rs, +381 63 8074141
Degree Type	Master of Science in Traffic Engineering
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	National Entity for Accreditation and Quality Assurance in Higher Education (NEAQA)
Training address	Vojvode Stepe 305
EQF Level	7
Usual entry age	23 years and above
Entry requirements / Prerequisites	Bachelor's degree in engineering
Potential progression for learners after graduation	None
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student
Expected learners numbers	10-15
Assessment of learning outcomes	Exams at the end of each teaching module and final exam at the end of the course

Diplomas/Certificates provided	*Master of Science in Traffic Engineering*
	OBJECTIVES
Overarching goals/visions	Master engineers should follow the technological progress in traffic that includes planning, maintenance and management of traffic, transportation as well as comprehensive engineering expertise. This course provides multidisciplinary training, which combines transversal technical knowledge with economic and legal subjects, useful for solving complex problems in practice, applying innovative techniques to maximize the overall performance of the railway system.
Targeted public	Engineering master's graduates
Potential jobs	The aim of the course is to train engineers capable of facing the needs of a large number of railway companies, such as infrastructure managers, freight and passenger operators, industries that provide systems, subsystems and components, public and private bodies that plan investments, approve certificates, etc. Also, with the knowledge acquired at the master's studies, they can work in the ministries responsible for transport and other public institutions dealing with organization, regulation, safety in railway transport.
Selection method	The order of candidates for enrolment in the first year of master's academic studies is determined based on the general average grade, the length of study in previous studies, the result achieved in the entrance exam, if such an exam is organized, and according to the criteria established by the general act of the faculty, i.e. the University. For a person who has completed basic academic or integrated studies, the average grade and length of study in those studies and other conditions prescribed by the general act of the faculty are evaluated.
Learning objectives and outcomes, challenges and expected impacts	The aim of the course is to train railway engineers that will know the system and meet future needs for the development of new skills and competencies. The training will be in accordance with market requirements, very attractive for companies in the transport market. Achieving this goal requires close cooperation with the companies that support the course, which contribute to the definition of module content, monitor student achievements and teaching activities, hold technical visits and internships, and provide scholarships to students.
Others	
	MEANS / MODALITIES

<table>
<tr><td>Human and material resources (pedagogical team, workshops, laboratory, etc.)</td><td></td></tr>
<tr><td>Training program (curriculum, contents, general and specific objectives of each course, etc.)</td><td>Railway traffic and transport: In the first semester, students have at their disposal 16 elective subjects, of which 9 subjects carry 5 ESPB each and 7 subjects carry 6 ESPB each. In the second semester, students attend a professional practice worth 10 ECTS credits and defend a master's thesis worth 20 ECTS credits. The following picture shows the contents of the teaching modules.

</td></tr>
<tr><td>Indicate the selected programme according to STAFFER findings</td><td>Rail transport engineering</td></tr>
<tr><td>Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings</td><td>Cybersecurity & Internet of Things (IoT) ☐
Norms, standards & certification ☐
Smart cities & Internet of Things (IoT) ☐
Living language ☐
Big Data & Artificial Intelligence ☐
Transportation systems ☒
Reliability, maintenance & life cycle management ☐
Learning skills ☐
Global new energies & technologies ☐
Formal methods for system design & verification ☐
Web development ☐
Communication ☐
Safety, dependability, security ☒
Networking & ICT technologies ☐
Virtual reality ☐
Soft skills ☐</td></tr>
<tr><td>Duration and type of work-based internships (if compulsory)</td><td>Internship (professional practice) of about 2 and a half months (minimum 150 hours) at railway companies or public and private institutions.</td></tr>
<tr><td>Companies that offer internships (please indicate if there are STAFFER partners among them)</td><td>Infrastructure železnice Srbije (IŽS) – (Staffer partner)
Srbija cargo
Srbija Voz
Directorate for railway
Ministry of transport and traffic engineering
Millsped</td></tr>
<tr><td>Teaching language</td><td>Serbian
In procedure for applying for accreditation in english</td></tr>
</table>

Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Ex cathedra traditional education method combine with face-to-face and remote lessons. in the contemporary classroom lectures, exercises, interactive workshops, case studies, team presentations, debate,visits to public city companies, visiting lecturers
Assessment methods and regulations	Some teaching modules require students to carry out group work. The exams of the teaching modules are generally oral (currently only one exam is written with multiple choice questions) like the final exam.
Qualification of teachers and trainers	Each year, the engagement of teaching staff in given course is defined and approved by the teaching and scientific council.
	PARTNERSHIP
Partners Name/Address	
	TRAINING EVALUATION
Evaluation Modalities	Survey of students' opinions at the end of the course analysed by teaching and scientific council • **evaluation of participants in the teaching process** • **evaluation of part of the study program** • **evaluation of the work of the Faculty and its parts** • **evaluation of the study program as a whole**
Results indicators	
Expected results	
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	The tuition fee is €3,000 for academic year 2023/2024.
	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2024/2025
Duration of the programme	1 academic year (corresponding to 60 ECTS credits). Normally the course starts in mid-February and ends in late October each year.
	DISSEMINATION
Supports (flyer, website, social media, etc.)	http://www.bg.ac.rs/en/members/faculties/TTE.php https://www.sf.bg.ac.rs/index.php/en/rail-transport-and-traffic-ms

Università di Genova

II.10 UNIGE

II.10.1 Safety engineering for Transport, Logistics and Production

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	University of Genoa
Faculty/Department	DIME - Department of Mechanical, Energy, Management and Transportation Engineering
Training Program Title	Safety engineering for Transport, Logistics and Production
Indicate if it is a new training program or an existing one to be adapted	Existing training program to be adapted
Contact Name/Function/Mail/Phone	Alice Consilvio, Deputy Head of the Programme, alice.consilvio@unige.it
Degree Type	Master of Science degree
Certification (Yes/No/In Process, type, etc.)	YES
Organism of Certification	CUN (National University Council) and ANVUR (Italian National Agency for the Evaluation of Universities and Research Institutes)
Training address	Via Montallegro 1 16166 Genova, Italy
EQF Level	7
Usual entry age	23 years age
Entry requirements / Prerequisites	Possession of a bachelor's degree in engineering. Adequate knowledge of the English language equivalent at least to the B2 level. In more detail: 1. possession of a bachelor's degree or master's degree, obtained at an Italian University or equivalent qualifications; 2. possession of at least 36 CFU (equivalent to ECTS) or equivalent knowledge, acquired in any university degree course (bachelor's, master's, five-year master's, first and second level "Master Universitario") in the disciplinary-scientific sectors (SSD) indicated for the basic educational activities of the classes L-7, L-8, L-9; 3.possession of at least 45 CFU or equivalent knowledge, acquired in any university degree course (bachelor's, master's, five-year master's, first and second level "master universitario") in the SSD

	indicated for the educational activities characterising the classes L-7, L-8, L-9
Potential progression for learners after graduation	Ph.D course in Transportation and Logistics or Master universitario di II livello (Post-Master course)
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student
Expected learners numbers	30
Assessment of learning outcomes	Exams at the end of each teaching course and final exam at the end of the programme
Diplomas/Certificates provided	Master of Science degree
	OBJECTIVES
Overarching goals/visions	The MSc in Safety Engineering for Transport, Logistics, and Production provides a high level of advanced training, to enable graduated students to operate in the areas related to safety engineering in • transportation systems • logistics • industrial production so as to realize the acquired ability to conceive, plan, design and manage complex, innovative systems and processes, with particular attention to safety aspects.
Targeted public	Recent engineering bachelor's graduates
Potential jobs	Job opportunities: • research structures (universities, research centers, ...) • engineering companies and/or large professional firms operating in the field of design, implementation, security management with reference of the transport and territorial systems • public and private institutions that handle large lines infrastructure (railways, highways, ...) • government (municipalities, provinces, regions, port authorities, ...) • freelance
Selection method	Students in possession of the curriculum requirements must pass a test aimed at verifying their personal preparation. The personal preparation is assumed to be adequate for the candidates who

	have obtained an Italian or foreign bachelor's degree, or a qualification considered to be equivalent according to what has been indicated about the assessment of curricular requirement, with a final mark of at least 9/10 of the maximum achievable grade of their degree, or who have obtained a final grade corresponding to at least the "A" classification of the ECTS system.
Learning objectives and outcomes, challenges and expected impacts	The MSc in Safety Engineering for Transport, Logistics and Production aims at providing to student a high and advanced level of training, with particular reference to: • the risk assessment and management, and in particular the planning, design and management of both safety (protection against accidental events) and security (protection than intentional events) • the planning and management of the mobility of people and goods, through the knowledge of the fundamental elements of transport and logistic systems, as well as the criteria to define the physical characteristics of isolated infrastructures or a network of infrastructures, with particular reference to the relevant functions and interdependencies • the development and use of advanced methods to manage logistics and production systems with the aim of achieve the best quality, safety and and sustainability of these kind of these systems • the analysis and evaluation of the externalities of transport, logistic and production systems, with explicit reference to the particular safety aspect and issues characterizing each phase of the mobility of people and goods, even within the production plants connected, and their interaction with surrounding environment.
Others	-
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	The course combines traditional lessons with: • lab activities and development of projects • intensive seminars and courses • (elective) internships in industry or in a research labs • (elective) study periods abroad All classes are taught in English.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	The program is a two-year programme equivalent to 120 ECTS. The first year is articulated in 12 modules (10 modules equivalent to 5 ECTS each and two modules equivalent to 6 ECTS each). The second year consists of: • 6 modules equivalent to 5 ECTS each • Final exam (15 ECTS) • Seminars and orientation (1 ECTS) • 2 elective modules equivalent to 6 ECTS each The main contents are:

	• Transport System Engineering - Tools for analyzing and designing transport systems • Rail and Maritime Transport Systems - Technical and functional characteristics of rail and maritime transport systems • ICT for Transport, Logistics, and Production - Methodologies and technologies for data collection, transmission and analysis • Smart Logistics and Automated Transport - Smart intermodal and automated transport systems and of the relevant technologies • Methods for Logistics and Applications - Logistics and integrated inventory management techniques • Principles of Industrial Safety Engineering - Safety, sustainability, and quality management in industrial systems Regarding rail-related contents, two courses are present: • Rail Transport (5 ECTS): The aim of the course is to provide the basic knowledge about the characteristics of rail transport systems both from the technical and functional point of view. A focus on the relevant sustainability is also provided. • Sustainable Rail and Road Infrastructure (elective course 6 ECTS): The aim of the course is to provide knowledge regarding the design and management of rail and road infrastructure with a particular reference to the application of innovative technologies and sustainability aspects. New trends such as automation and digitalisation are addressed focusing on users' perspective and acceptability. The detailed degree programme is available at the link: https://servizionline.unige.it/unige/stampa_manifesto/PD/2022/10377.html
Indicate the selected programme according to STAFFER findings	Rail transport engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ · Norms, standards & certification ☒ · Smart cities & Internet of Things (IoT) ☐ · Living language ☐ Big Data & Artificial Intelligence ☒ · Transportation systems ☒ · Reliability, maintenance & life cycle management ☒ · Learning skills ☐

	Global new energies & technologies ☒ — Formal methods for system design & verification ☐ — Web development ☐ — Communication ☐ Safety, dependability, security ☒ — Networking & ICT technologies ☐ — Virtual reality ☐ — Soft skills ☐
Duration and type of work-based internships (if compulsory)	Elective internships in industry or in a research labs
Companies that offer internships (please indicate if there are STAFFER partners among them)	Rail suppliers (Hitachi Rail STS), public transport companies, transportation engineering consultants.
Teaching language	English
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face to face
Assessment methods and regulations	Written and/or oral exams. Some teaching modules require students to carry out lab activities and projects. The final exam consists of a thesis dissertation.
Qualification of teachers and trainers	The study programme board is composed by full professors, associate professors and researchers of the University of Genoa.
	PARTNERSHIP
Partners Name/Address	-
	TRAINING EVALUATION
Evaluation Modalities	A quality assurance procedure for the programme is applied to identify areas for improvement, which includes: • the analysis of satisfaction surveys, compiled by students at the end of each course, • the analysis of satisfaction surveys compiled by graduates, • annual monitoring report according to defined performance indicators.
Results indicators	1. Percentage of students satisfied with the courses 2. Number of students enrolled in the programme 3. Percentage of enrolled students who graduate 4. Percentage of graduates satisfied with the programme 5. Percentage of graduates employed within one year from the end of the course

Expected results	1. 90% of satisfied students with the courses 2. target of 30 students per academic year 3. 25 graduated per academic year 4. 100% of satisfied graduates 5. 100% of graduates employed within one year from the end of the course
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	From 0 to 3000 euros per year. Scholarships and exemptions are available.
	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2023/2024
Duration of the programme	2 academic years. Each year is organized in two semesters: • First semester lessons – from mid-September to mid-December • Second semester lessons – from mid-February to the end of May.
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://corsi.unige.it/en/corsi/10377

II.10.2 PhD curriculum in Transport and Logistics

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	University of Genoa
Faculty/Department	
Training Program Title	PhD curriculum in Transport and Logistics
Indicate if it is a new training program or an existing one to be adapted	Existing training program to be adapted
Contact Name/Function/Mail/Phone	Alice Consilvio, alice.consilvio@unige.it
Degree Type	Ph.D degree
Certification (Yes/No/In Process, type, etc.)	YES
Organism of Certification	CUN (National University Council) and ANVUR (Italian National Agency for the Evaluation of Universities and Research Institutes)
Training address	Via Montallegro 1 16166 Genova, Italy
EQF Level	8
Usual entry age	25 years age
Entry requirements / Prerequisites	Possession of a master's degree. Adequate knowledge of the English language equivalent at least to the B2 level.
Potential progression for learners after graduation	-
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Ph.D. Student
Expected learners numbers	6
Assessment of learning outcomes	Exams at the end of each teaching course and final exam at the end of the programme
Diplomas/Certificates provided	Ph.D certificate

Co-funded by the Erasmus+ Programme of the European Union

	OBJECTIVES
Overarching goals/visions	The objective of the PhD programme is to train young people in scientific research on sustainable transport and logistics topics according to an interdisciplinary approach. This objective is pursued over the three-year period through participation in courses specifically developed for doctoral training, participation in seminars and conferences, summer and winter schools, inclusion in research groups, as well as constant contact with the teaching staff and with the supervisor of the final thesis.
Targeted public	Recent transport engineering master's graduates
Potential jobs	In addition to the possibility of accessing an academic career, PhDs will be able to find employment in a variety of sectors: • transport service companies and the logistics sector • transport sector authorities • public and private laboratories and research centres • project offices and/or technical office and/or R&D sector of companies in the transport sector • engineering studies
Selection method	Admission to the PhD programme is subject to an entry examination, which is typically announced each year in spring. Candidates who pass the entry examination are placed on a merit list, i.e. a list of suitable candidates, showing the allocated PhD positions.
Learning objectives and outcomes, challenges and expected impacts	The Ph.D. course addresses highly specialized knowledge and skills in the transport and logistics sector from a sustainable development perspective.
Others	-
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	The programme is flexible and the student can select all the courses according to his/her research topic. Traditional courses can be combined with: • courses specifically developed for doctoral training, • lab activities and development of projects, • participation in seminars and conferences, • participation in summer and winter schools, • inclusion in research groups, • research period abroad.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	The program is a three-year programme equivalent to 180 ECTS.
Indicate the selected programme according to STAFFER findings	Rail transport engineering

Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☒ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☒ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☐ Global new energies & technologies ☒ Formal methods for system design & verification ☐ Web development ☐ Communication ☐ Safety, dependability, security ☒ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☐
Duration and type of work-based internships (if compulsory)	-
Companies that offer internships (please indicate if there are STAFFER partners among them)	-
Teaching language	English
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face to face, distance
Assessment methods and regulations	Oral exams for the acquisition of each course/module ECTS. Doctoral research grants have a duration of one year and are renewed annually after students have passed a test, whose result is attested by the doctoral board, and which demonstrates that the research activities planned in the previous year have been carried out smoothly and productively. The final exam consists of a thesis dissertation.
Qualification of teachers and trainers	The teachers' board is composed by full professors, associate professors and researchers of the University of Genoa.
	PARTNERSHIP
Partners Name/Address	-
	TRAINING EVALUATION
Evaluation Modalities	The proposal to activate doctoral courses is formulated every year to the Academic Senate by the departments and the

	various university centres involved. The schools involved in the doctorate also express an opinion on the proposal. The proposal must meet the requirements defined by legislation. The loss of a mandatory requirement entails the withdrawal of accreditation. In such case, the activation of a new cycle of Doctoral courses is suspended with immediate effect.
Results indicators	-
Expected results	-
	FUNDING
Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Ph.D. positions available according to the number of scolarships
	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2023/2024
Duration of the programme	3 academic years. Each year is organized in two semesters: • First semester lessons – from mid-September to mid-December • Second semester lessons – from mid-February to the end of May.
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://unige.it/en/phd-programmes

II.11 UNIROMA1

II.11.1 Master of Science in "Transport Systems Engineering"

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	Università degli Studi di Roma "La Sapienza" (UNIROMA1)
Faculty/Department	Faculty of Civil and Industrial Engineering / Department of Civil, Building and Environmental Engineering
Training Program Title	"Transport Systems Engineering"
Indicate if it is a new training program or an existing one to be adapted	Existing training program to be adapted (the adaptation will concern the modules "Railway Engineering" and "Public Transprot Management")
Contact Name/Function/Mail/Phone	Luca Rizzetto / Temporary Researcher / luca.rizzetto@uniroma1.it / +393333557805
Degree Type	Master Degree
Certification (Yes/No/In Process, type, etc.)	Yes
Organism of Certification	CUN (National University Council) and ANVUR (Italian National Agency for the Evaluation of Universities and Research Institutes)
Training address	Via Eudossiana 18 – 00184 Roma (Italy)
EQF Level	7
Usual entry age	22 years and above
Entry requirements / Prerequisites	Bachelor's degree preferably in engineering. Below are general entry requirements based on whether candidates hold an Italian or international bachelor's degree. <u>Candidates with an Italian bachelor's degree</u> *An engineering bachelor's degree* As this programme is an engineering programme, the majority (however not all) of our students hold an engineering bachelor's

	degree. Good engineering skills provide a good starting point for the success in this programme. *Minimum curricular requirements:* 18 ECTS in one or more of the following sectors of disciplines: MAT/03, MAT/05, MAT/06, MAT/07, MAT/08 and MAT/09; 12 ECTS in one or more of the following sectors of disciplines: CHIM/03, CHIM/07, FIS/01, FIS/07, ING-IND/11 and ING-IND/21; 18 ECTS in one or more of the following sectors of disciplines: ICAR/01, ICAR/02, ICAR/03, ICAR/04, ICAR/05, ICAR/06, ICAR/07, ICAR/08, ICAR/09, ICAR/10, ICAR/11, ICAR/17 and ICAR/20. <u>Candidates with an international bachelor's degree (EU and non-EU)</u> *An engineering bachelor's degree or equivalent to engineering degree* As this programme is an engineering programme, the majority (however not all) of our students hold an engineering bachelor's degree. Good engineering skills provide a good starting point for the success in this programme. *Good mathematics and physics skills* Candidates are expected to possess a good knowledge in general engineering subjects such as math and physics. If this is not the case, we can provide selected preparation literature for them to cover before the start of the academic year. *English language requirements* A minimum of B2 level is required (according to the Common European Framework of Reference for Languages). Accepted certificates are also TOEFL and IELTS.
Potential progression for learners after graduation	• PhD in "Infrastructure and Transport" • Post-Master course in "Railway Infrastructure and Systems Engineering"
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student
Expected learners numbers	25
Assessment of learning outcomes	Exams at the end of each teaching course and graduation exam at the end of the programme
Diplomas/Certificates provided	Master of Science degree (Laurea Magistrale)
	OBJECTIVES
Overarching goals/visions	The Master Degree in "Transport Systems Engineering" aims at providing Students with high-level qualifications, so as to allow them to perform and manage a wide variety of activities

	connected with planning, programming, operating, monitoring transport systems and their components. The course in "Railway Engineering" aims at providing Students with basic elements of knowledge concerning the railway transport system and the educational elements to study the railway complex system operation, as well as the design criteria of infrastructure, vehicle and operation itself.
Targeted public	Recent engineering bachelor's graduates
Potential jobs	The transport systems engineer can find employment at: • European, national and local public administrations (for example the European Commission, Ministries, Regions, Provinces, Municipalities); • Organizations and companies responsible for the design, construction and management of transport infrastructures and services or responsible for the control and regulation of transport systems; • Manufacturers of vehicles and traffic command and control systems; • Freight transport and logistics operators; • Engineering and consulting firm; • Professional studies.
Selection method	There is no admission test. Candidate applications are evaluated in the pre-selection process by the Transport Engineering Educational Area.
Learning objectives and outcomes, challenges and expected impacts	The professional skills of a Transport Systems Engineer include: • methods to design transport systems: formulation of dimensional and performance specifications for system components; • models for mobility of people and goods, for transport supply on multi-modal networks, for demand/supply interaction and equilibrium calculation; • design and implementation of transport systems (technical and economic aspects), transport and mobility plans on different levels; • on-line and off-line models for transport system operations and management; • monitoring and ex-ante/ex-post assessment of mobility solutions from the technical, economic and environmental point of view.
Others	-
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	The Transport Engineering Educational Area is made up of 15 professors. The Railway Engineering course is taught by 2 professors.

	As part of the Railway Engineering course, three technical visits are usually organised: to a station, to a traffic control room and to a train maintenance plant.
Training program (curriculum, contents, general and specific objectives of each course, etc.)	The program is a two-year programme equivalent to 120 ECTS. The programme structure is composed by: • 4 compulsory modules related to core transport disciplines (equivalent to 48 ECTS) • 2 compulsory modules related to integrative disciplines (equivalent to 12 ECTS) • 11 elective modules related to transport disciplines (equivalent to 24 ECTS) • two freely chosen modules of 6 ECTS or one module of 12 ECTS With regards to railways the main course is Railway Engineering (equivalent to 12 ECTS), which has been chosen for the implementation of the STAFFER project. The syllabus outline of the Railway Engineering course is as follows: • Introduction and educational goals • Railway line layout • Operational constraints due to infrastructure, rolling stock and personnel • Timetable planning and train composition • Line headway • Functions and typology of signalling systems • Integrity and efficiency check during the trip • Level crossings protection • Criteria and methods for signalling maintenance • Traffic on lines and stations • Station interlocking • Station layouts • Metro lines plants • Marshalling yards • Reliability, maintainability and availability • Services quality requirements • Traffic control and management systems • Dynamic of railway vehicles • Structural components of vehicles. Suspension. Contact forces. Wheelset-rail interaction. Vertical stiffness. Vertical dynamics. Adhesion. Running stability in straight and in curve. Construction features in favour of stability. Experimental approach to driving dynamic studies • Formulation and development of the design of the traction system. Maximum speed of track. Correlations between commercial speed, vehicle speed, distance between stops, acceleration. Range of characteristic parameters of the vehicle for different categories of

	services. Correlation between mass of the locomotive, trailer mass and slope. Resistance to motion, power, traction performance. Power supply. Maintenance • Operation of rail systems. Timetable design. Traffic capacity at the station. Probabilistic method. Fixed Timetable method. Numerical exercises on the topics of the program
Indicate the selected programme according to STAFFER findings	Rail transport engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☒ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☐ Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☐ Safety, dependability, security ☒ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☐
Duration and type of work-based internships (if compulsory)	Internships are not mandatory. However, Companies supporting the Master Degree in Transport Systems Engineering offer students internship opportunities connected with the preparation of the degree thesis
Companies that offer internships (please indicate if there are STAFFER partners among them)	• Aitec, • AKKA Italy, • Ferrovie dello Stato Italiane spa (*STAFFER partner*), • Ikos Italy, • TEAM Engineering spa, • Technital spa
Teaching language	English
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face-to-face lessons
Assessment methods and regulations	Written and/or oral exams (the mark scale is 18/30 cum Laude). Some teaching modules require students to carry out lab

	activities and projects. The final exam consists of a thesis defense (the mark scale is 66/110 cum Laude)
Qualification of teachers and trainers	Generally, the teaching staff of the programme is made up of full professors, associate professors and researchers of the University of Rome "La Sapienza". When the permanent teachers are not able to cover all the courses, contract teachers are also used.
	PARTNERSHIP
Partners Name/Address	• Ferrovie dello Stato Italiane spa/ Piazza della Croce Rossa 1, 00161 Roma (RM), Italy; • Aitec / Parque Tecnológico. C/ Charles Robert Darwin, 20. 46980 Paterna (Valencia), Spain; • AKKA Italy / Via Rimini 7, 40128 Bologna (BO), Italy; • Ikos Italy / Largo Richini 6, 20122 Milano (MI), Italy; • TEAM Engineering spa / Via Casimiro Manassei 38, 00151 Roma (Roma), Italy; • Technital spa / Via Carlo Cattaneo 20, 37121 Verona (VR), Italy
	TRAINING EVALUATION
Evaluation Modalities	A quality assurance procedure for the programme is applied to identify areas for improvement, which includes: • the analysis of satisfaction surveys, compiled by students at the end of each course; • the analysis of satisfaction surveys compiled by graduates; • annual monitoring report according to defined performance indicators.
Results indicators	6. Percentage of students satisfied with the courses 7. Number of students enrolled in the programme 8. Percentage of enrolled students who graduate 9. Percentage of graduates satisfied with the programme 10. Percentage of graduates employed within one year from the end of the course
Expected results	6. 90% of satisfied students with the courses 7. target of 30 students per academic year 8. 25 graduated per academic year 9. 100% of satisfied graduates 10. 100% of graduates employed within one year from the end of the course
	FUNDING
Free of charge	No
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Variable according to students' family income (max about 3000 euros/year). Scholarships and exemptions are available.

	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2023/2024
Duration of the programme	2 academic years (corresponding to 120 ECTS credits). First semester lessons are from the last week of September to until the day before Christmas. Second semester lessons are from the last week of February to the end of May.
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://corsidilaurea.uniroma1.it/it/corso/2021/30841/home; https://web.uniroma1.it/cdaingtrasporti/

II.11.2 Mobility programme in Signalling Systems

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	Università degli Studi di Roma "La Sapienza" (UNIROMA1)
Faculty/Department	Faculty of Civil and Industrial Engineering / Department of Civil, Building and Environmental Engineering
Training Program Title	Mobility programme in Signalling Systems
Indicate if it is a new training program or an existing one to be adapted	New
Contact Name/Function/Mail/Phone	Luca Rizzetto / Temporary Researcher / luca.rizzetto@uniroma1.it / +393333557805
Degree Type	-
Certification (Yes/No/In Process, type, etc.)	No
Organism of Certification	-
Training address	Via Eudossiana 18 – 00184 Roma (Italy)
EQF Level	7
Usual entry age	23
Entry requirements / Prerequisites	The course was designed and implemented expressly for Le Cnam students in Electronic Engineering - Specialisation Railway Signalling.
Potential progression for learners after graduation	-
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student/apprentice (Le Cnam students are also apprentices at railway companies)

Expected learners numbers	17
Assessment of learning outcomes	-
Diplomas/Certificates provided	-
	OBJECTIVES
Overarching goals/visions	Provide students with an overview of the evolution of the Italian railway network in general and signalling systems in particular, through lectures and technical visits, highlighting similarities and differences with the French railway system.
Targeted public	The course was designed and implemented expressly for Le Cnam students in Electronic Engineering - Specialisation Railway Signalling.
Potential jobs	○ Design engineer for railway signalling systems ○ Railway signalling systems maintenance engineer
Selection method	-
Learning objectives and outcomes, challenges and expected impacts	The initiative aimed to provide Le Cnam students with a comprehensive understanding of signalling systems in the railway industry, with a focus on the Italian context. Through seminars, guided tours and interactive sessions, participants gained valuable knowledge about the historical, technical and operational aspects of railway infrastructure in Italy.
Others	-
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	
Training program (curriculum, contents, general and specific objectives of each course, etc.)	**Mobility programme in Signalling Systems for Le Cnam students at Sapienza University of Rome** ***Schedule***

Day	Activities
1. Monday 26/06	AM: arrival and accommodation. 16:00: welcome event with reciprocal presentations and drink *(Room 15)*.
2. Tuesday 27/06	9:00-13:00: seminar on historical evolution of railway signalling system in Italy – prof. Riccardo Licciardello *(Room 15)*.

Co-funded by the
Erasmus+ Programme
of the European Union

		15:30-18:00: guided visit of RFI traffic control centre at Roma Termini station.
	3. Wednesday 28/06	9:00-13:00: seminar on historical evolution of the Italian railway network and comparison with France – prof. Marco Antognoli *(Room 15)*. 14:30-17:30: guided visit of Trenitalia operations room.
	4. Thursday 29/06	AM: free time. 18:00-20:00: guided visit of ATAC transport history museum at Piramide metro station.
	5. Friday 30/06	12:40-13:53: Roma-Napoli transfer by high-speed train with technical visit in the driver's cabin. 15:00-18:00: seminar on historical, cultural and touristic activities of Fondazione FS with a focus on the adaptation of historic rolling stock to modern control command and signalling systems + guided visit of the historical-technical national railway museum in Pietrarsa.
	6. Saturday 01/07	Free time.
	7. Sunday 02/07	AM: free time. 16:35-17:45: transfer Napoli-Roma transfer by high-speed train with technical visit in the driver's cabin.
	8. Monday 03/07	9:00-12:30: seminars on railway engineering ongoing research activities at DICEA and DITS – prof. Stefano Ricci *(Room 8)*. 15:00-18:00: guided technical visit of control centre and depot of the fully automated metro line C.
	9. Tuesday 04/07	10:00-13:00: guided visit of Trenitalia maintenance facility at Roma Smistamento. 14:00-16:00: regional train dynamic driving simulator at Roma Smistamento.
	10. Wednesday 05/07	9:00-12:30: presentation of the metro line C project and guided visit of metro line C construction site at Fori Imperiali station. 14:00-15:00: presentation of the activities of the Ferrovie dello Stato Italiane Group and interest of the

	Group in the STAFFER project - Vito Pagliarisi *(Room 30)*. 15:00-17:00: interactive session with individual impressions of students.
Indicate the selected programme according to STAFFER findings	Railway systems engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☒ Smart cities & Internet of Things (IoT) ☐ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☐ Learning skills ☐ Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☒ Safety, dependability, security ☐ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☐
Duration and type of work-based internships (if compulsory)	-
Companies that offer internships (please indicate if there are STAFFER partners among them)	-
Teaching language	English
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face-to-face lessons and educational visits
Assessment methods and regulations	-
Qualification of teachers and trainers	The teaching staff of the programme is made up of full professors, associate professors and researchers of the University of Rome "La Sapienza"
	PARTNERSHIP

Partners Name/Address	Ferrovie dello Stato Italiane spa/ Piazza della Croce Rossa 1, 00161 Roma (RM), Italy.
	TRAINING EVALUATION
Evaluation Modalities	-
Results indicators	-
Expected results	-
	FUNDING
Free of charge	Yes
Type, modalities (estimated budget, contributions, fees, charges, etc.)	-
	PROVISIONAL TIMETABLE
Implementation school year	2023
Duration of the programme	26 June to 5 July 2024
	DISSEMINATION
Supports (flyer, website, social media, etc.)	-

II.11.3 Master universitario di II livello in Ingegneria delle Infrastrutture e dei Sistemi Ferroviari (Post-Master course in "Railway Infrastructure and Systems Engineering")

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	Università degli Studi di Roma "La Sapienza" (UNIROMA1)
Faculty/Department	Faculty of Civil and Industrial Engineering / Department of Civil, Building and Environmental Engineering
Training Program Title	Master universitario di II livello in Ingegneria delle Infrastrutture e dei Sistemi Ferroviari (Post-Master course in "Railway Infrastructure and Systems Engineering")
Indicate if it is a new training program or an existing one to be adapted	Existing training program to be adapted
Contact Name/Function/Mail/Phone	Luca Rizzetto / Temporary Researcher / luca.rizzetto@uniroma1.it / +393333557805
Degree Type	Master universitario di II livello (Post-Master course)
Certification (Yes/No/In Process, type, etc.)	The program is accredited by the University of Rome "La Sapienza"
Organism of Certification	The accreditation process requires approval by Department, Faculty and University
Training address	Via Eudossiana 18 – 00184 Roma (Italy)
EQF Level	8
Usual entry age	24 years and above
Entry requirements / Prerequisites	Master's degree in engineering
Potential progression for learners after graduation	None
Type of VET programme (initial/continuous/apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Student

Expected learners numbers	20
Assessment of learning outcomes	Exams at the end of each teaching module and final exam at the end of the course
Diplomas/Certificates provided	Diploma di Master Universitario di II livello (Post-Master's diploma)
	OBJECTIVES
Overarching goals/visions	Universities generally offer very specialist Bachelor and Master Courses for engineers, while the complexity of the railway sector requires a comprehensive systemic expertise from engineers. Therefore, the idea of this course is to provide a multidisciplinary training, which joins transversal technical knowledge with economic and legal subjects, useful to face both specialist problems and their connections with the railway system as a whole, in order to maximise the whole performances.
Targeted public	Recent engineering master's graduates
Potential jobs	The aim of the course is to train engineers able to encounter the needs of a large set of railway companies, such as infrastructure managers, freight and passenger operators, industries providing systems, subsystems and components, public and private bodies planning investments, endorsing certifications, etc.
Selection method	The selection of candidates is carried out in two stages: first an evaluation of the curriculum based on which a pre-established number of candidates (variable from year to year) is admitted to the subsequent entrance exam. The entrance exam is managed in cooperation between university and partner companies and includes three tests: a technical test on basic elements of railway engineering, an aptitude tests (developed by the HR Departments of the partner companies) and a test of English language proficiency.
Learning objectives and outcomes, challenges and expected impacts	The aim of the course is to train railway engineers who are very attractive for companies supporting the course, which can invest on them after a period of reciprocal knowledge and professional integration, as well as for other companies beyond them. To achieve this goal is essential a close collaboration with companies supporting the course, that contribute to the definition of the contents of the modules, collaborate to the selection of participants and to teaching activities, host technical visits and internships, issue scholarships for students.
Others	-
	MEANS / MODALITIES
Human and material resources (pedagogical team, workshops, laboratory, etc.)	A teaching committee is responsible to develop the general program of the course and to designate the teaching coordinators of each module. At least one technical visit is organised within each didactic module with the support of the

<table>
<tr><td></td><td>partner companies of the course, that guide the students in their stations, control rooms, repair shops, factories and construction sites.</td></tr>
<tr><td>Training program (curriculum, contents, general and specific objectives of each course, etc.)</td><td>The program is an annual course equivalent to 60 ECTS. It is articulated in:

12 teaching modules (the first 10 of them are equivalent to 4 ECTS each, the last two are equivalent to 2 ECTS each) with theoretical lessons, seminars, tests and technical visits, which in total correspond to 480 teaching hours;
a work experience of at least 150 hours (equivalent to 6 ECTS) at one of the partner companies;
a module of exchange of internship experiences (equivalent to 4 ECTS);
a final examination (equivalent to 6 ECTS).

The following table shows the contents of the teaching modules.
<table>
<tr><th>Module's title</th><th>N. of ECTS</th><th>Module's content</th></tr>
<tr><td>1. Principles of railway engineering</td><td>4</td><td>Fundamental elements necessary to effectively face the study of railway transport and mobility in general</td></tr>
<tr><td>2. Railway track and fixed installations</td><td>4</td><td>Basic elements of the railway track, fixed installations for electric traction, signalling and telecommunications</td></tr>
<tr><td>3. Traction systems and vehicle dynamics</td><td>4</td><td>Basic elements of traction systems on board of railway vehicles, vehicle architecture and dynamics</td></tr>
<tr><td>4. Infrastructure designing and planning</td><td>4</td><td>Main aspects of design and construction of rail infrastructure</td></tr>
<tr><td>5. Railway traffic technologies</td><td>4</td><td>Principles and rules of railway traffic, carrying capacity of lines and stations, command, control and signalling systems</td></tr>
<tr><td>6. Management of railway safety</td><td>4</td><td>Theoretical principles of safety, risk analysis and its applications to railway transport by ground based and on-board technologies. European and national legislation in the field of railway safety. Safety Management Systems of railway operation.</td></tr>
</table>
</td></tr>
</table>

	7. Passenger and freight terminals | 4 | Theoretical principles and methodologies for dimensioning and design of freight terminals and passenger stations and their relationships with the land-use
	8. Freight transport and logistics | 4 | Basic elements of logistics, techniques for multimodal freight transport management and international regulations for various categories of goods
	9. Service planning and quality | 4 | Theoretical principles of the railway service planning within a multimodal transport framework, quality management principles and transport costs assessment
	10. Public works planning and regulations | 4 | Main technical, regulatory, procedural and administrative issues related to planning, design and construction of transport infrastructures
	11. Environmental impact assessment of railways | 2 | Main technical and legislative issues related to the multi-components assessment of environmental impact in a life-cycle sustainability perspective
	12. Economics and soft skills | 2 | Development of internships in railway companies and final presentation to colleagues
	13. Exchange of internship experiences | 4 | In this module, students present the work they made during the period of internship at one of the Companies which support the Course to the other students, the Academia and Corporate Tutors and the HR Managers of partner Companies.
Indicate the selected programme according to STAFFER findings	Railway systems engineering
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐ Norms, standards & certification ☒ Smart cities & Internet of Things (IoT) ☒ Living language ☐ Big Data & Artificial Intelligence ☐ Transportation systems ☒ Reliability, maintenance & life cycle management ☒ Learning skills ☐

	Global new energies & technologies ☐ Formal methods for system design & verification ☐ Web development ☐ Communication ☐ Safety, dependability, security ☒ Networking & ICT technologies ☐ Virtual reality ☐ Soft skills ☒
Duration and type of work-based internships (if compulsory)	Internship of about 2 and a half months (minimum 150 hours) at one of the partner companies of the course
Companies that offer internships (please indicate if there are STAFFER partners among them)	• Ferrovie dello Stato Italiane spa *(STAFFER partner)*, • Almaviva spa , • Alstom Ferroviaria spa *(STAFFER partner)*, • Ferrotramviaria spa, • For.Fer srl *(STAFFER partner)*, • Hitachi Rail STS spa *(STAFFER partner)*, • Segula Technologies Italia srl, • Siemens Mobility srl *(STAFFER partner)* *(data of the 2021/2022 academic year)*
Teaching language	Italian
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	For the next academic year, it is still to be decided whether to organize only face-to-face lessons or in mixed modality (face-to-face and remote lessons).
Assessment methods and regulations	Some teaching modules require students to carry out group work. The exams of the teaching modules are generally oral (currently only one exam is written with multiple choice questions) like the final exam. Managers of the partner companies take part together with the university professors to the exams of each teaching module and to the final exam, so that companies are able to judge students at every stage of the learning process.
Qualification of teachers and trainers	A teaching committee designates the teaching coordinators of each module, who in turn identify the teachers. In each module about half the lecturers are professors and half managers of the partner companies to ensure an up-to-date teaching which provides both the academic and the industrial point of view of any rail subject.
	PARTNERSHIP
Partners Name/Address	• Ferrovie dello Stato Italiane spa/ Piazza della Croce Rossa 1, 00161 Roma (RM), Italy; • Almaviva spa/ via di Casal Boccone 188/190, 00137 Roma (RM), Italy; • Alstom Ferroviaria spa / Via Ottavio Moreno 23, 12038 Savigliano (CN), Italy;

	• BPS Deployment srl / Via Magliotto 2, 17100 Savona (SV), Italy • ETS srl / Via Appia Nuova 59, 00183 Roma (RM), Italy; • Ferrotramviaria Engineering spa / Piazza Giovanni Winckelmann 12, 00162 Roma (RM), Italy; • For.Fer srl / Piazza Giovanni Winckelmann 12, 00162 Roma (RM), Italy; • G.C.F. Generale Costruzioni Ferroviarie spa / Viale dell'Oceano Atlantico 190, 00144 Roma (RM), Italy; • Hitachi Rail STS, Via Argine 425, 80147 Napoli (NA), Italy; • IDOM Consulting, Engineering, Architecture S.A., Avenida Zarandoa, 23, 48015 Bilbao (Spain); • Salcef Group spa / Via di Pietralata 140, 00158 Roma (RM), Italy; • Segula Technologies Italia srl / Corso Unione Sovietica 612/3E, 10135 Torino (TO), Italy; • Siemens Mobility / Via Vipiteno 4, 20128 Milano (MI), Italy; • ZF Italia / Via Gaetano Donizetti 11, 20090 Assago (MI), Italy; *(data of the Academic Year 2023/2024)*
	TRAINING EVALUATION
Evaluation Modalities	Survey of students' opinions at the end of the course analysed by teaching committee and representatives of partner companies to identify areas for improvement.
Results indicators	1. Number of students enrolled in the course 2. Percentage of enrolled students who graduate 3. Percentage of graduates hired by the company where they completed their internship within 6 months of the end of the course 4. Percentage of graduates hired by other partner companies within 6 months of the end of the course 5. Percentage of graduates employed by non-partner railway companies within 6 months of the end of the course
Expected results	1. 20 2. 100% 3. 90% 4. 5% 5. 5%
	FUNDING
Free of charge	☐
Type, modalities (estimated budget, contributions, fees, charges, etc.)	The tuition fee is €3,000. The partner companies finance scholarships for the students. In the academic year 2021/2022, the maximum number of students enrolled in the course was 35 and the partner companies financed scholarships of € 3,000 for the first 20 students in the admission rankings and of € 2,500 for the remaining 15 students.

	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2023/2024
Duration of the programme	1 academic year (corresponding to 60 ECTS credits). Normally the course starts in mid-February and ends in late October each year.
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://web.uniroma1.it/masteriisf/ https://www.linkedin.com/in/master-iisf-41253a259

II.11.4 PhD course in "Infrastructure and Transports" - Curriculum "Infrastructures, Transport Systems and Geomatics"

TRAINING PROGRAM DESCRIPTION

	GENERAL INFORMATION
Institution/Organisation	Università degli Studi di Roma "La Sapienza" (UNIROMA1)
Faculty/Department	Faculty of Civil and Industrial Engineering / Department of Civil, Building and Environmental Engineering
Training Program Title	PhD course in "Infrastructure and Transports" - Curriculum "Infrastructures, Transport Systems and Geomatics"
Indicate if it is a new training program or an existing one to be adapted	Existing training program to be adapted
Contact Name/Function/Mail/Phone	Luca Rizzetto / Temporary Researcher / luca.rizzetto@uniroma1.it / +393333557805
Degree Type	Ph.D degree
Certification (Yes/No/In Process, type, etc.)	YES
Organism of Certification	CUN (National University Council) and ANVUR (Italian National Agency for the Evaluation of Universities and Research Institutes)
Training address	Via Eudossiana 18 – 00184 Roma (Italy)
EQF Level	8
Usual entry age	25 years age
Entry requirements / Prerequisites	Possession of a master's degree. Adequate knowledge of the English language equivalent at least to the B2 level.
Potential progression for learners after graduation	-
Type of VET programme (initial/continuous/ apprenticeship)	Continuous
Status of learners (student/apprentice/staff)	Ph.D. Student
Expected learners numbers	2
Assessment of learning outcomes	Exams for admission to the following year at the end of each of the two first years. Final exam at the end of the programme.

Diplomas/Certificates provided	Ph.D certificate
	OBJECTIVES
Overarching goals/visions	The PhD Course in Infrastructures and Transport aims to train a professional, multidisciplinary, highly qualified and integrated scientific figure. Its main topics include: the infrastructures and human settlement planning and management; the acquisition, analysis and management of geographic and spatial information; the integrated mobility; the construction and the operational service of the infrastructures and conventional and innovative transport systems, focusing on those with improved environmental friendly performances. The Curriculum "Infrastructures, transport systems and geomatics" will allow the acquirement, in-depth examination, development and implementation of actual and advanced technical methodologies for civil engineering works design and construction. The main interest will be pointed on the realization and management of large linear infrastructures, integrated in transportation networks (roads, railways, harbours, airports), taking into consideration the preservation of a good human equilibrium and the safeguard of territory and environment, considering economic and financial conditions.
Targeted public	Recent transport systems engineering master's graduates
Potential jobs	In addition to the possibility of accessing an academic career, PhDs will be able to find employment in a variety of sectors: • transport service companies and the logistics sector • transport sector authorities • public and private laboratories and research centres • project offices and/or technical office and/or R&D sector of companies in the transport sector • engineering studies
Selection method	Admission to the PhD programme is subject to an entry examination, which consists of an assessment of qualifications and an oral examination.
Learning objectives and outcomes, challenges and expected impacts	Scientific and educational objectives of the Curriculum “Infrastructures, transport systems and geomatics” are: o advanced design and construction methods for transportation infrastructures, especially regarding construction processes and integrated design procedures, with the aim to ensure the increase of safety and the preservation of environment, the measure of economic or financial resources employable and retractable.

	○ construction materials recycling and re-use, by means of the analysis of mechanical and ecological characteristics of waste products. ○ territorial analysis, according to methodologies and geomatics techniques that, through the acquisition, management (modeling and analysis) and dissemination of territorial information, allowing study of the territory in the design and service phases of civil infrastructures and monitoring their impact. ○ environmental sustainability of infrastructures, especially referred to hydro-geological problems, with the aim to recognize – also in advance – interactions between territory and transportation networks.			
Others	-			
	MEANS / MODALITIES			
Human and material resources (pedagogical team, workshops, laboratory, etc.)	The programme is flexible and the student can select all the courses according to his/her research topic. Traditional courses can be combined with: • courses specifically developed for doctoral training, • lab activities and development of projects, • participation in seminars and conferences, • participation in summer and winter schools, • inclusion in research groups, • research period abroad.			
Training program (curriculum, contents, general and specific objectives of each course, etc.)	The program is a three-year programme equivalent to 180 ECTS.			
Indicate the selected programme according to STAFFER findings	Rail transport engineering			
Indicate the subjects that you intend to implement or modify for the declared fields/trends/skillsets according to STAFFER findings	Cybersecurity & Internet of Things (IoT) ☐	Norms, standards & certification ☒	Smart cities & Internet of Things (IoT) ☒	Living language ☐
	Big Data & Artificial Intelligence ☒	Transportation systems ☒	Reliability, maintenance & life cycle management ☒	Learning skills ☐

	Global new energies & technologies ☒	Formal methods for system design & verification ☐	Web development ☐	Communication ☐
	Safety, dependability, security ☒	Networking & ICT technologies ☒	Virtual reality ☐	Soft skills ☐
Duration and type of work-based internships (if compulsory)	-			
Companies that offer internships (please indicate if there are STAFFER partners among them)	-			
Teaching language	Italian, English			
Teaching and learning forms and modalities (e.g. part-time, dual, distance)	Face to face			
Assessment methods and regulations	Examinations held by the doctoral board for admission to the following year at the end of each of the two first years, in order to verify that the research activities planned in the previous year have been carried out productively. Final examination at the end of the programme, consisting of a dissertation.			
Qualification of teachers and trainers	The doctoral board is composed by full professors, associate professors and researchers of the University of Rome "La Sapienza".			
	PARTNERSHIP			
Partners Name/Address	-			
	TRAINING EVALUATION			
Evaluation Modalities	The proposal to activate doctoral courses is formulated every year to the Academic Senate by the departments and the various university centres involved. The schools involved in the doctorate also express an opinion on the proposal. The proposal must meet the requirements defined by legislation. The loss of a mandatory requirement entails the withdrawal of accreditation. In such case, the activation of a new cycle of Doctoral courses is suspended with immediate effect.			
Results indicators	-			
Expected results	-			
	FUNDING			

Free of charge	☒
Type, modalities (estimated budget, contributions, fees, charges, etc.)	Ph.D. positions available according to the number of scolarships.
	PROVISIONAL TIMETABLE
Implementation school year	Academic Year 2024/2025
Duration of the programme	3 academic years. Each year is organised in two semesters: • First semester lessons – from mid-September to mid-December • Second semester lessons – from mid-February to the end of May.
	DISSEMINATION
Supports (flyer, website, social media, etc.)	https://phd.uniroma1.it/web/INFRASTRUCTURES-AND-TRANSPORT_nD3508_EN.aspx

ANNEX III - PILOT VETS' EVALUATION

III.1 CESI - Post Master Degree Manager of construction projects option Urban Transport (Mastère Spécialisé® Management de Projets de Construction, Option Transports Ferroviaires, Urbains et Nouvelles Mobilités)

III.1.1 Students' evaluation

III.1.1.1 Module 1: Tunnel Construction

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**12.50**	**0.00**	**25.00**	**62.50**	**0.00**
Average	0	3.125	0.00	18.75	62.50	
	84.38					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	**0.00**
Average	0	0	0	9.38	87.50	

	96.88

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**
Average	0	0.00	0.00	37.50	50.00	
	87.50					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**
Average	0	0.00	0.00	37.50	50.00	
	87.50					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**25.00**	**62.50**	**0.00**
Average	0	0.00	6.25	18.75	62.50	
	87.50					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0.00	0.00	28.13	62.50	
	90.63					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	**0.00**
Average	0	0.00	0.00	9.38	87.50	
	96.88					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**25.00**	**75.00**	**0.00**
Average	0	0.00	0.00	18.75	75.00	
	93.75					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
More technical project would be appreciated
I don't see any specific areas for improvement. The course seems well-designed and satisfactory overall.

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0	0	28.125	62.5	
	90.63					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	25.00	75.00	0.00
Average	0	0.00	0.00	18.75	75.00	
	93.75					

Item N°12 : What was the most valuable aspect of the course?
Overall, I found the course to be engaging.
Good Lesson
The subject itself

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0.00	0.00	0	100	
	100.00					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00
Average	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.00	50.00

	95.00

III.1.1.2 Module 2: Design and dimensioning of tracks

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**14,29**	**71,43**	0
Average	0	0	7,14	10,71	71,43	
	89,29					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**57,14**	0
Average	0	0	0	21,43	57,14	
	78,57					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	0,00	0,00	0,00	14,29	71,43	0
Average	0	0,00	0,00	10,71	71,43	
	82,14					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	0,00	57,14	42,86	0,00
Average	0	0,00	0,00	42,86	42,86	
	85,71					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0,00	0,00	0,00	100,00	
	100,00					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	**0,00**	**0,00**	**28,57**	**14,29**	**42,86**	0,00
Average	0	0,00	14,29	10,71	42,86	
	67,86					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**14,29**	**71,43**	0,00
Average	0	0,00	7,14	10,71	71,43	
	89,29					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,71	85,71	
	96,43					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
I don't see any specific areas for improvement. The course seems well-designed and satisfactory overall.
I do not have much to say , I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0	0	21,4285714	71,4285714	
	92,86					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,71	85,71	
	96,43					

Item N°12 : What was the most valuable aspect of the course?

The constructive interactions with the professor
Overall, I found the course to be engaging.
Good Lesson
The subject itself

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,4285714	71,4285714	
	92,86					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**
Average	0	0	0,00	0,00	0,00	0,00	0,00	0,00	0,00	25,71	71,43
	97,14										

III.1.1.3 Module 3: General concepts of railway equipment

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**28,57**	**57,14**	0,00
Average	0	0	7,14	21,43	57,14	
	85,71					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**42,86**	0,00
Average	0	0	0	32,14	42,86	
	75,00					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0,00	0,00	32,14	57,14	

	89,29

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**57,14**	0,00
Average	0	0,00	0,00	21,43	57,14	
	78,57					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**28,57**	**57,14**	0,00
Average	0	0,00	7,14	21,43	57,14	
	85,71					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**57,14**	0,00
Average	0	0,00	0,00	21,43	57,14	

	78,57

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	0,00
Average	0	0,00	0,00	0,00	100,00	
	100,00					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,71	85,71	
	96,43					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?

A little more technical aspects to be added in the training
I don't see any specific areas for improvement. The course seems well-designed and satisfactory overall.
Work for many site visits for understanding better the domain.
I do not have much to say, I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0	0	32,1428571	57,1428571	
	89,29					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**71,43**	**28,57**	0,00
Average	0	0,00	0,00	53,57	28,57	
	82,14					

Item N°12 : What was the most valuable aspect of the course?

Overall, I found the course to be engaging.
The part dediacted to energy and electrification
The humanity of the teacher and his passion for the subject

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,7142857	85,7142857	
	96,43					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**14,29**	**0,00**	**0,00**	**85,71**
Average	0	0	0,00	0,00	0,00	0,00	0,00	10,00	0,00	0,00	85,71
	95,71										

III.1.1.4 Module 4: Construction Law

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0	0,00	21,43	71,43	
	92,86					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0	0	10,71	85,71	
	96,43					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,43	71,43	

	92,86

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0,00	0,00	32,14	57,14	
	89,29					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**14,29**	**71,43**	0,00
Average	0	0,00	7,14	10,71	71,43	
	89,29					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,71	85,71	

	96,43

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	0,00
Average	0	0,00	0,00	0,00	100,00	
	100,00					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0,00	0,00	32,14	57,14	
	89,29					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?

A few more technical projects to add into the training prgram
I don't see any specific areas for improvement. The course seems well-designed and satisfactory overall.
Good Teacher
I do not have much to say, I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0	0	32,1428571	57,1428571	
	89,29					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Item N°12 : What was the most valuable aspect of the course?

Overall, I found the course to be engaging.
Professional Teacher
The subject itself

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,7142857	85,7142857	
	96,43					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**14,29**	**28,57**	**57,14**
Average	0	0	0,00	0,00	0,00	0,00	0,00	0,00	11,43	25,71	57,14
	94,29										

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**37.50**	**50.00**	**0.00**
Average	0	0	6.25	28.13	50.00	
	84.38					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0	0	28.13	62.50	
	90.63					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**
Average	0	0.00	0.00	37.50	50.00	
	87.50					

Co-funded by the
Erasmus+ Programme
of the European Union

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0.00	0.00	28.13	62.50	
	90.63					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**25.00**	**62.50**	**0.00**
Average	0	0.00	6.25	18.75	62.50	
	87.50					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	**0.00**
Average	0	0.00	0.00	9.38	87.50	
	96.88					

Co-funded by the Erasmus+ Programme of the European Union

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**25.00**	**75.00**	**0.00**
Average	0	0.00	0.00	18.75	75.00	
	93.75					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	**0.00**
Average	0	0.00	0.00	9.38	87.50	
	96.88					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training prgram
I don't see any specific areas for improvement. The course seems well-designed and satisfactory overall.

Insert more hours for this course
I do not have much to say, I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**
Average	0	0	0	37.5	50	
	87.50					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0.00	0.00	28.13	62.50	
	90.63					

Item N°12 : What was the most valuable aspect of the course?
The constructive interactions with the tacher
Overall, I found the course to be engaging.
Good lesson
The principles and criteria of conception
The subject itself

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**25.00**	**75.00**	**0.00**
Average	0	0.00	0.00	18.75	75	
	93.75					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**12.50**	**0.00**	**25.00**	**62.50**
Average	0	0	0.00	0.00	0.00	0.00	0.00	8.75	0.00	22.50	62.50
	93.75										

III.1.1.6 Module 6: Issues and organization of rail and urban transport

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**16,67**	**0,00**	**33,33**	**50,00**	0,00
Average	0	4,16666667	0,00	25,00	50,00	
	79,17					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**16,67**	**83,33**	0,00
Average	0	0	0	12,50	83,33	
	95,83					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**33,33**	**66,67**	0,00
Average	0	0,00	0,00	25,00	66,67	

	91,67

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**50,00**	**50,00**	0,00
Average	0	0,00	0,00	37,50	50,00	
	87,50					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**16,67**	**83,33**	0,00
Average	0	0,00	0,00	12,50	83,33	
	95,83					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**16,67**	**83,33**	0,00
Average	0	0,00	0,00	12,50	83,33	

	95,83

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**33,33**	**66,67**	0,00
Average	0	0,00	0,00	25,00	66,67	
	91,67					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**33,33**	**66,67**	0,00
Average	0	0,00	0,00	25,00	66,67	
	91,67					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training prgram

I do not have much to say, I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0**	**0,00**	**0,00**	**66,67**	**33,33**	0,00
Average	0	0	0	50	33,3333333	
	83,33					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**33,33**	**66,67**	0,00
Average	0	0,00	0,00	25,00	66,67	
	91,67					

Item N°12 : What was the most valuable aspect of the course?
The subject itself

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	0,00	0,00	0,00	16,67	83,33	0,00
Average	0	0,00	0,00	12,5	83,3333333	
	95,83					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	16,67	33,33	50,00
Average	0	0	0,00	0,00	0,00	0,00	0,00	0,00	13,33	30,00	50,00
	93,33										

III.1.1.7 Module 7: Construction waste management

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	12.50	37.50	50.00	0.00

Average	0	0	6.25	28.13	50.00	
	84.38					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0	0	28.13	62.50	
	90.63					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**
Average	0	0.00	0.00	37.50	50.00	
	87.50					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0.00	0.00	28.13	62.50	
	90.63					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**25.00**	**62.50**	**0.00**
Average	0	0.00	6.25	18.75	62.50	
	87.50					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	**0.00**
Average	0	0.00	0.00	9.38	87.50	
	96.88					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**12.50**	**75.00**	**0.00**
Average	0	0.00	6.25	9.38	75.00	

	90.63

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**25.00**	**75.00**	**0.00**
Average	0	0.00	0.00	18.75	75.00	
	93.75					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training prgram
I don't see any specific areas for improvement, the course seems well designed and satisfactory overall
I do not have much to say, I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0**	**0.00**	**12.50**	**37.50**	**50.00**	**0.00**
Average	0	0	6.25	28.125	50	

	84.38

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0.00	0.00	28.13	62.50	
	90.63					

Item N°12 : What was the most valuable aspect of the course?
The examples given by the teacher were pertinenet and allowed to better understand the notions seen in class
Overall I find the course to be engaging
The subject itself

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**25.00**	**75.00**	**0.00**
Average	0	0.00	0.00	18.75	75	
	93.75					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?

Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**12.50**	**0.00**	**25.00**	**62.50**
Average	0	0	0.00	0.00	0.00	0.00	0.00	8.75	0.00	22.50	62.50
	93.75										

III.1.1.8 Module 8: Environmental Impacts

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**57,14**	**28,57**	0,00
Average	0	0	7,14	42,86	28,57	
	78,57					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0	0	32,14	57,14	

	89,29

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**57,14**	**42,86**	0,00
Average	0	0,00	0,00	42,86	42,86	
	85,71					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**57,14**	**28,57**	0,00

Average	0	0,00	7,14	42,86	28,57	
	78,57					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**0,00**	**85,71**	0,00
Average	0	0,00	7,14	0,00	85,71	
	92,86					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,71	85,71	
	96,43					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training prgram
I don't see any specific areas for improvement, the course seems well designed and satisfactory overall
I do not have much to say, I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**28,57**	**57,14**	0,00
Average	0	0	7,14285714	21,4285714	57,1428571	
	85,71					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**71,43**	**28,57**	0,00
Average	0	0,00	0,00	53,57	28,57	
	82,14					

Item N°12 : What was the most valuable aspect of the course?
Overall I find the course to be engaging
A good teacher
The importance of sustanability on the performance of rail projects
The humanity of the teacher and his passion for the subject

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,7142857	85,7142857	
	96,43					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10

% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	0,00	0,00	0,00	0,00	0,00	0,00	14,29	0,00	0,00	0,00	85,71
Average	0	0	0,00	0,00	0,00	0,00	8,57	0,00	0,00	0,00	85,71
	94,29										

III.1.1.9 Module 9: BIM and construction management

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**71,43**	**28,57**	0,00
Average	0	0	0,00	53,57	28,57	
	82,14					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0	0	32,14	57,14	
	89,29					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	0,00	71,43	28,57	0,00
Average	0	0,00	0,00	53,57	28,57	
	82,14					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	0,00	28,57	71,43	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	28,57	42,86	28,57	0,00
Average	0	0,00	14,29	32,14	28,57	
	75,00					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**14,29**	**71,43**	0,00
Average	0	0,00	7,14	10,71	71,43	
	89,29					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00

Average	0	0,00	0,00	21,43	71,43	
	92,86					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training prgram
I don't see any specific areas for improvement, the course seems well designed and satisfactory overall
Make more exercises
The interaction was not good enough

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0**	**0,00**	**0,00**	**57,14**	**42,86**	0,00
Average	0	0	0	42,8571429	42,8571429	
	85,71					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**57,14**	**42,86**	0,00

Average	0	0,00	0,00	42,86	42,86	
	85,71					

Item N°12 : What was the most valuable aspect of the course?
Overall I find the course to be engaging
A professional tecaher
The knoledge of the different phases of project management
What was tin the course helped in our homework and evaluations

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0,00	0,00	32,1428571	57,1428571	
	89,29					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**28,57**	**14,29**	**57,14**
Average	0	0	0,00	0,00	0,00	0,00	0,00	0,00	22,86	12,86	57,14

Co-funded by the
Erasmus+ Programme
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	92,86

III.1.1.10 Module 10: Project management in BIM

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**14,29**	**0,00**	**0,00**	**57,14**	**28,57**	0,00
Average	0	0	0,00	42,86	28,57	
	71,43					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0	0	32,14	57,14	
	89,29					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	0,00	0,00	14,29	71,43	14,29	0,00
Average	0	0,00	7,14	53,57	14,29	
	75,00					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	14,29	0,00	0,00	28,57	57,14	0,00
Average	0	0,00	0,00	21,43	57,14	
	78,57					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	14,29	42,86	42,86	0,00
Average	0	0,00	7,14	32,14	42,86	
	82,14					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	0,00	0,00	14,29	0,00	71,43	0,00
Average	0	0,00	7,14	0,00	71,43	
	78,57					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	0,00	28,57	71,43	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	0,00	28,57	71,43	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training prgram
I don't see any specific areas for improvement, the course seems well designed and satisfactory overall
Make more exercises
More courses not just one as it was very important

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**57,14**	**28,57**	14,29
Average	0	0	0	42,8571429	28,5714286	
	71,43					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**57,14**	**42,86**	0,00
Average	0	0,00	0,00	42,86	42,86	
	85,71					

Item N°12 : What was the most valuable aspect of the course?

Overall I find the course to be engaging
A professional tecaher
The new way to see things

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0,00	0,00	32,1428571	57,1428571	
	89,29					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**12,50**	**12,50**	**12,50**	**50,00**
Average	0	0	0,00	0,00	0,00	0,00	0,00	14,29	14,29	14,29	57,14
	100,00										

III.1.1.11 Module 11: Management of Rail Projects

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0	0,00	32,14	57,14	
	89,29					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0	0	21,43	71,43	
	92,86					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0,00	0,00	32,14	57,14	
	89,29					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**14,29**	**28,57**	**57,14**	0,00
Average	0	0,00	7,14	21,43	57,14	
	85,71					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**28,57**	**71,43**	0,00
Average	0	0,00	0,00	21,43	71,43	
	92,86					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	0,00
Average	0	0,00	0,00	0,00	100,00	
	100,00					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**14,29**	**85,71**	0,00
Average	0	0,00	0,00	10,71	85,71	
	96,43					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training prgram
I don't see any specific areas for improvement, the course seems well designed and satisfactory overall

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**42,86**	**57,14**	0,00
Average	0	0	0	32,1428571	57,1428571	
	89,29					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**57,14**	**42,86**	0,00
Average	0	0,00	0,00	42,86	42,86	
	85,71					

Item N°12 : What was the most valuable aspect of the course?
Overall I find the course to be engaging
Good lesson
What was in the course helped us in future homework and evaluation

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	0,00

Average	0	0,00	0,00	0	100	
	100,00					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**14,29**	**14,29**	**71,43**
Average	0	0	0,00	0,00	0,00	0,00	0,00	0,00	11,43	12,86	71,43
	95,71										

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**37.50**	**50.00**	**0.00**
Average	0	0	6.25	28.13	50.00	
	84.38					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**50.00**	**0.00**
Average	0	0	0	28.13	50.00	
	78.13					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0.00	0.00	28.13	62.50	
	90.63					

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Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0.00	0.00	28.13	62.50	
	90.63					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**25.00**	**62.50**	**0.00**
Average	0	0.00	6.25	18.75	62.50	
	87.50					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	**0.00**
Average	0	0.00	0.00	9.38	87.50	
	96.88					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	12.50	87.50	0.00
Average	0	0.00	0.00	9.38	87.50	
	96.88					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	12.50	87.50	0.00
Average	0	0.00	0.00	9.38	87.50	
	96.88					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
A few more technical projects to add into the training program
I don't see any specific areas for improvement, the course seems well designed and satisfactory overall
I do not have much to say I was very satisfied

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**37.50**	**62.50**	**0.00**
Average	0	0	0	28.125	62.5	
	90.63					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**
Average	0	0.00	0.00	37.50	50.00	
	87.50					

Item N°12 : What was the most valuable aspect of the course?
The constructive interactions with the professor
Overall, I find the course to be engaging
Very Good teacher
The impact of the rolling stock on the conception of railway infrastructures
The humanity of the teacher and his passion for his subject

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	**0.00**
Average	0	0.00	0.00	9.375	87.5	
	96.88					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**25.00**	**75.00**
Average	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.50	75.00
	97.50										

III.1.2 Teachers’ evaluation

III.1.2.1 Module 1: Maintenance of earthworks

Maintenance of earthworks

Teachers' Evaluation	El Janyani Sanane	**Date**	**27.03.2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100.00
Average	0	0.00	0.00	0.00	0.00	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Presentation of case studies for the reinforcement of an earthen structure with the project manager's vision (crisis management, communication, work planning, identification of emergencies) and interface meetings with the various project professions

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.2 Module 2: Conception of the Earthworks

Conception of the Earthworks

Teachers' Evaluation Clériaux Emilie **Date** **26.03.2024**

Number of course Teachers **1**

Number of responding Teachers: **1**

Number of participants in the course: **8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0	0.00	75.00	0.00	
	75.00					

Item N°2 : Are transversal skills assessed?

Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**
Average	0	0.00	0.00	0.00	0.00	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

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Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0	0	75.00	0.00	
	75.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
The progress of a project with study phases, interactions between designers, work management on the works part as well / Design office

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.3 Module 3: Hydraulic structures design

Hydraulic structures design

Teachers' Evaluation	Moulin Loic	**Date**	**28.03.2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**
Average	0	0	0.00	75.00	0.00	
	75.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	100.00	0.00	0.00	0.00
Average	0	0.00	50.00	0.00	0.00	
	50.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Design of hydraulic structures creating a continuous network for the flow to the water outlet & Reflection on the route and project management to integrate rainwater management in interface with the territories

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.4 Module 4: Rolling Stock Maintenance

Rolling Stock Maintenance

Teachers' Evaluation Verdun Cyril **Date** **22.04.2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO

		XX

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0.00	0.00	75.00	0.00	
	75.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	100.00	0.00	0.00	0.00
Average	0	0	50.00	0.00	0.00	
	50.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Maintenance / Exploitation, Maintenance / Design, Predictive maintenance and Artificial Intelligence

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.5 Module 5: Digital Twin

Digital Twin

Teachers' Evaluation Landes Bruno **Date** **22.05.2024**

Number of course Teachers **1**
Number of responding Teachers: **1**
Number of participants in the course: **8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0.00	0.00	0.00	100.00	
	100.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**
Average	0	0	0	0.00	0.00	
	0.00					

Item N°9 : Have those activities been communicated to the learners?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.6 Module 6 : Multimodal exchange pole

Multimodal exchange pole

Teachers' Evaluation Mraieh Florence **Date** **26.06.2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO

	XX	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**	**0.00**
Average	0	0.00	50.00	0.00	0.00	
	50.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
The course gives students the keys to understanding the games of actors, tools to identify the issues and warning points of transport projects from the upstream phases on the design of the exchange hubs, students learn the useful methodology to carry out a feasibility study

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.7 Module 7: Track Design

Track Design

Teachers' Evaluation Laurans Emmanuel **Date** **1/18/2024**

Number of course Teachers **1**
Number of responding Teachers: **1**
Number of participants in the course: **8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**	**0.00**
Average	0	0	50.00	0.00	0.00	
	50.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO

Item N°3 : Are digital skills explicitly taught?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100.00
Average	0	0.00	0.00	0.00	0.00	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Due to my personal experience, I naturally teach them work related activities directly inspired by my experience, mainly in track design, track maintenance and asset management of infrastructures. This vision is technically by some aspects, but I often try to bring them the system vision and how the track is part of a bigger subsystem (infrastructure) and itself part of a bigger system

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

III.1.2.8 Module 8: Rail Project Management (rail Infrastructures conception)

Rail Project Management (rail Infrastructures conception)

Teachers' Evaluation Bouthros Pierre-Jean **Date** **2/6/2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**
Average	0	0	0.00	75.00	0.00	
	75.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	XX	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**100.00**	**0.00**	**0.00**	**0.00**	**0.00**
Average	0	25.00	0.00	0.00	0.00	
	25.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0	0.00	75.00	0.00	
	75.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100.00
Average	0	0	0	0.00	0.00	
	0.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders						
Average	0	0	0	0	0	
	0.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders						
Average	0	0	0	0	0	
	0.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders						
Average	0	0	0	0	0	
	0.00					

III.1.2.9 Module 9: Delay Analysis

Delay Analysis

Teachers' Evaluation Nottin Carine **Date** **8/7/2024**

Number of course Teachers **1**
Number of responding Teachers: **1**
Number of participants in the course: **23**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0.00	0.00	75.00	0.00	
	75.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.10 Module 10: Risk Management (Crisis management)

Risk Management (Crisis management)

Teachers' Evaluation Torres Clement **Date** **6/27/2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**16**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO

	XX	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**
Average	0	0.00	0.00	0.00	0.00	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Even if the students are not necessarly part of a risk management or crisis cell, they might be involved as expert to deal with risk mitigation plan review and / or crisis cell. During the design phase they may be involved to prepare risk assessment for investment, and for operation to manage crisis

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

III.1.2.11 Module 11: Energy and catenaries and electric traction

Energy and catenaries and electric traction

Teachers' Evaluation	Mingassou Philippe	**Date**	**19.01.2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**
Average	0	0	0.00	0.00	0.00	
	0.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**
Average	0	0.00	0.00	0.00	0.00	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
From personal experience of the teacher, focus on overall dimensioning and construction activities of electric traction equipment

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

III.1.2.12 Module 12: Organisation and issues of urban railway tranport projects

Organisation and issues of urban railway tranport projects

Teachers' Evaluation Maperon **Date** **3/6/2024**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**8**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO

	XX	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100.00
Average	0	0.00	0.00	0.00	0.00	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Co-funded by the
Erasmus+ Programme
of the European Union

Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	0.00	0.00	0.00	0.00	0.00	100.00
Average	0	0	0	0.00	0.00	
	0.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.2.13 Module 13: Maintenance of drainage for railway infrastructure

Maintenance of drainage for railway infrastructure

Teachers' Evaluation	hidalgo Contreras Nick	**Date**	29.03.2024

Number of course Teachers	1
Number of responding Teachers:	1
Number of participants in the course:	8

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00

Average	0	0	0.00	0.00	100.00	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100.00
Average	0	0.00	0.00	0.00	0.00	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100.00
Average	0	0	0	0	0	

Co-funded by the
Erasmus+ Programme
of the European Union

	0.00

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0.00	0.00	100.00	

	100.00

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0.00	100.00	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Project management Global vision of a transportation network and their impact in hydraulics, earthworks and drainage Interaction with other domains of public services (Law on waterà Awareness of rainfall and their impact on railway…

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.1.3 In Company Supervisor's evaluation

Number of course Supervisors	7
Number of responding Supervisors:	7
Number of students supervised:	8

Your experience with our Institution

Item N°1 : Are you satisfied with acquired knowledge on railway topics by the learner/trainee?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	14.29	71.43	14.29
Average	0.00	0.00	0.00	10.71	71.43	
	82.14					

Item N°2 : Are you satisfied with acquired skills* by the learner/trainee?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**28.57**	**71.43**	**0.00**
Average	0.00	0.00	0.00	21.43	71.43	
	92.86					

Item N°3 : Has the support provided by the training institution team met your needs as a supervisor?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	**0.00**	**0.00**	**14.29**	**85.71**	**0.00**
Average	0.00	0.00	0.00	10.71	85.71	

	96.43

Item N°4 : Did the training programme, your learner completed, prepare them for their current responsibilities in your organisation?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**14.29**	**85.71**	**0.00**
Average	0.00	0.00	0.00	10.71	85.71	
	96.43					

Item N°5 : Has your learner's performance improved due to the programme?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**28.57**	**71.43**	**0.00**
Average	0.00	0.00	0.00	21.43	71.43	
	92.86					

Item N°6 : As a contribution to the continuous improvement of the training programme, what would you consider skills to be developed to meet the current needs of the job? in the course?
management of works in an operated network, railway technology
Continuous improvement integrating complexity and how to solve it "project management"

The training program meets the current needs
CSR (Carbon footprint, reuse.)
intellectual agility and decision-making independence
Entrepreneur mindset
complete training - environmental aspects can be expanded (carbon footprint)

Item N°7 : In your opinion, are there any specific topics that should be introduced in the course? If so, which ones?
management of works in an operated network, railway technology and industrial regeneration
complete training - environmental aspects can be expanded (carbon footprint)

Recommendation

Item N°8 : Would you recommend this course to others?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**14.29**	**28.57**	**57.14**
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.43	25.71	57.14
	94.29										

III.1.4 Organiser's Evaluation

Item N°1 : INumber of participants in the course.
8

Item N°2 : Number of participants having successfully completed the course.
To be confirmed (the different modules have been validated, and the thesis defenses are scheduled for early October 2024).

Item N°3: Does your institution actively apply internal quality assurance systems?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0,00	0,00	0,00	0,00	100,00	
	100,00					

Item N°4: Is the implemented pilot programme accredited?				
Grade	NO	In Process	YES	NA
			XX	

Item N°5 : Are students able to select specific modules or focus areas to customise their course content according to their preferences and perceived requirements?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	**0,00**
Average	0,00	0,00	0,00	0,00	100,00	
	100,00					

Item N°6: Does the information provided to students about the programme contain data on employment and career opportunities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	**0,00**
Average	0,00	0,00	0,00	0,00	100,00	
	100,00					

Item N°7: Do students have the opportunity to visit local employers?		
Grade	YES	NO
	XX	

Item N°8: Do students have the opportunity to travel and visit foreign employers?			
Grade	YES	NO	NA

			XX

Item N°9: Do students have the opportunity for virtual visits of foreign employers?			
Grade	YES	NO	NA
			XX

Item N°10: Are students regularly provided with information about available employment opportunities, such as through annual job fairs or similar activities?			
Grade	YES	NO	NA
			XX

Item N°11: Are there any online resources related to employability available for students?				
Grade	YES		NO	NA
	XX			
List of ressources	Data base	Intranet	Others	CESI Apprenticeship Training Center facilitates direct connections between applicants and companies.
	Website	Social channel		

Item N°12: Does the educational staff know who actually employs their graduates?			
Grade	YES	NO	NA
	XX		

Item N°13: Are professional career possibilities and profiles available to students?			
Grade	YES	NO	NA
	XX		

Item N°14: Is there explicit guidance within the programme to encourage students to connect with the office responsible of careers services?			
Grade	YES	NO	NA
	XX		

Item N°15: Does the information provided about the programme contain data on employment and career opportunities?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	0,00	100,00
Average	0,00	0,00	0,00	0,00	0,00	
	0,00					

Item N°16: Are there any admission tests or assessment that could be usefully shared with employers in case of placement?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0,00	0,00	0,00	0,00	100,00	
	100,00					

Item N°17: Are students explicitly instructed in management skills?			
Grade	YES	NO	NA
	XX		

Item N°18: Do employers review your programme and provide feedback on its content?			
Grade	YES	NO	NA

	XX		

Item N°19: Do you know strengths and weaknesses of your graduates as perceived by employers?			
Grade	YES	NO	NA
	XX		

Item N°20: Do you review and update your programme based on employer feedback regularly?			
Grade	YES	NO	NA
	XX		

Item N°21: Do you use any other mechanisms to review and update your programme based on railway sector innovation and railway labour market training needs?			
Grade	YES	NO	NA
	XX		

Item N°22: Do you have active communication with major employers of your students?			
Grade	YES	NO	NA

	XX		

Item N°23: Do employers visit your institution and present their employment opportunities?			
Grade	YES	NO	NA
	XX		

Item N°24: Do employers attend student project presentations?			
Grade	YES	NO	NA
	XX		

Item N°25: Are foreign employment placements possible and encouraged for students?			
Grade	YES	NO	NA
	XX		

Item N°26 :What strategies have been employed to enhance access to the programme?
Communication and marketing strategies are implemented by specific departments within CESI.

Item N°27: Are foreign employment placements possible and encouraged for students?			
Grade	YES	NO	NA
	XX		

III.2 CTU - Transportation Systems and Technology

III.2.1 Students' evaluation

CTU - "Transport systems and technologies" course

Student's Evaluation **Date** Sep 2024

Number of students taking the course	9
Number of responding Students:	9

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	15.00	80.00	5.00	0.00
Average	0	0	7.5	60	5	
	72.50					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	0.00	0.00	5.00	35.00	60.00	0.00
Average	0	0	2.5	26.25	60	
	88.75					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	30.00	70.00	0.00
Average	0	0	0	22.5	70	
	92.50					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	10.00	35.00	55.00	0.00
Average	0	0	5	26.25	55	
	86.25					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	0.00	0.00	5.00	25.00	70.00	0.00
Average	0	0	2.5	18.75	70	
	91.25					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	5.00	25.00	70.00	0.00
Average	0	0	2.5	18.75	70	
	91.25					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	25.00	75.00	0.00
Average	0	0	0	18.75	75	
	93.75					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**15.00**	**85.00**	**0.00**
Average	0	0	0	11.25	85	
	96.25					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**5.00**	**10.00**	**85.00**	**0.00**
Average	0	0	2.5	7.5	85	
	95.00					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**5.00**	**15.00**	**80.00**	**0.00**
Average	0	0	2.5	11.25	80	
	93.75					

Item N°12 : What was the most valuable aspect of the course?

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**5.00**	**10.00**	**85.00**	**0.00**
Average	0	0	2.5	7.5	85	
	95.00					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**10.00**	**10.00**	**80.00**	**0.00**

Average	0	0	5	7.5	80	
	92.50					

III.2.2 Teachers' evaluation

CTU - "Transport systems and technologies" course

Teachers' Evaluation **Date** Sep 2024

Number of course Teachers	1
Number of responding Teachers:	1
Number of participants in the course:	9

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	50.00	0.00	0.00	50.00	0.00
Average	0	12.5	0	0	50	
	62.50					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	XX	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	75.00	25.00	0.00
Average	0	0	0	56.25	25	
	81.25					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	50.00	50.00	0.00	0.00	0.00
Average	0	12.5	25	0	0	
	37.50					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**60.00**	**40.00**	**0.00**
Average	0	0	0	45	40	
	85.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**	**0.00**
Average	0	0	25	37.5	0	
	62.50					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**	**0.00**
Average	0	0	25	37.5	0	
	62.50					

Item N°9 : Have those activities been communicated to the learners?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	10.00	90.00	0.00
Average	0	0	0	7.5	90	
	97.50					

Item N°10 : Optional: please specify which are the work-related activities within the course?
-

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	10.00	90.00	0.00
Average	0	0	0	7.5	90	
	97.50					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0	0.00
Average	0	0	0	75	0	
	75.00					

III.3 ESTACA - Transport engineering / System design

III.3.1 Students' evaluation

ESTACA - "Railway Engineering-Cybersecurity and the Internet of Things (IoT) module" course (4 ECTS)

Student's Evaluation **Date** **Mar-24**

Number of students taking the course **25**

Number of responding Students: **10**

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**20,00**	**20,00**	**40,00**	**20,00**	0
Average	0	5	10	30	20	
	65,00					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

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% of the responders	**0,00**	**0,00**	**0,00**	**50,00**	**50,00**	0
Average	0	0	0	37,5	50	
	87,50					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**0,00**	**60,00**	**40,00**	0
Average	0	0	0	45	40	
	85,00					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**20,00**	**30,00**	**50,00**	0
Average	0	0	10	22,5	50	
	82,50					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	30,00	30,00	40,00	0
Average	0	0	15	22,5	40	
	77,50					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	0,00	40,00	60,00	0
Average	0	0	0	30	60	
	90,00					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0,00	0,00	10,00	30,00	60,00	0
Average	0	0	5	22,5	60	
	87,50					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**10,00**	**60,00**	**30,00**	0
Average	0	0	5	45	30	
	80,00					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
If it is possible to give more examples of computer attacks
More practice on cybersecurity
Common Cyber-Attacks in the IoT
The damage that web attacks can cause
Solutions for protection against attacks
IoT in Raily system
Different examples on IoT
Practical work more oriented towards railways
Projects in the Railways field
Smart City, IoT and Railways

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**10,00**	**20,00**	**30,00**	**40,00**	0
Average	0	2,5	10	22,5	40	
	75,00					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**30,00**	**20,00**	**40,00**	0
Average	0	0	15	15	40	
	70,00					

Item N°12 : What was the most valuable aspect of the course?
Practical work on cybersecurity
Current topics covered in the course
The definition and simplicity of treatment of the subjects
Working conditions
The IoT part is well covered especially on the technical aspect
The element part of a system with IoT

IoT aspects and the railway sector
Perspectives and conclusions

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**30,00**	**20,00**	**30,00**	**20,00**	0
Average	0	7,5	10	22,5	20	
	60,00					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0,00**	**0,00**	**20,00**	**30,00**	**50,00**	0
Average	0	0	10	22,5	50	
	82,50					

III.3.2 Teachers' evaluation

ESTACA - "Railway Engineering Cybersecurity and the Internet of Things (IoT) module" course (4 ECTS)

Teachers' Evaluation | **Date** | **Mar-23**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**25**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	**0,00**
Average	0	0	0	0	100	
	100,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	**0,00**
Average	0	0	0	0	100	
	100,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0,00**	**0,00**	**100,00**	**0,00**	**0,00**	**0,00**
Average	0	0	50	0	0	
	50,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0,00**	**0,00**	**0,00**	**100,00**	**0,00**	**0,00**
Average	0	0	0	75	0	
	75,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	100,00	0,00	0,00	0,00
Average	0	0	50	0	0	
	50,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0	0	0	100	
	100,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0	0	0	100	
	100,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	100,00	0,00	0,00
Average	0	0	0	75	0	
	75,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
-
ESTACA students are engineers in the automotive, aviation and railway fields. This course allowed students to understand the direct link between the aspects of the course and the challenges of cybersecurity and IoT in the industrial field. The applications presented in the course in the form of practical work gave a world of work dimension

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0,00**	**0,00**	**0,00**	**0,00**	**100,00**	**0,00**
Average	0	0	0	0	100	
	100,00					

III.4 SGH - Postgraduate course in "Ogranistation of extra-urban public transport"

III.4.1 Students' evaluation

SGH - Extra-Urban Public Transport Management (30 ECTS)

Student's Evaluation **Date**

Number of students taking the course	**30**
Number of responding Students:	**21**

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**10.53**	**0.00**	**26.32**	**21.05**	**42.11**	**0.00**
Average	0	0	13.16	15.79	42.11	
	71.05					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**10.53**	**0.00**	**0.00**	**31.58**	**57.89**	**0.00**

Average	0	0	0	23.68	57.89	
	81.58					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**10.53**	**10.53**	**26.32**	**31.58**	**21.05**	**0.00**
Average	0	2.63	13.16	23.68	21.05	
	60.53					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**15.79**	**5.26**	**10.53**	**31.58**	**36.84**	**0.00**
Average	0	1.32	5.26	23.68	36.84	
	67.11					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**10.53**	**10.53**	**15.79**	**42.11**	**21.05**	**0.00**

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Erasmus+ Programme
of the European Union

Average	0	2.63	7.89	31.58	21.05	
	63.16					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**5.26**	**10.53**	**26.32**	**31.58**	**26.32**	**0.00**
Average	0	2.63	13.16	23.68	26.32	
	65.79					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**5.26**	**10.53**	**10.53**	**31.58**	**42.11**	**0.00**
Average	0	2.63	5.26	23.68	42.11	
	73.68					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	5.26	5.26	5.26	42.11	42.11	0.00
Average	0	1.32	2.63	31.58	42.11	
	77.63					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders						
Average	0	0	0	0	0	
	0.00					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**15.79**	**10.53**	**5.26**	**10.53**	**57.89**	**0.00**
Average	0	2.63	2.63	7.89	57.89	
	71.05					

Item N°12 : What was the most valuable aspect of the course?

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**9.52**	**28.57**	**61.90**	**0.00**
Average	0	0.00	4.76	21.43	61.90	
	88.10					

III.4.2 Teachers' evaluation

SGH - Extra-Urban Public Transport Management (30 ECTS)

Teachers' Evaluation **Date**

Number of course Teachers	**6**
Number of responding Teachers:	**6**
Number of participants in the course:	**30**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	XX	

Item N°3 : Are digital skills explicitly taught?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	33.33	16.67	16.67	33.33
Average	0	0	16.67	12.5	16.67	
	45.83					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	50.00	0.00	16.67	0.00	0.00	33.33
Average	0	0	8.34	0	0	
	8.34					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	83.33	16.67
Average	0	0	0	0	83.33	
	83.33					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**16.67**	**0.00**	**83.33**	**0.00**
Average	0	0	8.335	0	83.33	
	91.67					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°9 : Have those activities been communicated to the learners?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Network planning

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00

Average	0	0	0	0	100	
	100.00					

III.4.3 Organiser's evaluation

Public Transport Management

Teachers' Evaluation **Date** **02.08.2024**

Number of course Teachers	6
Number of responding Teachers:	6
Number of participants in the course:	30

Item N°1 : INumber of participants in the course.
30

Item N°2 : Number of participants having successfully completed the course.
0 (only 1 semester completed)

Item N°3: Does your institution actively apply internal quality assurance systems?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	100.00	0.00	0.00	0.00	0.00
Average	0	25	0	0	0	

	25.00

Item N°4: Is the implemented pilot programme accredited?				
Grade	NO	In Process	YES	NA

Item N°5 : Are students able to select specific modules or focus areas to customise their course content according to their preferences and perceived requirements?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**	**0.00**
Average	0	0	50	0	0	
	50.00					

Item N°6: Does the information provided to students about the programme contain data on employment and career opportunities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**100.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Average	0	0	0	0	0	
	0.00					

Item N°7: Do students have the opportunity to visit local employers?		
Grade	YES	NO
		XX

Item N°8: Do students have the opportunity to travel and visit foreign employers?			
Grade	YES	NO	NA
		XX	

Item N°9: Do students have the opportunity for virtual visits of foreign employers?			
Grade	YES	NO	NA
		XX	

Item N°10: Are students regularly provided with information about available employment opportunities, such as through annual job fairs or similar activities?			
Grade	YES	NO	NA

		XX	

Item N°11: Are there any online resources related to employability available for students?				
Grade	YES		NO	NA
			XX	
List of ressources	Data base	Intranet	Others	
	Website	Social channel		

Item N°12: Does the educational staff know who actually employs their graduates?			
Grade	YES	NO	NA
		XX	

Item N°13: Are professional career possibilities and profiles available to students?			
Grade	YES	NO	NA
		XX	

Item N°14: Is there explicit guidance within the programme to encourage students to connect with the office responsible of careers services?			
Grade	YES	NO	NA
		XX	

Item N°15: Does the information provided about the programme contain data on employment and career opportunities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°16: Are there any admission tests or assessment that could be usefully shared with employers in case of placement?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**100.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Average	0	0	0	0	0	
	0.00					

Item N°17: Are students explicitly instructed in management skills?

Grade	YES	NO	NA
	XX		

Item N°18: Do employers review your programme and provide feedback on its content?			
Grade	YES	NO	NA
	XX		

Item N°19: Do you know strengths and weaknesses of your graduates as perceived by employers?			
Grade	YES	NO	NA
	XX		

Item N°20: Do you review and update your programme based on employer feedback regularly?			
Grade	YES	NO	NA
	XX		

Item N°21: Do you use any other mechanisms to review and update your programme based on railway sector innovation and railway labour market training needs?			
Grade	YES	NO	NA
	XX		

Item N°22: Do you have active communication with major employers of your students?			
Grade	YES	NO	NA
	XX		

Item N°23: Do employers visit your institution and present their employment opportunities?			
Grade	YES	NO	NA
		XX	

Item N°24: Do employers attend student project presentations?			
Grade	YES	NO	NA
		XX	

Item N°25: Are foreign employment placements possible and encouraged for students?			
Grade	YES	NO	NA
		XX	

Item N°26 :What strategies have been employed to enhance access to the programme?
Social media information, Polish Local Authorities Associations’ media

Item N°27: Are foreign employment placements possible and encouraged for students?			
Grade	YES	NO	NA
	XX		

III.5 UNIGE - Master of Science in "Safety engineering for transport, logistics and production" - "Rail Transport" module – course on "Sustainable Powertrains and Green Mobility in Rail Transport"

III.5.1 Students' evaluation

Rail Transport (5 ECTS)

Specific course: Sustainable powertrain and green mobility in rail transport

Student's Evaluation **Date**

Number of students taking the course	**17**
Number of responding Students:	**12**

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**41.67**	**33.33**	**25.00**	**0.00**
Average	0	0	20.83	25	25	
	70.83					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**33.33**	**66.67**	**0.00**
Average	0.00	0.00	0.00	25.00	66.67	
	91.67					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**33.33**	**66.67**	**0.00**
Average	0.00	0.00	0.00	25.00	66.67	
	91.67					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**25.00**	**33.33**	**33.33**	8.33
Average	0.00	0.00	12.50	25.00	33.33	
	70.83					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	16.67	8.33	66.67	8.33
Average	0.00	0.00	8.33	6.25	66.67	
	81.25					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	8.33	25.00	66.67	0.00
Average	0.00	0.00	4.17	18.75	66.67	
	89.58					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	16.67	25.00	58.33	0.00
Average	0.00	0.00	8.33	18.75	58.33	
	85.42					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	8.33	0.00	33.33	58.33	0.00
Average	0.00	2.08	0.00	25.00	58.33	
	85.42					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
There could be more details about green rail infrastructure and energy reusable for trains through braking.
Rail transport systems
Maybe the numerical part (data) could be a little reduced
Since I couldn’t attend the lessons, it would be interesting to provide additional video-lessons so that, even working student like me them can get them.
Numerical examples

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**25.00**	**25.00**	**8.33**	**41.67**	**0.00**
Average	0	6.25	12.5	6.25	41.67	
	66.67					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**8.33**	**8.33**	**25.00**	**50.00**	8.33
Average	0.00	2.08	4.17	18.75	50.00	
	75.00					

Item N°12 : What was the most valuable aspect of the course?
The purpose toward more green transportation plus re usage of consumed energy.
I liked it when we watched pictures and videos to see illustrations of the theory that we learned about

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**8.33**	**0.00**	**41.67**	**41.67**	8.33
Average	0.00	2.08	0.00	31.25	41.67	

	75.00

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0.00**	**0.00**	**8.33**	**0.00**	**0**	**0.00**	**8.33**	**8.33**	**25**	**16.67**	**33.33**
Average	0	0	1.67	0.00	0.00	0.00	5.00	5.83	20.00	15.00	33.33
	80.83										

Co-funded by the
Erasmus+ Programme
of the European Union

III.5.2 Teachers' evaluation

Sustainable powertrain and green mobility in rail transport

Rail Transport (5 ECTS)

Specific course: Sustainable powertrain and green mobility in rail transport

Teachers' Evaluation **Date** **4/12/2023**

Number of course Teachers	**1**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**
Average	0	0	0	0	0	
	0.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°9 : Have those activities been communicated to the learners?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	0.00	100
Average	0	0	0	0	0	
	0.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00

Average	0	0	0	0	100	
	100.00					

III.6 UNIGE - Master of Science in "Safety engineering for transport, logistics and production" - "Sustainable Rail and Road Infrastructure" module - course on "Design and modelling of the track access charges system for the use of rail infrastructure"

III.6.1 Students' evaluation

Sustainable Rail and Road Infrastructure (6 ECTS)

Specific course: Track access charges system for the use of rail infrastructure

Student's Evaluation **Date**

Number of students taking the course	20
Number of responding Students:	20

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**15.00**	**45.00**	**40.00**	**0.00**
Average	0	0	7.5	33.75	40	
	81.25					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**5.00**	**10.00**	**25.00**	**60.00**	**0.00**
Average	0	1.25	5	18.75	60	
	85.00					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**5.00**	**10.00**	**40.00**	**45.00**	**0.00**
Average	0	1.25	5	30	45	
	81.25					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**20.00**	**15.00**	**65.00**	**0.00**
Average	0	0	10	11.25	65	
	86.25					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**25.00**	**15.00**	**60.00**	**0.00**
Average	0	0	12.5	11.25	60	
	83.75					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**20.00**	**25.00**	**55.00**	**0.00**
Average	0	0	10	18.75	55	
	83.75					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**5.00**	**5.00**	**10.00**	**45.00**	**35.00**	**0.00**
Average	0	1.25	5	33.75	35	
	75.00					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**5.00**	**15.00**	**20.00**	**60.00**	**0.00**
Average	0	1.25	7.5	15	60	
	83.75					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?

The course was more toward rules and regulations of EU about railway mechanism if professor had included more technical topics like optimizing schedules, and trains capacity, blocking system it would be better.
The material was very focused on a specific topic and it could cover much more rather than just one topic. Since it got hard to understand the goal of the topic and the relevance to other topics of the course. Also the course timetable was very close to the exam dates which is not fair specially when the professors specify that the first one is the easiest and they recommend everyone to take the first call.
The amount of content is very large and this can have a negative effect on learning.
An higher coordination with other courses, especially for the railway part, because some concepts are repeated.
For about the Safety Training for Managers and Employers: Safety Protocols: Develop comprehensive modules on safety standards and emergency response. Leadership in Safety: Train managers on fostering a safety-first culture. Regulatory Compliance: Update curriculum with current safety regulations. Risk Management: Provide in-depth training on risk assessment and mitigation strategies
I believe a read example would be a plus.
Yes, in my opinion, the large amount of material presented near the exam increases students' stress for the exam. I hope it would be understandable for you if instead of these resources being taught near the time of the exam, they were taught at an earlier time so that there was an opportunity to study.

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**10.00**	**35.00**	**15.00**	**40.00**	**0.00**
Average	0	2.5	17.5	11.25	40	
	71.25					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**5.00**	**20.00**	**25.00**	**50.00**	**0.00**
Average	0	1.25	10	18.75	50	
	80.00					

Item N°12 : What was the most valuable aspect of the course?
I appreciate a lot the fact of having different perspectives during this course, with the explanation of topic that I didn't know, expanding my knowledge about an important topic.
It was nice to have a Professor from another university come visit.
The numerous knowledge given in the rail and road transport sectors, that are fundamental for our degree and our future working career.
I was very interested in the rail part of the course.
That rail transportation is a huge engineering topic but still has a lot to go.
Issues related to solving congestion problems in the rail sector

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**10.00**	**0.00**	**45.00**	**45.00**	**0.00**
Average	0	2.5	0	33.75	45	
	81.25					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?											
Grade	0	1	2	3	4	5	6	7	8	9	10
% Equivalent	0	10	20	30	40	50	60	70	80	90	100
Number of responders	**0.00**	**0.00**	**5.00**	**5.00**	**0.00**	**5.00**	**15.00**	**25.00**	**10.00**	**10.00**	**20.00**
Average	0	0	1.00	1.50	0.00	2.50	9.00	17.50	8.00	9.00	20.00
	68.50										

III.6.2 Teachers' evaluation

Sustainable Rail and Road Infrastructure (6 ECTS)

Specific course: Track access charges system for the use of rail infrastructure

Teachers' Evaluation **Date**

Number of course Teachers 1
Number of responding Teachers: 1
Number of participants in the course: 20

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		XX

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	100.00	0.00	0.00	0.00	0.00

Average	0	25	0	0	0	
	25.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**
Average	0	0	0	0	0	
	0.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**

Average	0	0	0	0	100	
	100.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0	0	75	0	
	75.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders						
Average	0	0	0	0	0	
	0.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

III.7 UNIROMA1 - Master of Science in “Transport Systems Engineering” - “Railway Engineering” module

III.7.1 Students’ evaluation

UNIROMA1 - "Railway Engineering" course (12 ECTS)

Student's Evaluation **Date** Dec 2023

Number of students taking the course	31
Number of responding Students:	16

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	12.50	25.00	25.00	37.50	0.00
Average	0	3.125	12.5	18.75	37.5	
	71.88					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	43.75	56.25	0.00

Average	0	0	0	32.8125	56.25	
	89.06					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**
Average	0	0	0	37.5	50	
	87.50					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**37.50**	**50.00**	**0.00**
Average	0	0	6.25	28.125	50	
	84.38					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**6.25**	**43.75**	**50.00**	**0.00**

Average	0	0	3.125	32.8125	50	
	85.94					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**43.75**	**56.25**	**0.00**
Average	0	0	0	32.8125	56.25	
	89.06					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**31.25**	**68.75**	**0.00**
Average	0	0	0	23.4375	68.75	
	92.19					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	6.25	31.25	62.50	0.00
Average	0	0	3.125	23.4375	62.5	
	89.06					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
I would be better to be more practical and less theory.
Subway
I am honestly satisfied of this course. It is important to work on the skills in managing the line.
Everything was up to the mark
I think the visits should be in the beginning of the course to give the student perspective about the lessons
Mechanical and electrical parts were a bit challenging to understand for someone who hasn't got the background in this field.
In the exercise part
Considering more data of extreme weather conditions, how the potential cyber threats can be considered to ensure the safety
First of all, everything was excellent and method of teaching inside classroom as well as field visit were awesome. Appreciate and thank you so much.
A break between the two classes and a shorter lecture time would make it more effective.
I'm very satisfied of this course and the technical visits allow us to see with our eyes what we study.
Maybe individual assignments could be treated a little bit better, by giving them more time during the course (exercises in classroom instead of simply explaining them)
If the dynamic section in the course spends more time in the class and how to do the issues, I think it can help the student to learn better this section.

This course can be improved by increasing the visualization of concepts.
Great course
Project Work

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	12.50	25.00	62.50	0.00
Average	0	0	6.25	18.75	62.5	
	87.50					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	43.75	56.25	0.00
Average	0	0	0	32.8125	56.25	
	89.06					

Item N°12 : What was the most valuable aspect of the course?
Understanding new subjects about railways and trains, and the future of mobility can be invested on railways. Also, how important is to know about this course for a Transport Systems Engineers.
Collaboration with students and student's internship opportunity
Technical Visits, where we had the possibility to see with our eyes, what we have studied
It provided with lots of technical knowledge

being able to discuss about topics with professors
Valuable aspect was field trips. it helped us a lot to visualize.
Visits and class participation
The automation of metro C and its operation
Technical knowledge as well as practical experience
The technical visits and class activities
The challenge to develop individual projects by ourself.
The chance to visit stations and marshalling yards
I think, that we had some visits during the courses, which helped us to better know the different topics and have better relationships between the Practical and theoretical.
The number of visiting were perfect, because it was more than what I could guess. Also, the endeavour of professors for making concepts clear was awesome.
Field trips
both professors

<table>
<tr><th colspan="7">Item N°13 : Overall, how satisfied are you with the course you completed?</th></tr>
<tr><td>Grade</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td rowspan="2">NA</td></tr>
<tr><td>% Equivalent</td><td>0</td><td>25</td><td>50</td><td>75</td><td>100</td></tr>
<tr><td>% of the responders</td><td>0.00</td><td>0.00</td><td>6.25</td><td>18.75</td><td>75.00</td><td rowspan="2">0.00</td></tr>
<tr><td rowspan="2">Average</td><td>0</td><td>0</td><td>3.125</td><td>14.0625</td><td>75</td></tr>
<tr><td colspan="6">92.19</td></tr>
</table>

Recommendation

Item N°14 : Would you recommend this course to your friends and family?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	6.25	18.75	75.00	0.00
Average	0	0	3.125	14.0625	75	
	92.19					

III.7.2 Teachers' evaluation

UNIROMA1 - "Railway Engineering" course (12 ECTS)

Teachers' Evaluation **Date** **Dec 2023**

Number of course Teachers	**2**
Number of responding Teachers:	**2**
Number of participants in the course:	**31**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	50.00	0.00	0.00	50.00	0.00
Average	0	12.5	0	0	50	
	62.50					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	XX	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	50.00	0.00	50.00	0.00	0.00
Average	0	12.5	0	37.5	0	
	50.00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	50.00	50.00	0.00	0.00	0.00	0.00
Average	0	12.5	0	0	0	
	12.50					

Item N°5 : Does the course teach railway related professional skills?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	50.00	50.00	0.00
Average	0	0	0	37.5	50	
	87.50					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	50.00	0.00	50.00	0.00	0.00
Average	0	12.5	0	37.5	0	
	50.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**50.00**	**50.00**	**0.00**	**0.00**
Average	0	0	25	37.5	0	
	62.50					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Role play with students pretending to work in rail sector organisations (Railway Undertaking, Infrastructure Manager, Entity in Charge of Maintenance, manufacturer, National Safety Authority etc.), practice with design methods used in the initial stages of rail vehicle design, practice with teamwork and oral presentations to colleagues.
During the technical visits and some seminars in the classroom, the students enter in contact with people directly involved into the daily working activities (operation, maintenance, design, construction, etc.) that practically exemplify what they do and answer questions from students about their daily activity and the potential roles of Transport Systems Engineers in that. This is a good direct example to better focus their future potential placements.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**
Average	0	0	0	75	0	
	75.00					

III.8 UNIROMA1 - Master of Science in “Transport Systems Engineering” - “Public Transport Management” module

III.8.1 Students’ evaluation

UNIROMA1 - "Public Transport Management" course (6 ECTS)

Student's Evaluation **Date** **Aug 2024**

Number of students taking the course	**9**
Number of responding Students:	**8**

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	0.00
Average	0	0	0	0	100	
	100.00					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	25.00	75.00	0.00
Average	0	0	0	18.75	75	
	93.75					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	12.50	87.50	0.00
Average	0	0	0	9.375	87.5	
	96.88					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	12.50	87.50	0.00
Average	0	0	0	9.375	87.5	
	96.88					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	0.00
Average	0	0	0	9.375	87.5	
	96.88					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
Provide further information regarding regional and long-distance railway solutions, as well as new pilot projects and pioneering solutions (Coventry Ultra-light rail, Perugia Minimetro, Washington and Heathrow Personal rapid transit, Nevomo/Ironlev, moving walkway solutions)
More videos and animation during lectures
Elasticità della Domanda
For me everything is clear
I did not attend any Staffer activity :(
Probably, the project part should be aggregated to the course of Sustainable Transport Planning, especially in the SUMP part of that course: in this way, it is possible to understand better which way of transport is suitable for a given urban context, by considering the available data (passengers, directions of travel, costs, etc.)
Impeccable coursework and great tutors
having more practical lessons would be better

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**25.00**	**75.00**	0.00
Average	0	0	0	18.75	75	
	93.75					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**12.50**	**87.50**	0.00
Average	0	0	0	9.375	87.5	
	96.88					

Item N°12 : What was the most valuable aspect of the course?
The possibility of having a field trip visit gave the opportunity to obtain a supplementary insight view of how rail traffic is managed on large scale. Further field trips are recommended
Mechanical part
the interaction that was during the lesson
Knowledge which I will able to apply in my future job
I do not know
Kindness, availability and clearance of the professors
Rail traffic
Management part

Item N°13 : Overall, how satisfied are you with the course you completed?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	25.00	75.00	0.00
Average	0	0	0	18.75	75	
	93.75					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

III.8.2 Teachers' evaluation

UNIROMA1 - "Public Transport Management" course (6 ECTS)

Teachers' Evaluation **Date** **Aug 2024**

Number of course Teachers **1**

Number of responding Teachers: **1**

Number of participants in the course: **9**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**
Average	0	0	0	75	0	
	75.00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**100.00**	**0.00**	**0.00**	**0.00**
Average	0	0	50	0	0	
	50.00					

Item N°4 : Are digital skills separately assessed?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	100.00	0.00	0.00	0.00
Average	0	0	50	0	0	
	50.00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0	0	75	0	
	75.00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0	0	75	0	
	75.00					

Item N°7 : Are realistic simulations used to give experience of real work situations?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	100.00	0.00	0.00
Average	0	0	0	75	0	
	75.00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0.00	0.00	0.00	0.00	100.00	0.00
Average	0	0	0	0	100	
	100.00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Co-funded by the
Erasmus+ Programme
of the European Union

Role play on the design of a new Public Transport line choosing from several possible solutions (road and rail-based) from the point of view of different stakeholders. Technical visits.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**	**0.00**
Average	0	0	0	0	100	
	100.00					

III.9 UNIROMA1 - Post-Master course in “Railway Infrastructure and Systems Engineering”

III.9.1 Students’ evaluation

UNIROMA1 - Post-Master course in “Railway Infrastructure and Systems Engineering” (60 ECTS)

Student's Evaluation **Date** **Aug 2024**

Number of students taking the course	**17**
Number of responding Students:	**17**

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**11.76**	**17.65**	**35.29**	**35.29**	0.00
Average	0.00	2.94	8.82	26.47	35.29	
	73.53					

Item N°2 : Were the objectives of the course clear?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**11.76**	**29.41**	**58.82**	0.00
Average	0.00	0.00	5.88	22.06	58.82	
	86.76					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**11.76**	**23.53**	**64.71**	0.00
Average	0.00	0.00	5.88	17.65	64.71	
	88.24					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**11.76**	**58.82**	**29.41**	0.00
Average	0.00	0.00	5.88	44.12	29.41	
	79.41					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**17.65**	**41.18**	**41.18**	0.00
Average	0.00	0.00	8.82	30.88	41.18	
	80.88					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**29.41**	**29.41**	**41.18**	0.00
Average	0.00	0.00	14.71	22.06	41.18	
	77.94					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**11.76**	**88.24**	0.00
Average	0.00	0.00	0.00	8.82	88.24	
	97.06					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**11.76**	**23.53**	**64.71**	0.00
Average	0.00	0.00	5.88	17.65	64.71	
	88.24					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
Electrical and electronic devices, signalling
Improve teaching materials and provide handouts to study from
The part relating to fixed installations for electric traction
Collaboration with the corporate side
The course is very high quality but very compress also and after 8 hours of attending lessons, students' ability to focus and learn decreases significantly during the final hours.
There have been some problems about the internship (positioning, lack of communication from company's side etc.)
Project works
Have more time between lessons and exams
Computer engineering
Design of infrastructure and related civil works
Timing
Study material
Video lessons
Currently, lessons are structured by doing two modules at the same time and two exams in a row. One could teach one module at a time, with both morning and afternoon classes, take the

exam for this module and then start the next module. The way the master is currently structured, inevitably the preparation of one of the two exams suffers.
The guided tours were a very interesting part, I recommend focusing heavily on this aspect
The quality of video lessons. Also, the lessons' materials should be loaded on the repository before the lessons, not after

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**5.88**	**5.88**	**29.41**	**58.82**	0.00
Average	0.00	1.47	2.94	22.06	58.82	
	85.29					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**41.18**	**58.82**	0.00
Average	0.00	0.00	0.00	30.88	58.82	
	89.71					

Item N°12 : What was the most valuable aspect of the course?
Educational visits and discussions with industry experts
Each course was mixed by site visit.
The connection with companies and the systemic view on railway topic guaranteed by the course

Technical visits on site
We have achieved a detailed overall view about railway system
The Sapienza team
Educational visits
Professors
The content
The fact that the teachings are practical
The opportunity to rub shoulders with many professionals who have a great deal of experience in the field
The railway system vision
The railway passion from each who made lessons

Item N°13 : Overall, how satisfied are you with the course you completed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**5.88**	**41.18**	**52.94**	0.00
Average	0.00	0.00	2.94	30.88	52.94	
	86.76					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

% of the responders	**0.00**	**0.00**	**11.76**	**41.18**	**47.06**	0.00
Average	0.00	0.00	5.88	30.88	47.06	
	83.82					

III.9.2 Teachers' evaluation

III.9.2.1 Module 1: Principles of railway engineering

Teachers' Evaluation	**Date**	**Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO

	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°9 : Have those activities been communicated to the learners?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Through group works and technical visits.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

III.9.2.2 Module 2: Railway track and fixed installations

Teachers' Evaluation	**Date**	**Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA

% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Guided plant visits allow for work-related activities.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

III.9.2.3 Module 3: Traction systems and vehicle dynamics

Teachers' Evaluation	**Date**	**Sept 2024**
	Number of course Teachers	**Many**
	Number of responding Teachers:	**1**
	Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders		**100,00**				
Average	0	25	0	0	0	
	25,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		X

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	100,00					
Average	0	0	0	0	0	
	0,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
The railway professionals clearly related the theory to its practical application in the role within their companies.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders		**100,00**				
Average	0	25	0	0	0	
	25,00					

III.9.2.4 Module 4: Infrastructure design and construction

Teachers' Evaluation	Date	Sept 2024

Number of course Teachers	Many
Number of responding Teachers:	1
Number of participants in the course:	17

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		X

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

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Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
A simple railway alignment verifying and dimensioning is presented.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

III.9.2.5 Module 5: Railway traffic technology

Teachers' Evaluation **Date** **Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			**100,00**			
Average	0	0	50	0	0	
	50,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		X

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	100,00					
Average	0	0	0	0	0	
	0,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			**100,00**			
Average	0	0	50	0	0	
	50,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Technical visits are planned to understand the work real situations.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

III.9.2.6 Module 6: Management of railway safety

Teachers' Evaluation **Date** **Sept 2024**

Number of course Teachers Many
Number of responding Teachers: 1
Number of participants in the course: 17

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders			**100,00**			
Average	0	0	50	0	0	
	50,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			**100,00**			
Average	0	0	50	0	0	
	50,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

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Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Students carry out group work related to the normal activities of Safety Management System employees of an infrastructure manager or railway undertaking.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

III.9.2.7 Module 7: Passenger and freight terminals

Teachers' Evaluation **Date** **Sept 2024**

Number of course Teachers	Many
Number of responding Teachers:	1
Number of participants in the course:	17

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		X

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	100,00					
Average	0	0	0	0	0	
	0,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		

Average	0	0	0	75	0	
	75,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

III.9.2.8 Module 8: Freight transport and logistics

Teachers' Evaluation **Date** **Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders	100,00					
Average	0	0	0	0	0	
	0,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	100,00					
Average	0	0	0	0	0	
	0,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Some case studies.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

III.9.2.9 Module 9: Service planning and quality

Teachers' Evaluation		**Date**	**Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Some case studies.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

III.9.2.10 Module 10: Railway works planning and legislation

Teachers' Evaluation | **Date** | **Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	100,00					
Average	0	0	0	0	0	
	0,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?
Students are trained for professional activities in the railway transport sector both in terms of management of operations and the construction of infrastructures, with specific in-depth studies on the management of construction sites and works.

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

III.9.2.11 Module 11: Economic and Environmental impact assessment of railway projects

Teachers' Evaluation	**Date**	**Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				**100,00**		
Average	0	0	0	75	0	
	75,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
		X

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	100,00					
Average	0	0	0	0	0	
	0,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

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Number of responders					100,00	
Average	0	0	0	0	100	
	100,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders			100,00			
Average	0	0	50	0	0	
	50,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		

Average	0	0	0	75	0	
	75,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

III.9.2.12 Module 12: Economics and Soft skills

Teachers' Evaluation **Date** **Sept 2024**

Number of course Teachers	**Many**
Number of responding Teachers:	**1**
Number of participants in the course:	**17**

Item N°1 : Are transversal skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°2 : Are transversal skills assessed?		
Grade	YES	NO
	X	

Item N°3 : Are digital skills explicitly taught?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°4 : Are digital skills separately assessed?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°5 : Does the course teach railway related professional skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°6: Does the course prepare students for future professional roles within the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°7 : Are realistic simulations used to give experience of real work situations?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders		100,00				
Average	0	25	0	0	0	
	25,00					

Item N°8 : Are there in the course work-related learning activities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders				100,00		
Average	0	0	0	75	0	
	75,00					

Item N°9 : Have those activities been communicated to the learners?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					100,00	

Average	0	0	0	0	100	
	100,00					

Item N°10 : Optional: please specify which are the work-related activities within the course?

Item N°11 : Do you think that the course could result in an improvement in the students' performance in the railway sector?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

Item N°12 : Does the course actively support students in reflection and review of their accomplishments throughout the programme/module?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders					**100,00**	
Average	0	0	0	0	100	
	100,00					

III.9.3 Organiser's evaluation

UNIROMA1 - Post-Master course in "Railway Infrastructure and Systems Engineering" (60 ECTS)

Organisers' Evaluation **Date** **Aug 2024**

Number of participants in the course: **17**

Item N°1 : Number of participants in the course.
18

Item N°2 : Number of participants having successfully completed the course.
17

Item N°3: Does your institution actively apply internal quality assurance systems?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0	0	0	100	
	100,00					

Item N°4: Is the implemented pilot programme accredited?

Grade	NO	In Process	YES	NA
			X	

Item N°5 : Are students able to select specific modules or focus areas to customise their course content according to their preferences and perceived requirements?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders						X
Average	0	0	0	0	0	
	0,00					

Item N°6: Does the information provided to students about the programme contain data on employment and career opportunities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0	0	0	100	
	100,00					

Item N°7: Do students have the opportunity to visit local employers?		
Grade	YES	NO

	X	

Item N°8: Do students have the opportunity to travel and visit foreign employers?			
Grade	YES	NO	NA
	X		

Item N°9: Do students have the opportunity for virtual visits of foreign employers?			
Grade	YES	NO	NA
	X		

Item N°10: Are students regularly provided with information about available employment opportunities, such as through annual job fairs or similar activities?			
Grade	YES	NO	NA
			X

Item N°11: Are there any online resources related to employability available for students?				
Grade	YES		NO	NA
	X			
List of ressources	Data base	Intranet	Others	
	Website	Social channel		

Item N°12: Does the educational staff know who actually employs their graduates?			
Grade	YES	NO	NA
	X		

Item N°13: Are professional career possibilities and profiles available to students?			
Grade	YES	NO	NA
	X		

Item N°14: Is there explicit guidance within the programme to encourage students to connect with the office responsible of careers services?

Grade	YES	NO	NA
		X	

Item N°15: Does the information provided about the programme contain data on employment and career opportunities?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0	0	0	100	
	100,00					

Item N°16: Are there any admission tests or assessment that could be usefully shared with employers in case of placement?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
Number of responders	0,00	0,00	0,00	0,00	100,00	0,00
Average	0	0	0	0	100	
	100,00					

Item N°17: Are students explicitly instructed in management skills?

Grade	YES	NO	NA
	X		

Item N°18: Do employers review your programme and provide feedback on its content?			
Grade	YES	NO	NA
	X		

Item N°19: Do you know strengths and weaknesses of your graduates as perceived by employers?			
Grade	YES	NO	NA
	X		

Item N°20: Do you review and update your programme based on employer feedback regularly?			
Grade	YES	NO	NA
	X		

Item N°21: Do you use any other mechanisms to review and update your programme based on railway sector innovation and railway labour market training needs?			
Grade	YES	NO	NA
	X		

Item N°22: Do you have active communication with major employers of your students?			
Grade	YES	NO	NA
	X		

Item N°23: Do employers visit your institution and present their employment opportunities?			
Grade	YES	NO	NA
	X		

Item N°24: Do employers attend student project presentations?			
Grade	YES	NO	NA
	X		

Item N°25: Are foreign employment placements possible and encouraged for students?			
Grade	YES	NO	NA
	X		

Item N°26 :What strategies have been employed to enhance access to the programme?
Website, course LinkedIn page, sending of informative e-mails to recent graduates and other Italian universities, course presentation day, advertising by partner companies

Item N°27: Are teachers and trainers have been engaged in additional training?			
Grade	YES	NO	NA
		X	

III.10 STAFFER - Summer school on “The European Railway System”

III.10.1 Students’ evaluation

UNIROMA1 - Summer School on “The European Railway System”

Student's Evaluation **Date** **Aug 2024**

Number of students taking the course
Number of responding Students: **24**

Course Contents

Item N°1 : Was your existing knowledge sufficient to understand the topics covered in the course ?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**12.50**	**12.50**	**75.00**	0.00
Average	0	0	6.25	9.38	75	
	90.63					

Item N°2 : Were the objectives of the course clear?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	

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% of the responders	**0.00**	**4.17**	**4.17**	**29.17**	**62.50**	0.00
Average	0	1.04	2.08	21.88	62.50	
	87.50					

Item N°3 : Do you think the objectives of the course have been achieved?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**4.17**	**0.00**	**33.33**	**62.50**	0.00
Average	0	1.04	0	25	62.50	
	88.54					

Teaching and Study Material

Item N°4 : Do you think the lessons were sufficient for understanding the course topics?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**45.83**	**54.17**	0.00
Average	0	0	0	34.38	54.17	
	88.54					

Item N°5 : Do you think the teaching methods used made it easy to understand the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	8.33	41.67	50.00	0.00
Average	0	0	4.17	31.25	50.00	
	85.42					

Item N°6 : Do you think the study material was sufficient for understanding the course concepts?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	29.17	70.83	0.00
Average	0	0	0	21.88	70.83	
	92.71					

Professional Relevance

Item N°7 : Do you think this course will be beneficial for your job, professional aspirations or academic pursuits?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	4.17	12.50	25.00	58.33	0.00
Average	0	1.04	6.25	18.75	58.33	
	84.38					

Support Environment

Item N°8 : Was the information provided about the course clear and comprehensive?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**0.00**	**29.17**	**70.83**	0.00
Average	0	0	0	21.88	70.83	
	92.71					

Item N°9 : Could you please specify any areas where you believe improvements could be made to enhance the course?
better presentation of the visits and what we're going to do.
Mention in previous answers, more interactive approach to teaching.
I would wish to learn a bit more how the signalling and the atp in the host country works
Dividing group into smaller sections and forming specific assignments related to certain topics that are on the schedule that day, mixing people from different universities so more communication between the whole group is achieved
Career counselling and job market
Introducing companies and teaching how to find a job in the industry.
It was hot in the classroom so maybe next time doing the courses in classroom in the basement where it is maybe colder.
I really liked the selection of the field trips, and I can imagine that it is difficult to organize these. But for some field trips I had the feeling that the groups were too big. For the traffic control centres of RFI and Trenitalia for example, although it is fascinating what they are doing there, the only thing we saw were people sitting in front of computers. Because of their work, we students were more of a hinderance (it felt like) instead of an opportunity for the people working there to tell us firsthand

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what they are doing and why it is important. I know it's difficult to organize because companies have limited availability, but 30 pupils at once was too much from my point of view in the traffic control rooms. The maintenance facility of Trenitalia was amazing, because after splitting the group we were 10-12 students, we could listen to the explanations, ask questions about the rolling stock and facilities and we could understand everything.
I do not have any proposal to improve because it was already at a very high level
everything was good
It could be approved with more group type of studying or solving problems. (Same as we did when calculating energy usage at one presentation)
A fixed time schedule would be nice when booking flights but all in all it was very nice.
Define more exactly the target group and knowledge requirements.
Some of the professors did not speak the best English, which resulted in a lot of ähs. That also made it harder to follow at times.
Everything were fine, but I think the visits are more useful than presentation in the class, so maybe focusing on practical visit and classes may enhance the course.
A creative approach to learning, focuses on real-world skills, and encourages teamwork, making it a unique experience for students.
It could be better defined what the targeted group of students of the summer is. For students like me who already had many courses in railway engineering most of the topics were repetitions but with interesting possibilities for comparisons between the Italian and German railway systems.
Allocate more time to cover further details of topics discussed
Giving the opportunities to international students in railway sector after the completion (Like at least a month of internship to understand it better)
Preparations for the practical trips. For example, an operations centre was visited and the day before, it would have been possible to briefly explain what the centre’s role is, etc.
maybe more prof can participate the technical visit, it can be better
I think that all areas were sufficiently covered

Overall Evaluation

Item N°10 : Did this course assist you in improving your technical skills?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**8.33**	**33.33**	**29.17**	**29.17**	0.00
Average	0	2.08	16.67	21.88	29.17	
	69.79					

Item N°11 : Did the shared experiences contribute to the development of your knowledge?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	**0.00**	**0.00**	**4.17**	**29.17**	**66.67**	0.00
Average	0	0	2.08	21.88	66.67	
	90.63					

Item N°12 : What was the most valuable aspect of the course?
Visits to various facilities and companies.
Connecting with different People, exchange of ideas and knowledge.
The exchange of information and improving of my English
Visits to facilities, labs and construction sites.
Afragola bari high speed line field visit
practicality

We discover a part of the railway we didn't now, because in our formation we are more focusing on the technique of the railway signalling. Thanks to the staffer program, we discover the global view of organizing the railway, whereas we are more specialize in day-to-day field maintenance.
Stressing of the importance, that as a railway engineer the integrated way of thinking and problem solving is very important. For this one must know the intersection points with infrastructure, vehicles, operation, law and economics.
Definitely the aspect of how European legislation works and impacts railways in member states
visited many sites
Using the train driving simulator.
To see different between Germany and Italy regarding railway systems / laws …
Getting an inside view in the railway system of a different country.
The visit of the construction site of the tunnel in Naples was the most interesting for me. Although a short presentation about the process of construction would have been nice, similar to the video, that had been sent later.
Giving the vision of different aspects of railway engineering fields in the real world.
Focused on real-world skills
The contact with railway students from a lot of different countries. Making contacts and learning about the different study programmes. Also, the interesting technical visits that allowed to leave the perspective on railways from my own country!
Field visits, practical examples
The visits to understand how the Italian railway operates
The opportunity to gain a practical insight into railway operations.
technical visits were awesome we had real experience there
Visits to the technical centres

Item N°13 : Overall, how satisfied are you with the course you completed?

Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	8.33	25.00	66.67	0.00
Average	0	0	4.17	18.75	66.67	
	89.58					

Recommendation

Item N°14 : Would you recommend this course to your friends and family?						
Grade	1	2	3	4	5	NA
% Equivalent	0	25	50	75	100	
% of the responders	0.00	0.00	0.00	12.50	87.50	0.00
Average	0	0	0	9.375	87.5	
	96.88					

ANNEX IV COMMON TEACHING MATERIAL

IV.1 CESI - Post Master Degree Manager of construction projects option Urban Transport (Mastère Spécialisé® Management de Projets de Construction, Option Transports Ferroviaires, Urbains et Nouvelles Mobilités)

FORMATION CESI
Etude de cas
Création d'un pas d'IPCS

Cas : Création d'un pas d'IPCS :

- Travail à partir d'un schéma simplifié
- Plan de voie actuel pleine voie et plan de voie futur avec un IPCS
- Création des signaux / modifications des zones
- Modifications sur les postes encadrants

Les éléments attendus (livrables) :

Jour 1 : Le plan de management du projet

- Descriptions des acteurs du projet
- Planning général de l'opération (hors travaux)
- Les livrables à produire et à valider. Les données d'entrées nécessaires pour ces livrables.
- Descriptions des contraintes
- Gestion des risques
- Choix des solutions techniques. Justifiez ces choix.
- Découpage des marchés
- (Hors gestion des coûts)

Jour 2 : phasage de l'opération et constructibilité. Organisation du chantier.

- Phasage de construction
- Planning de construction yc compris planning minuté de certaines opérations
- Gestion des risques : sécurité ferroviaire, SST, sécurité projet
- Logistique du chantier : acteurs travaux, capacité, matériaux
- Focus sur la MeS et MeX

Les documents utiles pour produire ces livrables :

- Schéma simplifié
- Le dossier

LE DOSSIER

Il est composé d'un préambule et de quatre parties, complétés éventuellement d'annexes, portant sur les aspects suivants :

Préambule :
Pourquoi faire cette opération ? A quel(s) besoin(s) répond-elle ?
Pour répondre aux besoins grandissant du trafic entre Paris et Bordeaux et afin de maitriser la disponibilité de la ligne, celle-ci va être dotée de pas d'IPCS, faute d'itinéraire alternatif et du fait des nombreuses grandes gares à desservir.
Le 1er pas d'IPCS à créer est celui entre les postes techniques 21 et 22.

1. L'opération :
De quelle opération s'agit-il ? Quelles en sont les principales caractéristiques ?
Quelles sont les limites et interfaces de l'opération ?
L'opération consiste à créer un pas d'IPCS au pk 150. Il y a lieu de compléter la possibilité des changements de voie au poste 21 et 22. Ainsi, 4 cantons de 10km environ sont créés.
En sens normal, les trains continuent à rouler à 160km/h. En contre-sens, les trains roulent à 140km/h. Les aiguilles de changement de voie pourront être abordées à 120 km/h.

2. Objectifs et niveaux de performances associés :
Quelles offres de services ferroviaires sont visées ?
Quelles sont les fonctionnalités à assurer et pour quels niveaux de performances ?
En prenant en compte quelles sujétions ou contraintes.
Le débit train devra être de 4 trains voyageurs + 2 FRET par H et par sens, avec une disponibilité commerciale nominale qui prévoit une fenêtre de 4h max en journée d'interruption sur une voie.

3. Spécifications :
Quelles sont les spécifications de l'opération en matière de sécurité et de sureté, d'exploitation, de maintenance, d'environnement, de conception et de réalisation ?
Pas de dossier de de sécurité. (SNCF Réseau sait faire avec son propre agrément)
Problématique sûreté : sur les accès et ouvrages crées ou impactés par les travaux. (Sûreté physique des installations de SNCF Réseau).
Problématique de sécurité d'exploitation en phase travaux : quels sont les travaux qui peuvent être réalisés en ligne exploitée ?
Problématique environnementale :

- avec un cours d'eau + zone Natura 2000 pour la création du pont/route
- zone urbaine pour le PAI23. Bruit / Monument classé / Emprise au sol à acquérir

Maintenance : mise à jour des bases de données patrimoniales

4. Description sommaire des installations techniques :

Quelles sont les installations techniques actuelles et en référence ?

Caractéristique de la ligne:

La ligne de Paris à Bordeaux est à double voie, non banalisée, électrifiée et équipée en KVB. L'espacement des trains est assuré par le BAL.
La ligne est classée en groupe UIC 4.
La ligne est équipée de Radio sol Train.
La ligne n'est pas équipée de fibre optique.

Caractéristique des postes:

Les installations de sécurité du poste 21 sont commandées par le Poste I en 3x8h de type PRS en commande locale.
Les installations de sécurité du poste 22 sont commandées par le Poste I en 3x8h de type PAI en commande locale.
Energie électrique : Branchement au réseau ENEDIS

Quelles sont les installations techniques projetées ?

Caractéristique de la ligne :

Entre le poste 21 et 22, la ligne de Paris à Bordeaux sera en double voie, munie d'Installation Permanente de Contre Sens, électrifiée et équipée en KVB.
L'espacement des trains est assuré par le BAL en sens Normal, par BAPR en contre-sens.
La ligne sera tjs classée en groupe UIC 4.
Le rail est de type LRS.
La caténaire est de type 1500v.

Caractéristique des postes :

Les installations de sécurité du poste 21 sont commandées par le Poste I en 3x8h de type PRS en commande locale.
Les installations de sécurité du poste 22 sont commandées par le Poste I en 3x8h de type PAI en commande locale. L'exploitation du poste 23 se fera par une extension de l'IHM, accompagné d'un agrandissement du local des agents exploitation.
Les installations de sécurité du pas d'IPCS du pk 150 seront commandés par un PAI poste 23, lui-même télécommandé depuis le Poste 22. Il s'agira de construire un local technique en dur (environ 15mx4m) recevant les locaux techniques de la signalisation et des télécom ainsi qu'un local de maintenance pour les agents voie.
Lors de la création du poste 23, les zones actuelles UM71CB seront à remplacer par des ITE.

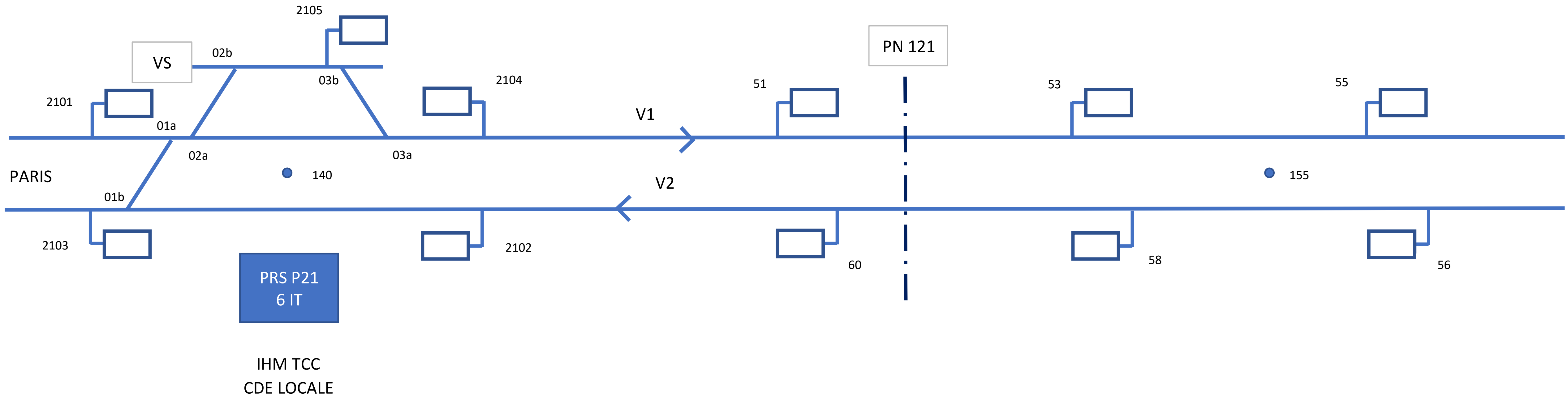
Caractéristique des travaux :

Les surfaces terrain nécessaire à la mise en œuvre des infrastructures seront à acheter en amont de ces dits travaux.
8 appareils de voie seront créés.
Des panneaux d'arrêt et d'annonce seront à implanter.
Les Téléphones des signaux d'arrêt du poste 23 seront à renvoyer à l'agent circulation du poste 22.
Les lignes d'orientations entre les postes 21 et 22 seront à mettre en œuvre.
Le piquetage caténaire est à reprendre, les communication V1/V2 seront électrifiées.
Ce tronçon de ligne sera équipé de GSMR.
Il est prévu que le plan fibre passe en amont de la mise en service de ce pas d'IPCS.

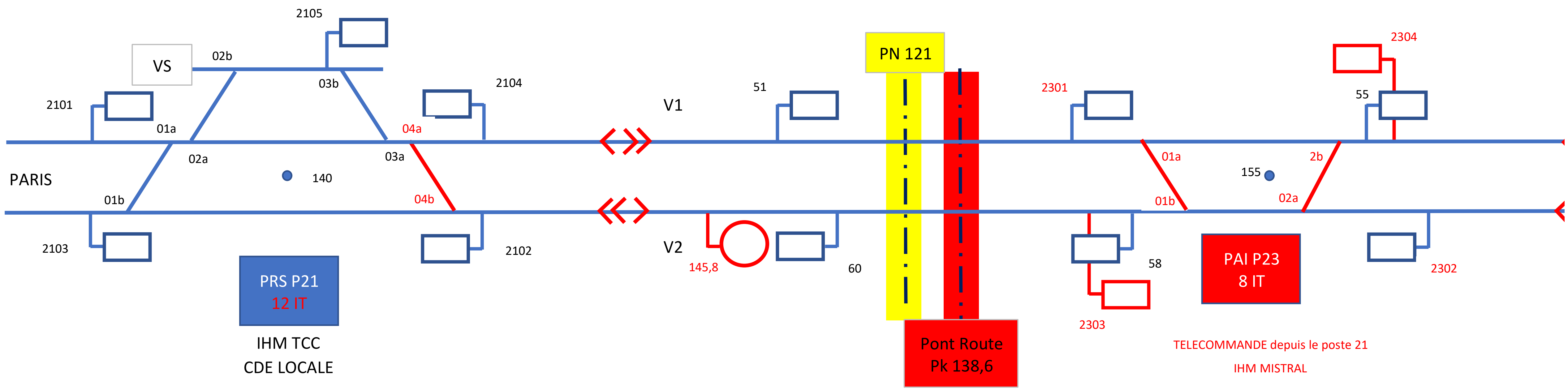
Au regard de l'augmentation de trafic, le PN 121 a un risque d'accidentologie supérieur à la norme. Aussi, il sera supprimé et un pont route (sans voie piétonne, ni cyclable) sera créé en itinéraire de remplacement.
Les sectionnements électriques liées à l'implantation des aiguilles sont à télécommander depuis le CSS de Bordeaux.
La télésurveillance du pas d'IPCS sera à renvoyer, comme pour les postes 21 et 22 au centre de télésurveillance à Bordeaux.

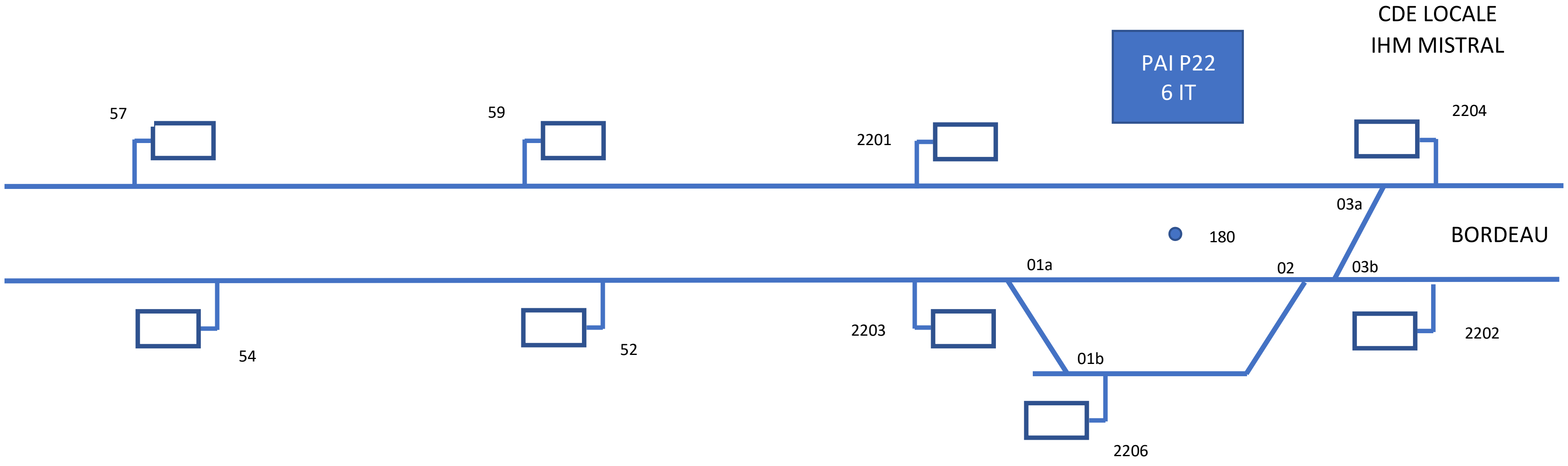
Création d'un pas d'IPCS

SITUATION ACTUELLE



SITUATION FUTURE

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IHM MISTRAL
PAI P22
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59
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180
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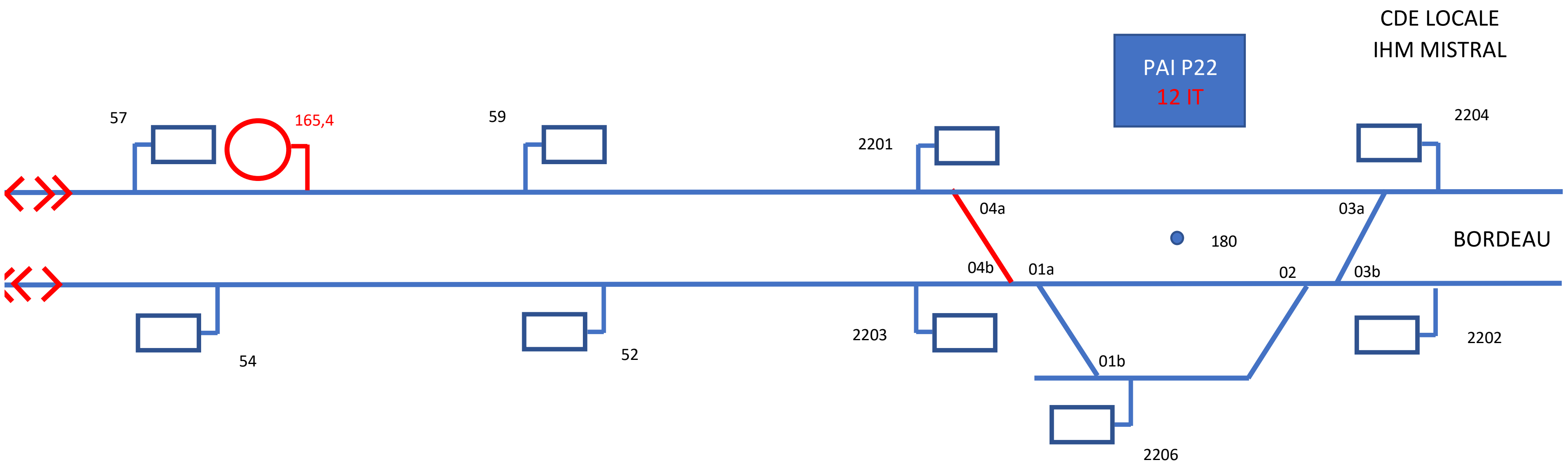
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180
BORDEAU
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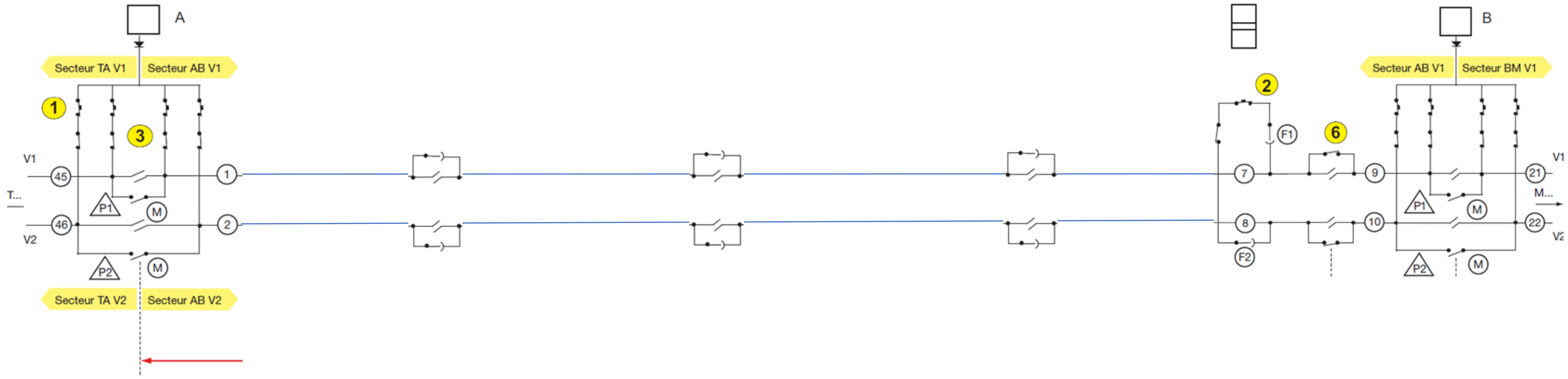
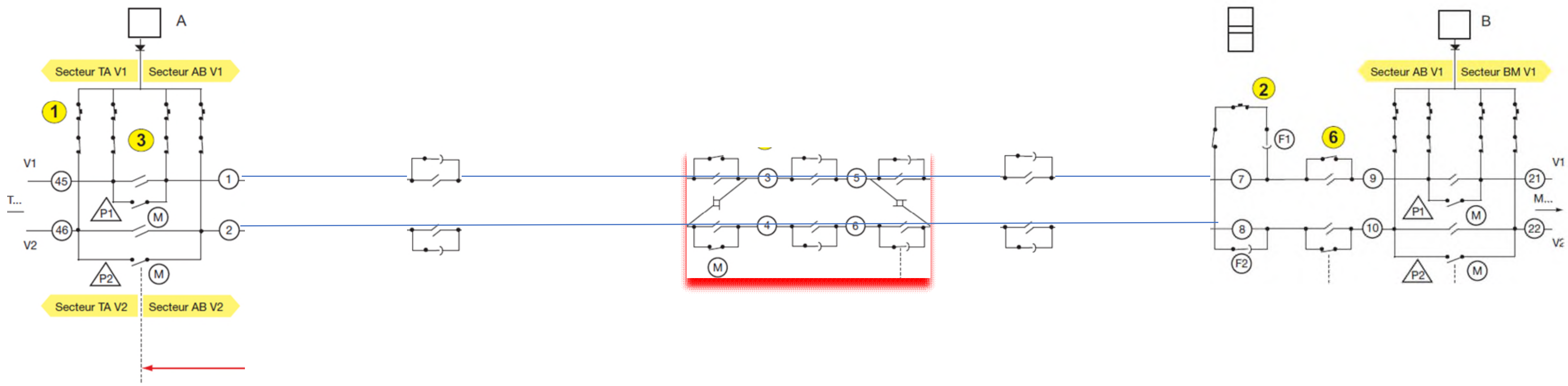
2203
01b
2202
2206

Création d'un pas d'IPCS

SITUATION ACTUELLE



SITUATION FUTURE



Principe de découpage du secteur en 1 500 V

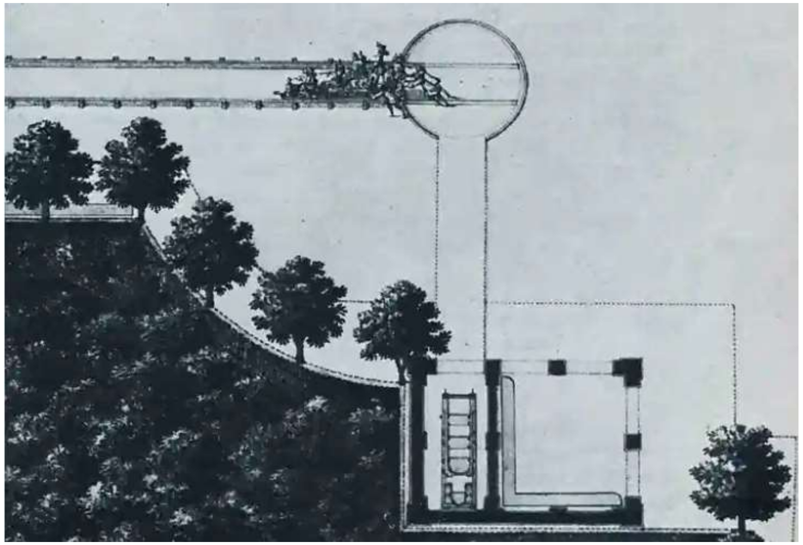
1. Disjoncteur de départ
2. Disjoncteur de mise en parallèle
3. Interrupteurs (ou sectionneurs) de tête de câble
4. Interrupteurs (ou sectionneurs) de pontage
5. Interrupteurs de mise en parallèle
6. Interrupteurs (ou sectionneurs) de ligne

CESI Nanterre
14 décembre 2023

Aperçu du Système Ferroviaire

André Huber

Fig. 1. Reproduction d'une gravure des Archives nationales, montrant le jeu de la *Roulette* dans les jardins de Marly, sous Louis XIV Chariot glissant sur des rails, avec plaque tournante.



TREVITHICKS 1804 LOCOMOTIVE
'Pen-y-Darren'

Trevithick's 1804 locomotive was technically speaking the first locomotive designed, made and fully tested at carrying heavy loads of cargo.

Trevithick built a high-pressure steam engine in 1802 to drive a hammer at the Pen-y-Darren Iron works in Merthyr, south Wales. Due to the success of this particular incarnation of his steam engine he made the decision with backing from high ranking officials at the iron works to mount the engine onto wheels, driven by a series of cross bars and cogs - not too dissimilar from trains today.

Trevithick sold the patent for his steam locomotive to Samuel Humphrey - the proprietor of the ironworks at Pen-y-Darren. He was so impressed with the machine that Trevithick had constructed from what was originally a steam driven hammer driver that he placed a bet with iron master Richard Crawshay that Trevithicks Locomotive can pull ten tons of iron along the Mythyr Tydfill Tram-road to Abercyn. This was a distance of 10 mile, no mean feat for an untested machine such as Trevithick's locomotive. Although only making a top steam of 2.4mph, it successfully traveled the full distance in four hours hauling 10 tons of iron

In today's standard the locomotive was of very primitive design. It comprised of a boiler, a single flue mounted on-top of four wheels. Two of which had extruded cog sections to make contact with the central cogwheel - in turn creating the rotation of the wheels.

Due to there only being one cylinder a large fly wheel was mounted on to the other side, the rotational inertia created by this wheel was counteracted by the rotation of the central cog wheel.

Trevithick's locomotive used a high-pressure cylinder without a condenser; exhaust steam was directed to the chimney, which in-turn increased efficiency by assisting in the draught of the fire. The large proportion of the cylinder was taken up by the boiler and furnace used to summon the power to create steam - which in turn was used to push the crosshead forward and back to create movement in the wheels.

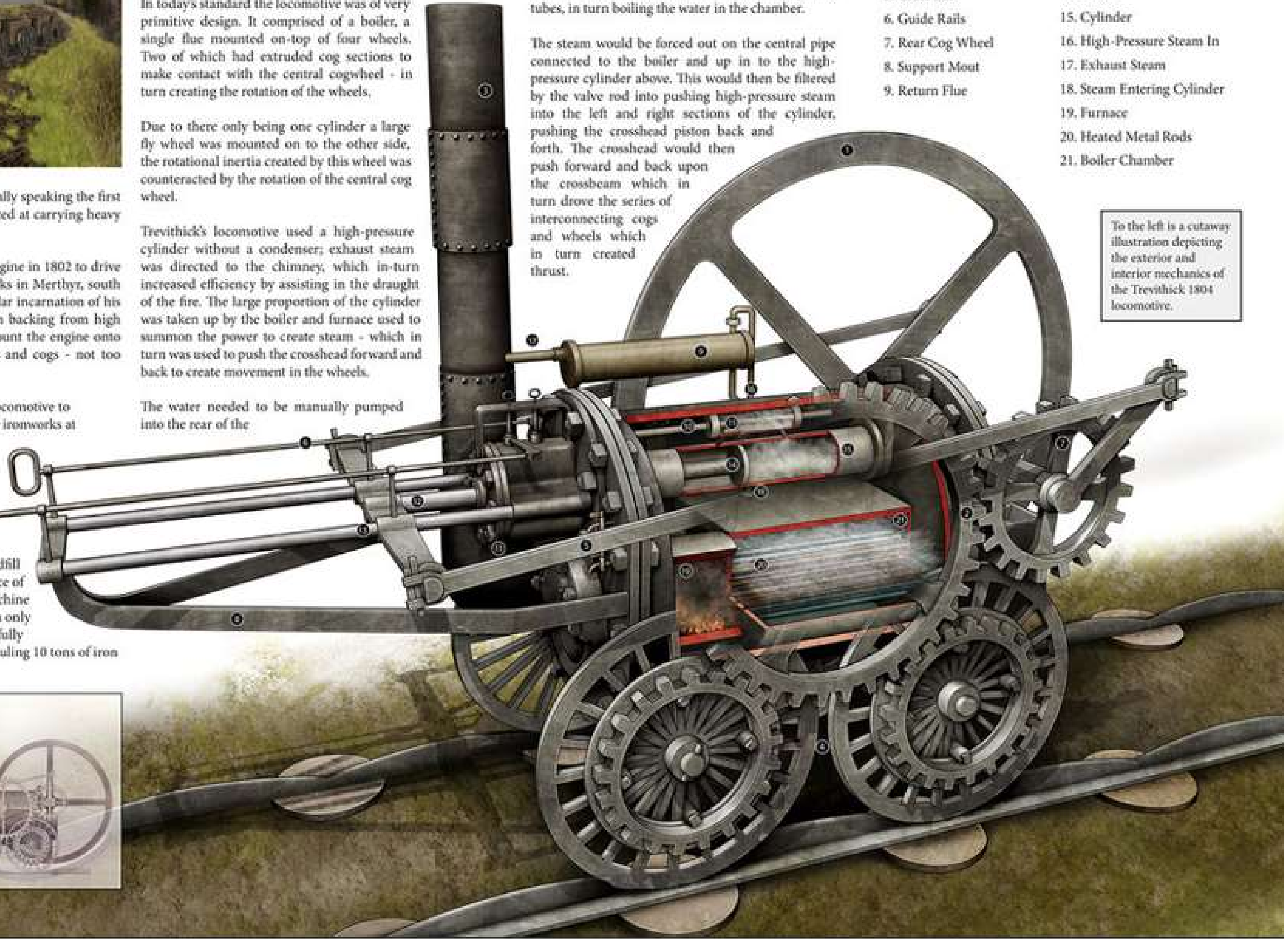
The water needed to be manually pumped into the rear of the steam engine – into which it would slowly fill the boilers chamber. Within the chamber where 15 - 20 metallic tubes connected to the furnace, the heat from the furnace would travel down through the tubes, in turn boiling the water in the chamber.

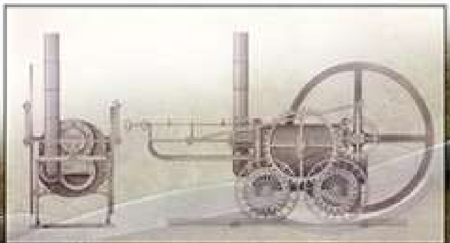
The steam would be forced out on the central pipe connected to the boiler and up in to the high-pressure cylinder above. This would then be filtered by the valve rod into pushing high-pressure steam into the left and right sections of the cylinder, pushing the crosshead piston back and forth. The crosshead would then push forward and back upon the crossbeam which in turn drove the series of interconnecting cogs and wheels which in turn created thrust.

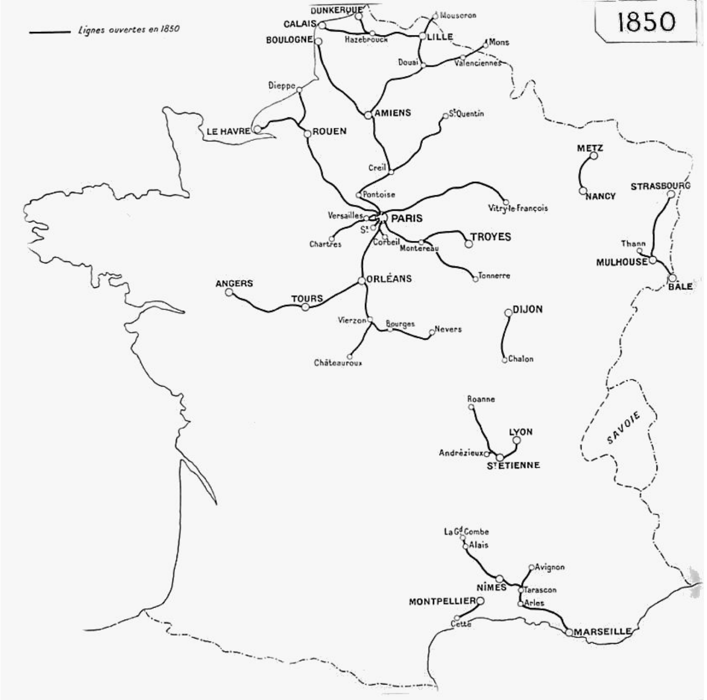
Exterior
1. Fly Wheel
2. Central Cog Wheel
3. Chimney
4. wheeled base
5. Cross Bar
6. Guide Rails
7. Rear Cog Wheel
8. Support Mout
9. Return Flue

Interior (Red)
10. Valve Rod
11. Slide Valve
12. Cross Head
13. Cross-Head Guide
14. Piston
15. Cylinder
16. High-Pressure Steam In
17. Exhaust Steam
18. Steam Entering Cylinder
19. Furnace
20. Heated Metal Rods
21. Boiler Chamber

To the left is a cutaway illustration depicting the exterior and interior mechanics of the Trevithick 1804 locomotive.

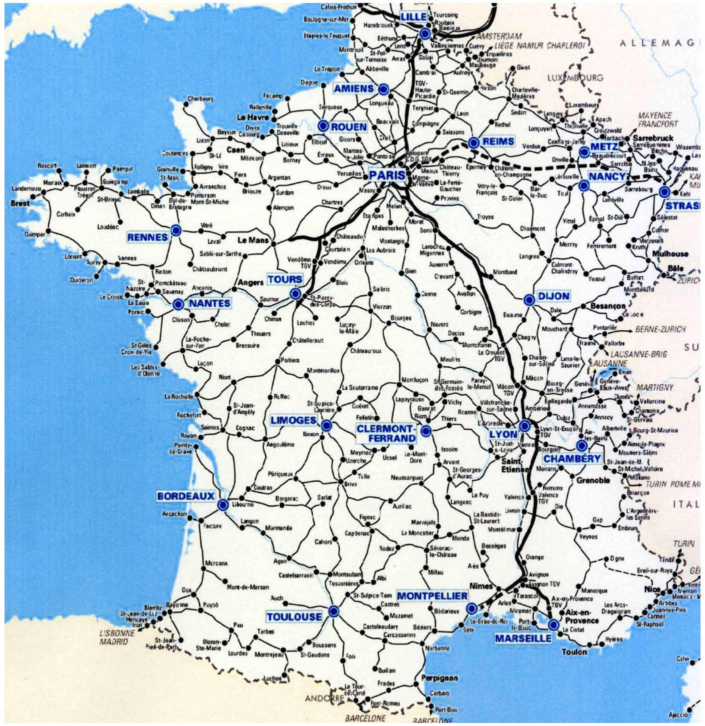


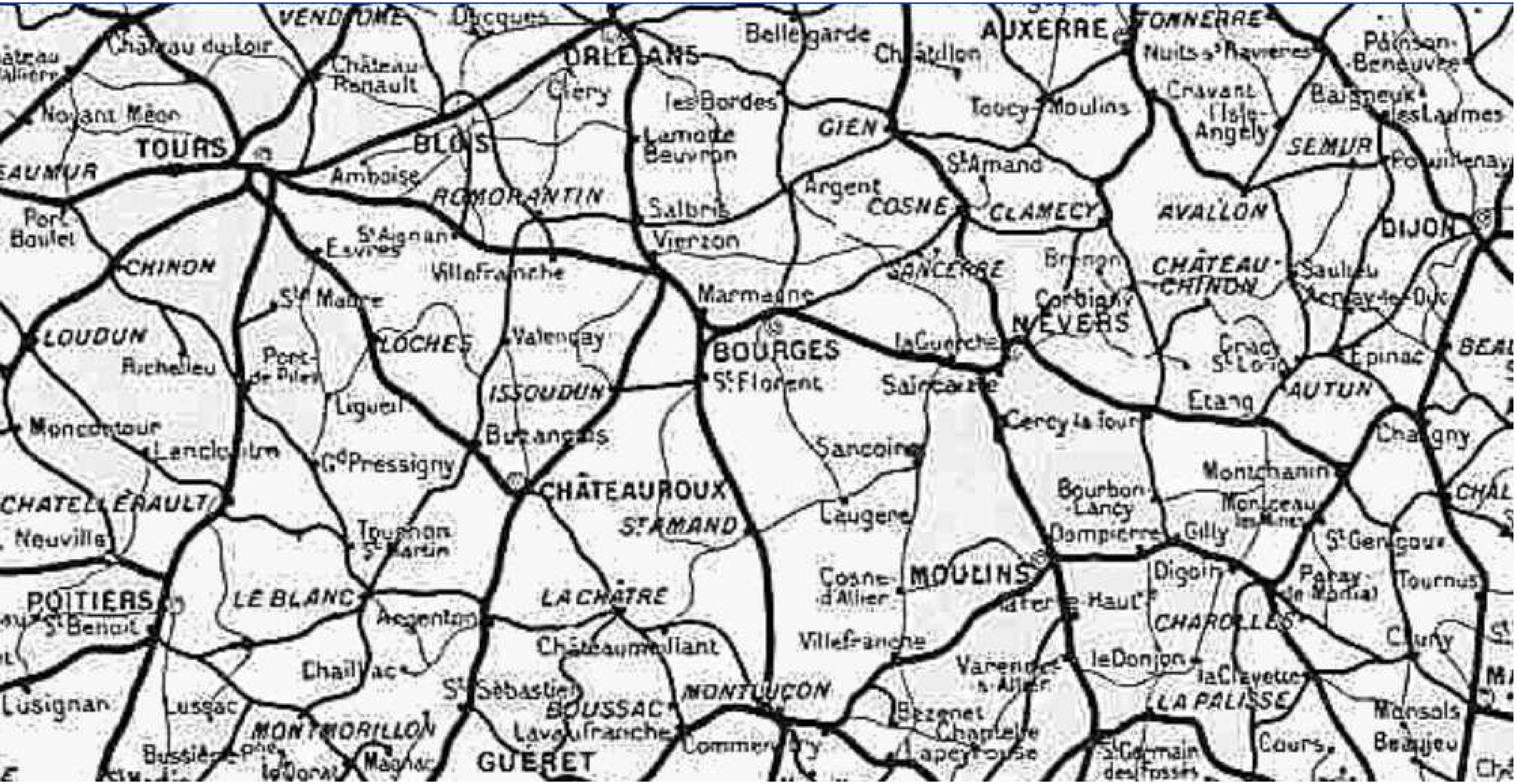



1850
Lignes ouvertes en 1850


1870
Lignes ouvertes en 1870
Grands réseaux
Réseaux secondaires


1910-1930
Lignes ouvertes en 1910
Grands Réseaux
Réseaux Secondaires
Lignes ouvertes entre 1910 et 1930
Grands Réseaux
Réseaux Secondaires
Ligne des Gds Réseaux en construction ou en projet en 1930
Frontière en 1930
Frontière en 1910




VENDÔME
Château du Loir
Château-Renault
ORLÉANS
Cléry
Bellegarde
Châtillon
AUXERRE
TONNERRE
Nuits s/ Ravières
Poinson-Beneuvre
Noyant Méon
TOURS
BLOIS
les Bordes
Lamotte Beuvron
GIEN
Toucy
Moulins
Cravant
l'Isle-Angely
Baigneux
les Laumes
SEMUR
Amboise
ROMORANTIN
Salbris
Argent
St Amand
COSNE
CLAMECY
AVALLON
Pouillenay
DIJON
Port Boulet
CHINON
St Aignan
Esvres
Vierzon
Villefranche
SANCERRE
Brinon
CHÂTEAU-CHINON
Saulieu
Corbigny
Arnay-le-Duc
St Maure
Marmagne
LOUDUN
LOCHES
Valençay
BOURGES
la Guerche
NEVERS
Cercy
St Loup
Epinac
Richelieu
Port-de-Piles
ISSOUDUN
St Florent
Saincaize
Étang
AUTUN
Ligueil
Moncontour
Buzançais
Sancoins
Cercy la Tour
Chagny
Lencloître
Gd Pressigny
CHÂTEAUROUX
Montchanin
Bourbon-Lancy
Montceau les Mines
CHATELLERAULT
St AMAND
Laugère
Dompierre
Gilly
St Gengoux
Neuville
Tournon St Martin
Digoin
Paray le Monial
Tournus
POITIERS
LE BLANC
LA CHÂTRE
Cosne d'Allier
MOULINS
St Benoit
Argenton
Châteaumeillant
Villefranche
CHAROLLES
Cluny
Chaillac
leDonjon
Varennes s Allier
la Clayette
Lusignan
Lussac
St Sébastien
BOUSSAC
MONTLUÇON
LA PALISSE
MONTMORILLON
Lavaufranche
Bézenet
Chantelle
Monsols
Commentry
Lapeyrouse
St Germain des Fossés
Cours
Beaujeu
le Dorat
Magnac
GUÉRET

	Train	Métro	Tramway
• Site	propre		partagé
• Distances	grandes	petites	
• Réseaux	multiples	unique	
• Fret	oui	non	
• Vitesse	variées	uniforme	
• Rampes	faibles	élevées	
• Propulsion	variée	électrique	
• Arrêts	longs	courts	
• Turnbacks	longs	courts	
• Critère	horaire	intervalle	

	Voyageurs	Fret
• Arrêts	gares	triages
• Durée	temps trajet	temps triages
• Réseaux	multiples	nombreux
• Vitesse	variées	limitées
• Rampes	variables	faibles
• Desserte	gares	particuliers
• Priorité	forte	faible

Pavillon de la Muette
Rte Forestière des Pavillons
Rte Forestière des Pavillons
Rte Forestière des Pavillons
Foyer Orféa Achères
Technicentre
SNCF Achères
Télécom Achères
ESTI SNCF
N184
her d'Achères
Entrée livraisons - SNCF
- TECHNICENTRE...
P
C2MI PSL
CPJLMSD
Croix Dauphine
Achères Grand Cormier
N184
SRBG
ermain-en-Laye
N184


55
CAFFE

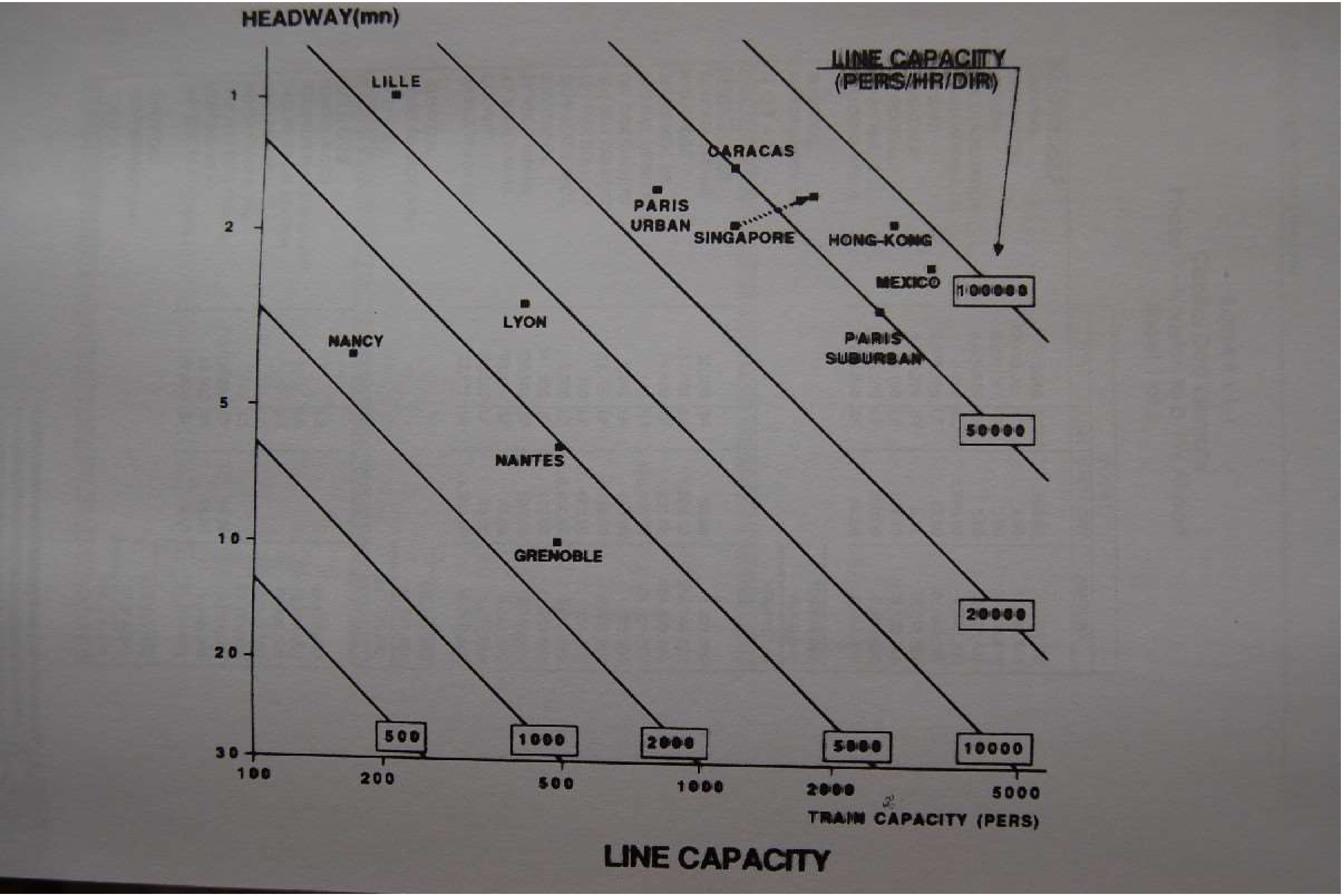

53

Table O-D

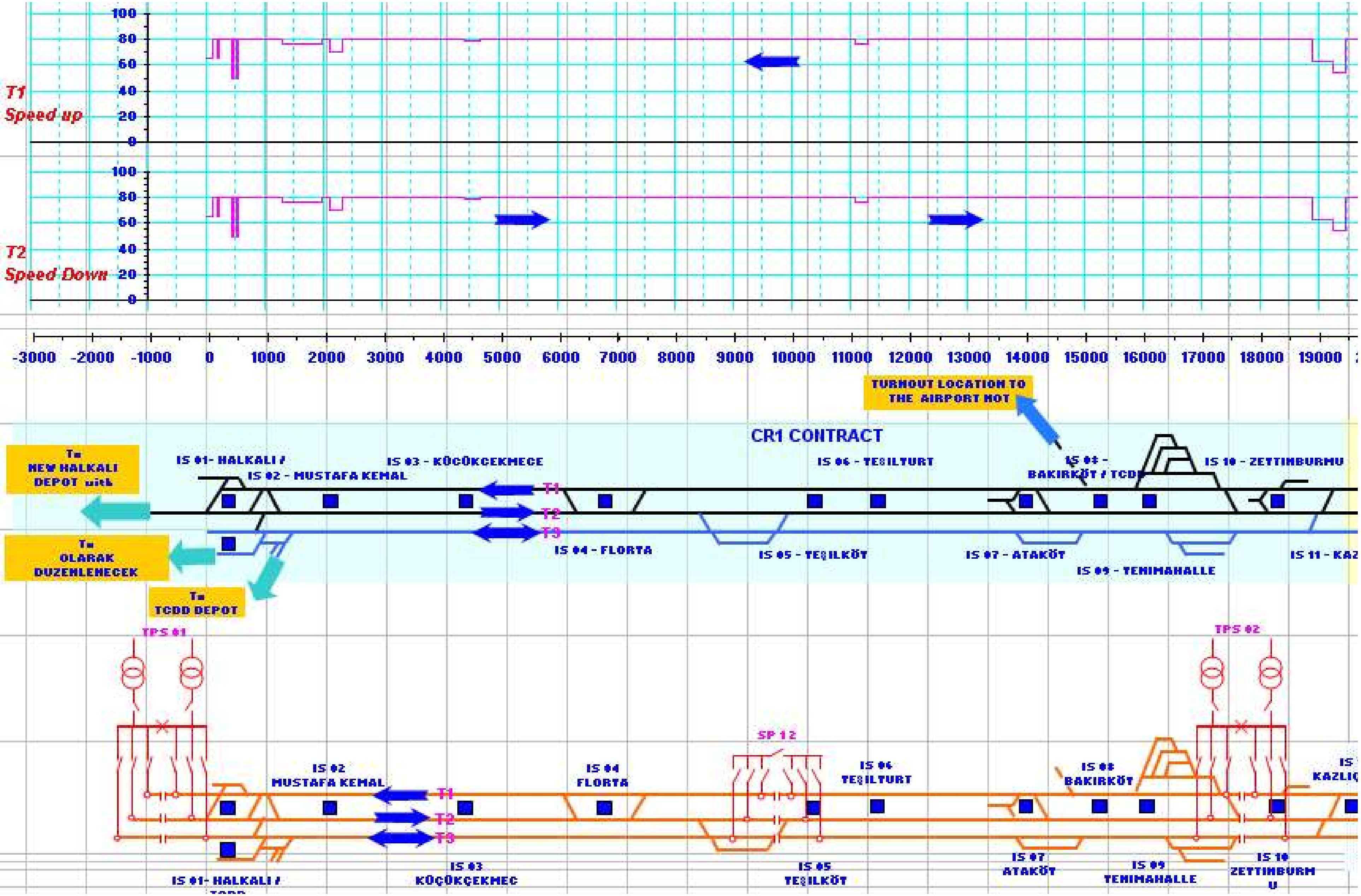
Estimated Transportation Demand of Seoul-Pusan HSR by Years
(in thousand persons)

	Seoul	Ch'onan	Taejon	Taegu	Kyongju	Pusan	Total
1998	0	749	8,012	6,734	2,937	9,885	28,317
	774	0	136	43	11	35	999
	8,041	133	0	948	331	773	10,226
Ch'onan	6,678	42	913	0	1,073	1,913	10,619
Taejon	3,125	11	330	1,087	0	1,004	5,557
Taegu	10,027	36	775	1,940	1,073	0	13,851
Kyongju							
Pusan	28,645	971	10,166	10,752	5,425	13,610	69,569
2001	0	807	9,215	8,184	3,664	12,057	33,927
	834	0	138	43	11	35	1,061
	9,246	134	0	980	349	804	11,513
	8,114	43	943	0	1,205	2,100	12,405
	3,890	11	348	1,218	0	1,128	6,595
Ch'onan	12,236	36	807	2,131	1,205	0	16,415
Taejon							

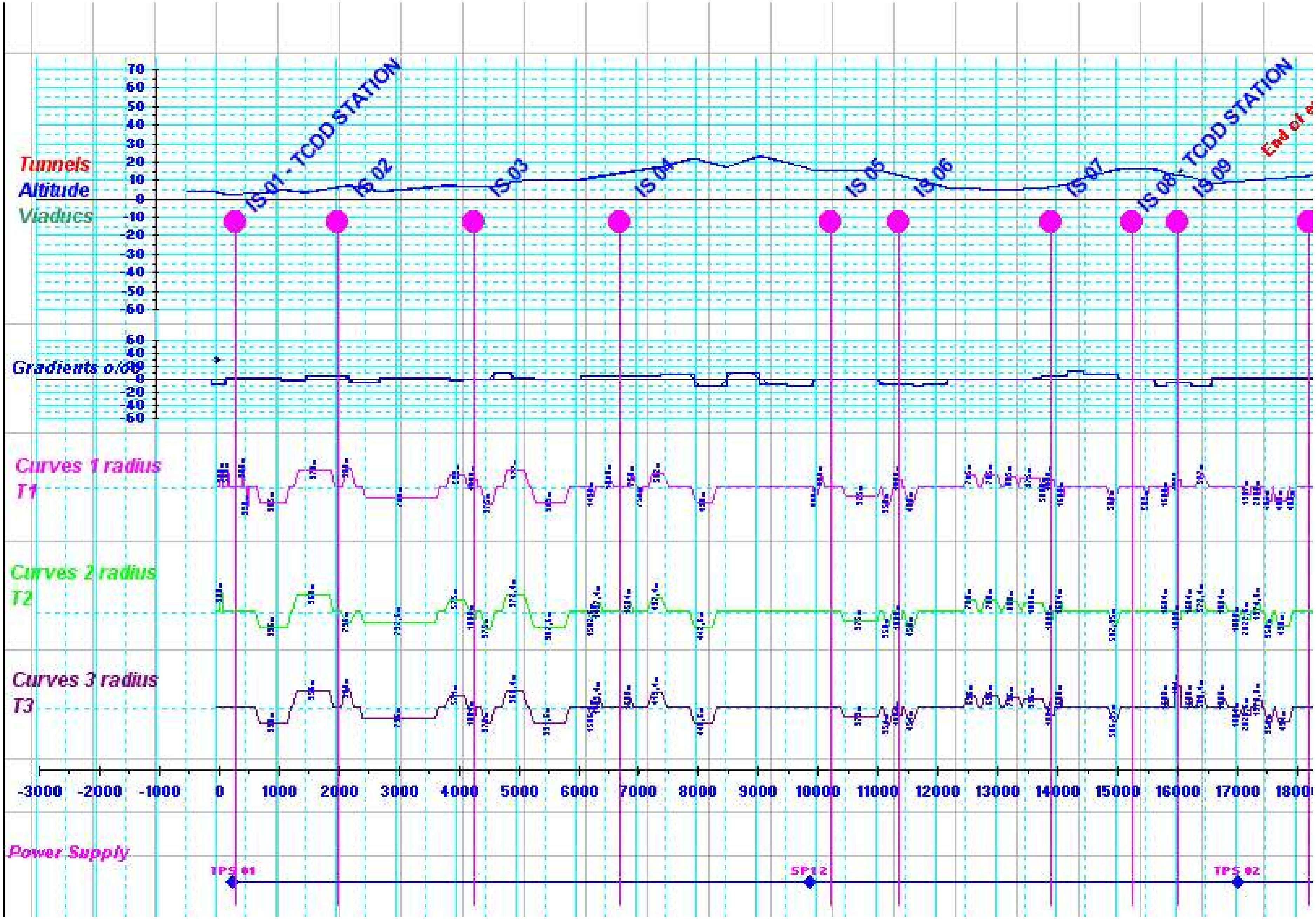
Capacité par heure et par direction



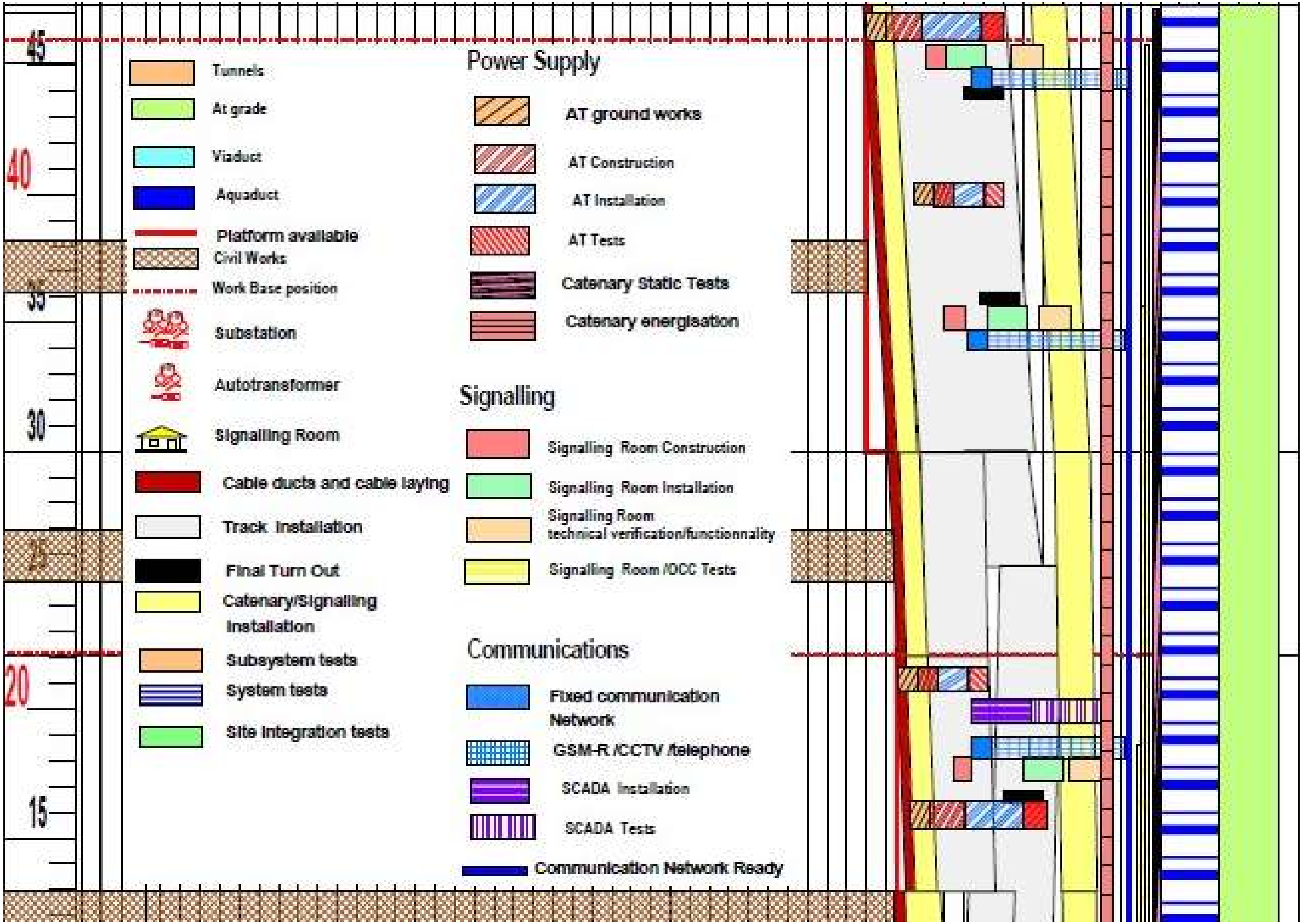
Descriptif de ligne 1/2



Descriptif de ligne 2/2



Planning Chemin de Fer



Contraintes générales du MR

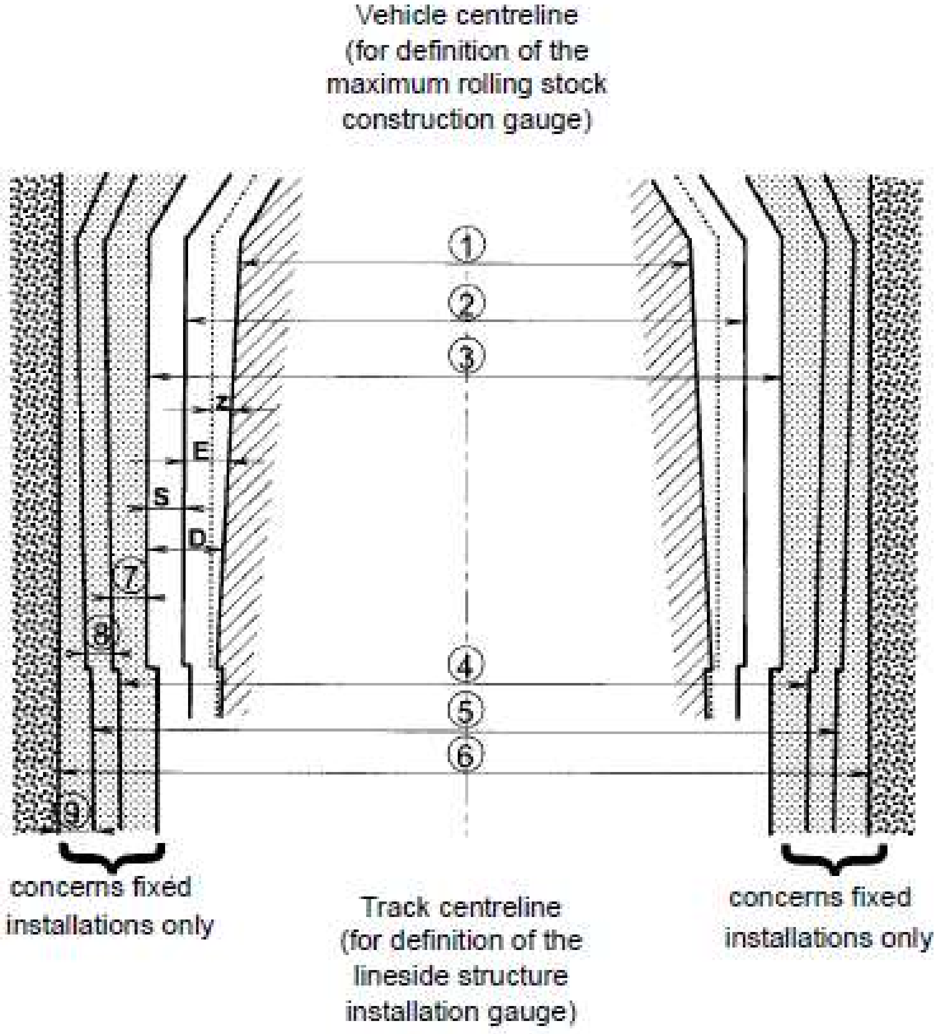
Gabarit statique
Gabarit dynamique (statique+tolérances+jeux+usures
+souplesse+affaissements
Gabarit d'obstacle (dynamique+lame d'air
+éléments sous tension)
Cornes et ventres
Garage franc

Longueur des trains, longueur des quais

Vitesse maximale
Réductions de vitesses dues au profil en long,
courbes, aiguillages, …

Adaptation à la voie, la signalisation, l'alimentation électrique

Le gabarit



Référence: fiche UIC 505-1

1 Gabarit maximum de construction du matériel roulant

2 Gabarit cinématique de référence

3 Position limite du matériel roulant

4 Gabarit cinématique du matériel roulant

5 Gabarit limite des structures

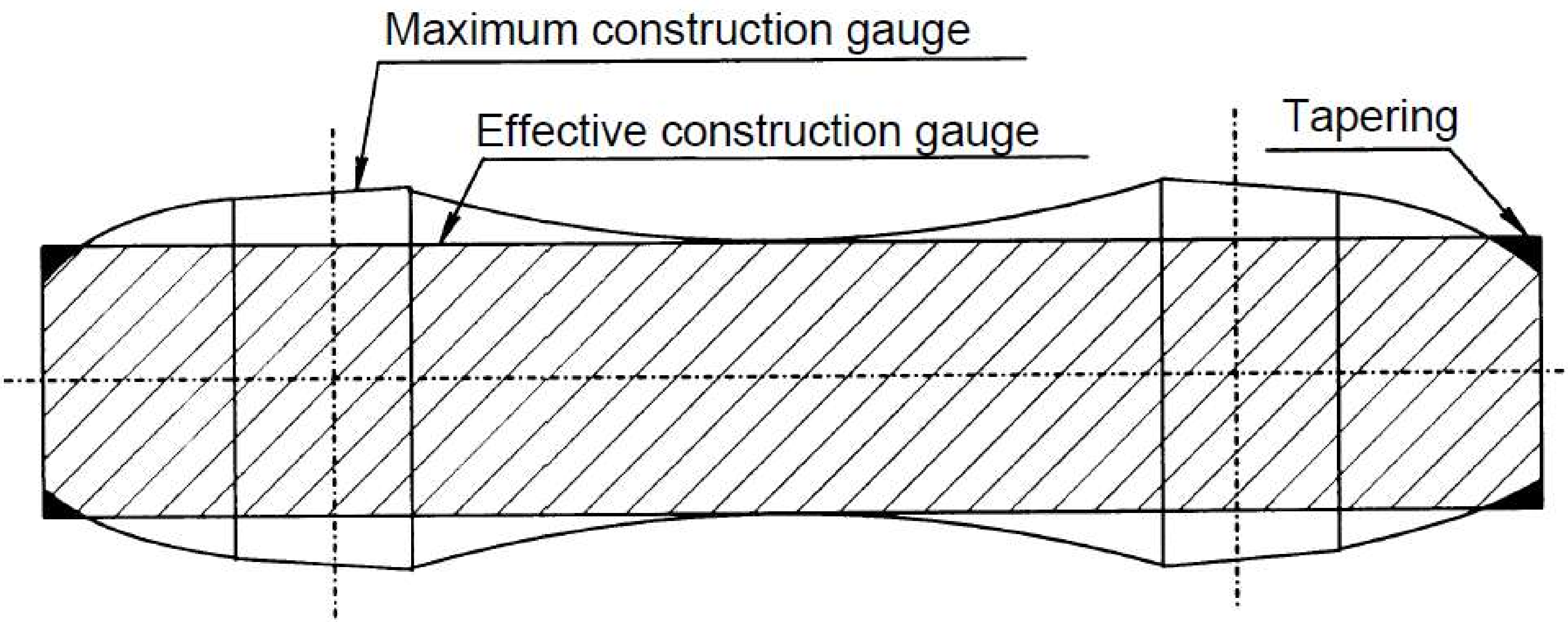
6 Gabarit limite des installations fixes

7 Mouvement dû à un excès/défaut de dévers supérieur à 0,05

8 Prise en compte des défauts de voie

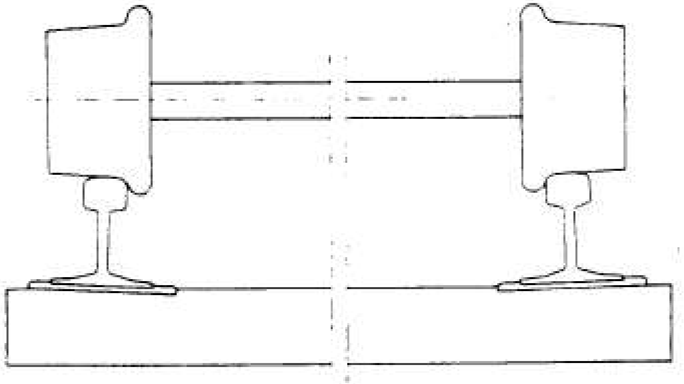
9 Marge spécifique au réseau

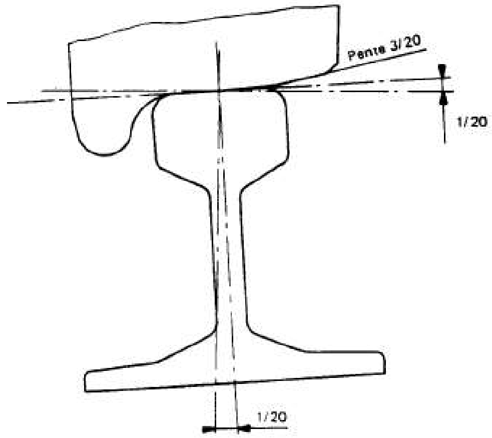
Le gabarit

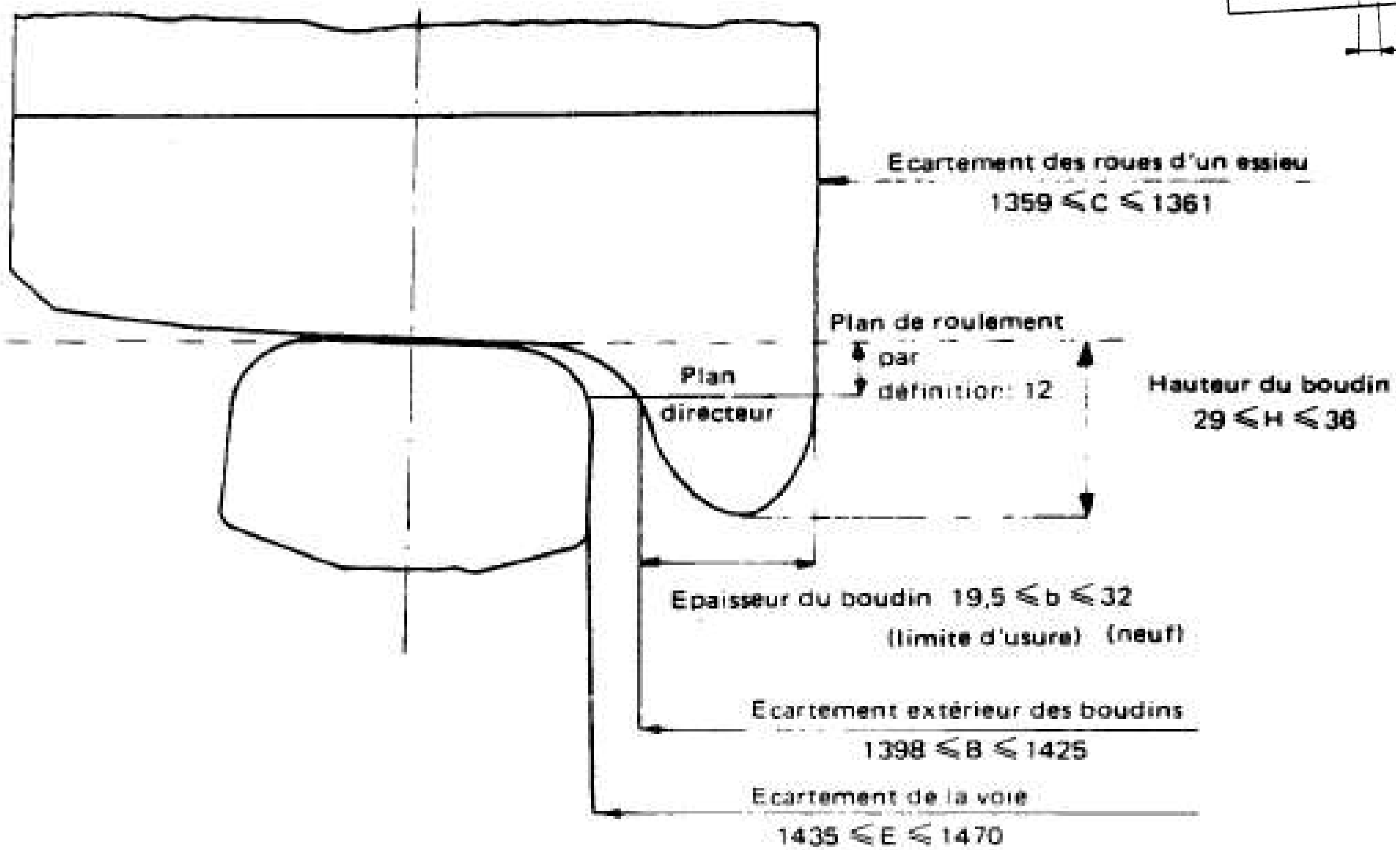


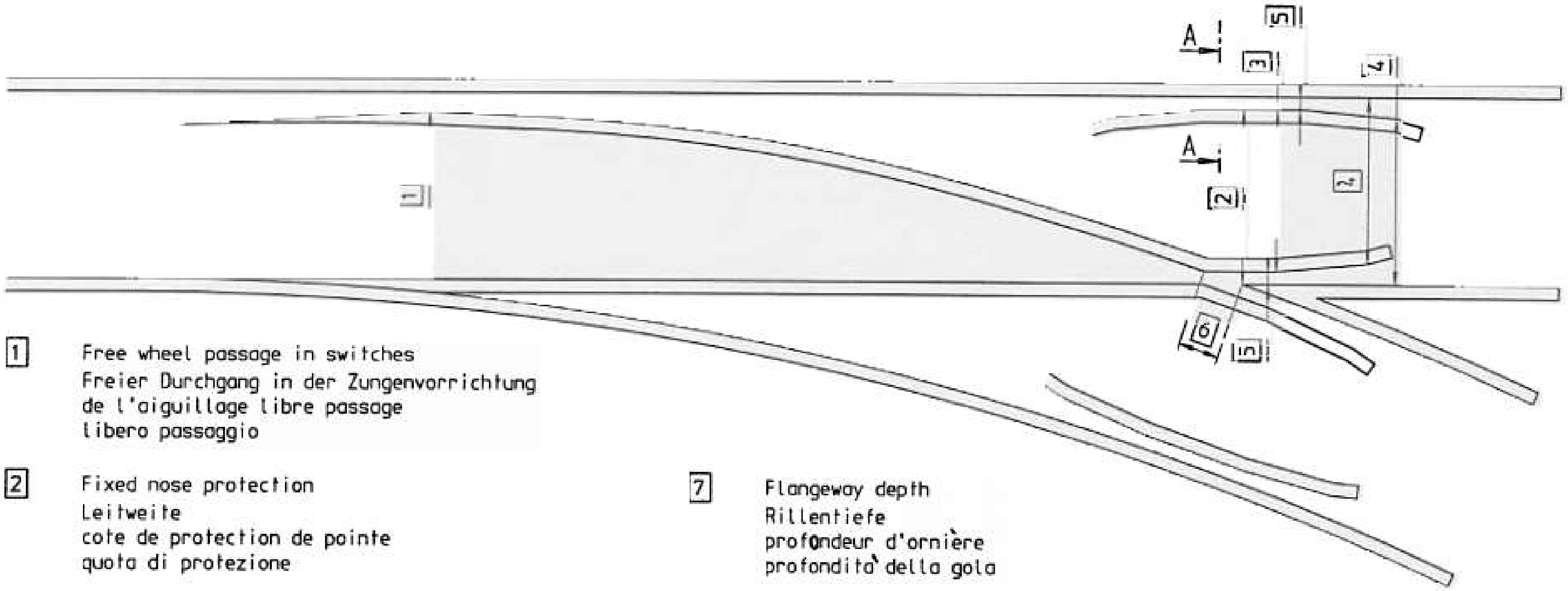
Maximum construction gauge
Effective construction gauge
Tapering

Le roulement fer









1. Free wheel passage in switches
   Freier Durchgang in der Zungenvorrichtung
   de l'aiguillage libre passage
   libero passaggio

2. Fixed nose protection
   Leitweite
   cote de protection de pointe
   quota di protezione

3. Free wheel passage at crossing nose
   Leitkantenabstand im Bereich der Spitze
   libre passage de la pointe
   quota di libero passaggio della punta

4. Free wheel passage at check/wing rail entry
   Freier Durchgang im Bereich Radlenker/Fluegelschiene
   Libre passage du contre rail/patte de lièvre
   Libero passaggio della controrotaia/piegata a gomito

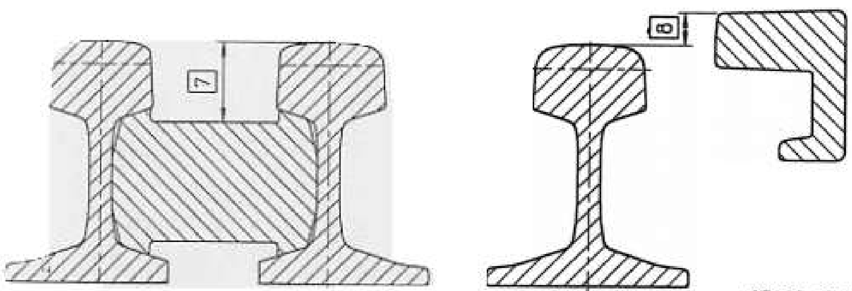
5. Minimum flangeway width
   Kleiste Rillenweite
   ornière minimale
   gola minimale

6. Crossing gap
   Herzstueckluecke
   lacune d' ornière
   spazio nocivo

7. Flangeway depth
   Rillentiefe
   profondeur d'ornière
   profondità della gola

8. Excess Height of Check Rail
   Radlenkerueberhoehung
   surelevation du contre rail
   altezza della controrotaia

section A-A



05-07-2002

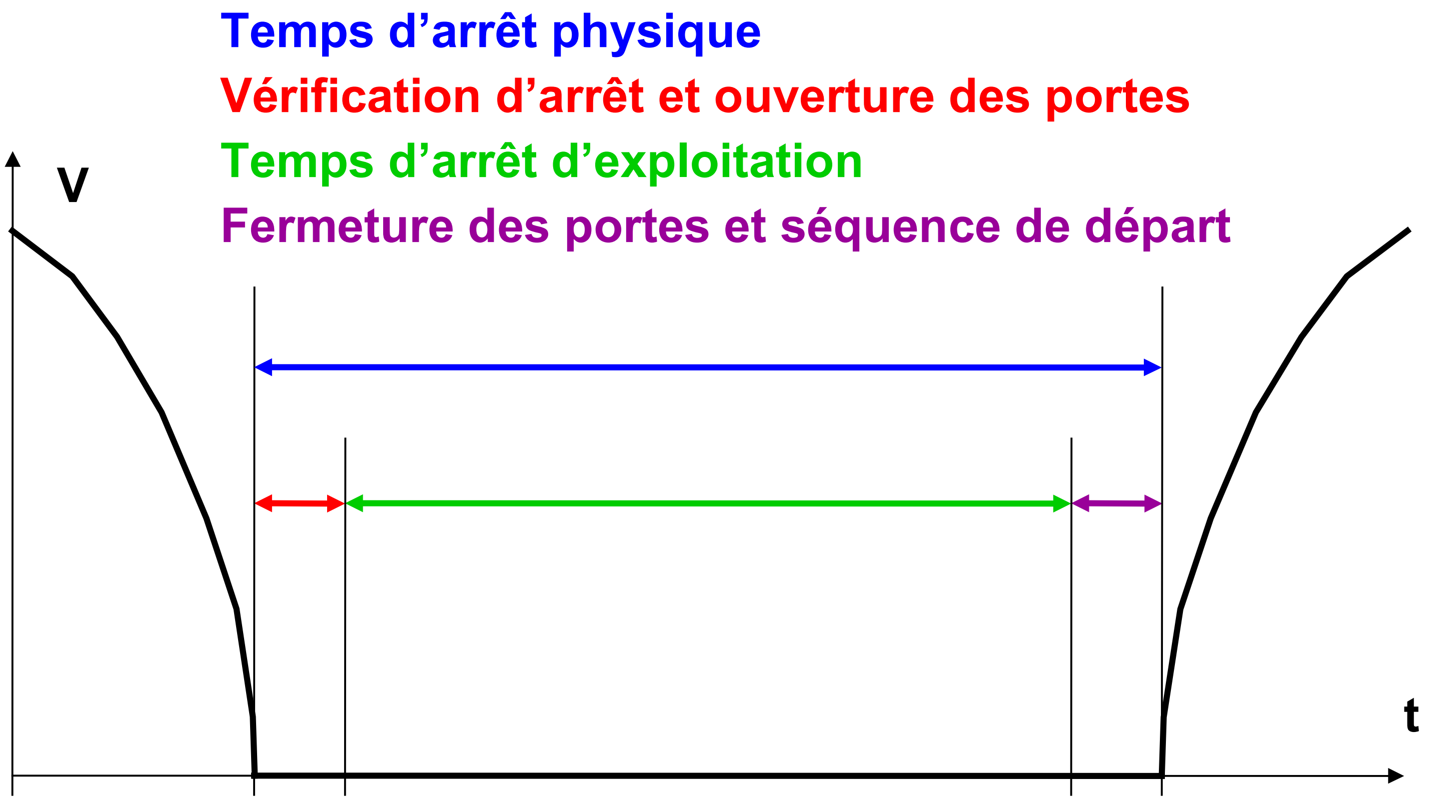
L'accès au train

Figure 13: The Lille VAL was fully automated and designed for completely safe passenger transport.

Temps d'arrêt et temps d'accès

Les temps d’arrêt en gare

- Physique: durée pendant laquelle la vitesse est nulle
- Exploitation: durée pendant laquelle l’échange de passagers est possible



Temps d'accès

Nombre de portes

Largeur des portes

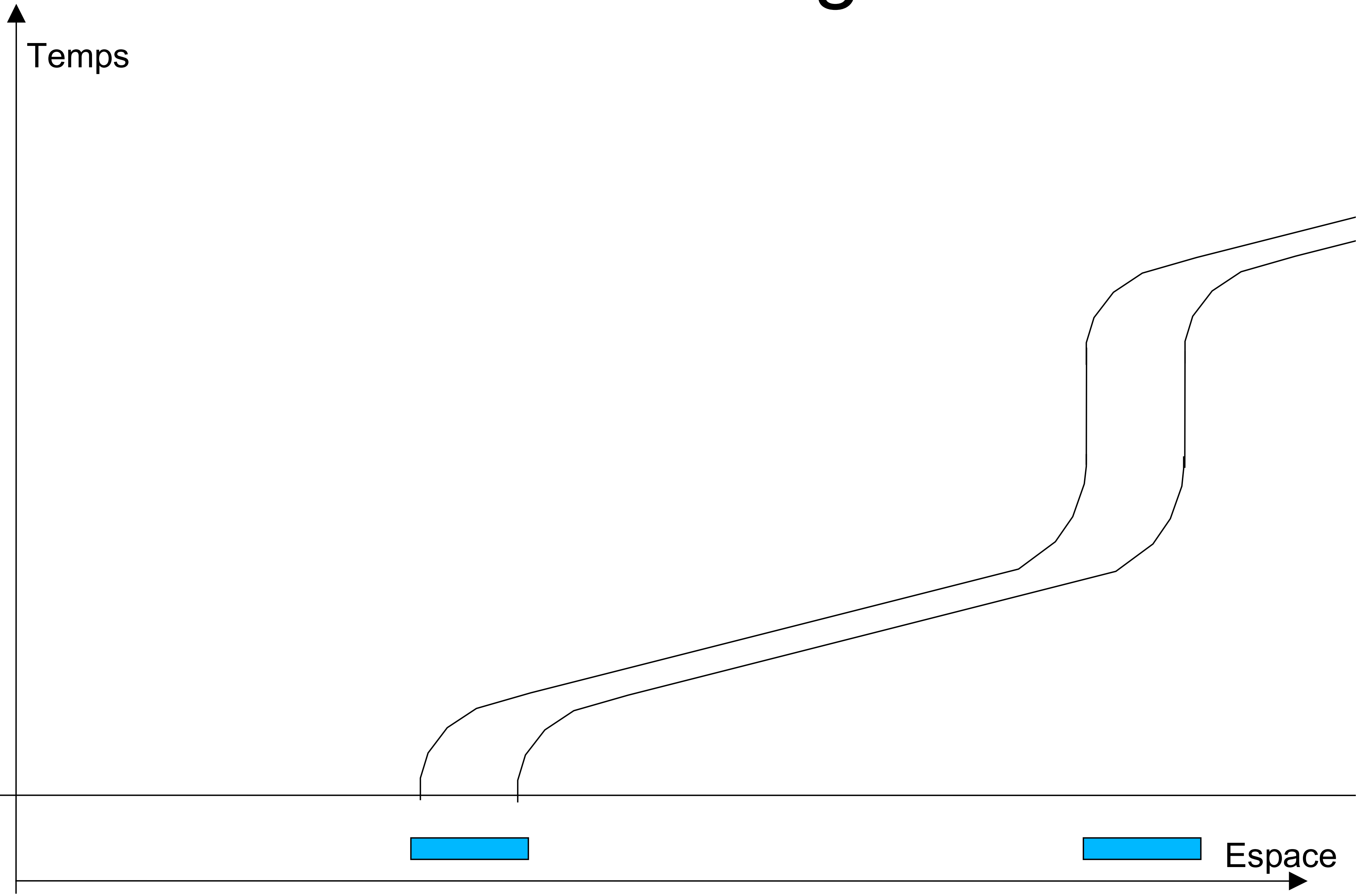
Nombre de passagers à échanger

- Distribution temporelle de la table O/D

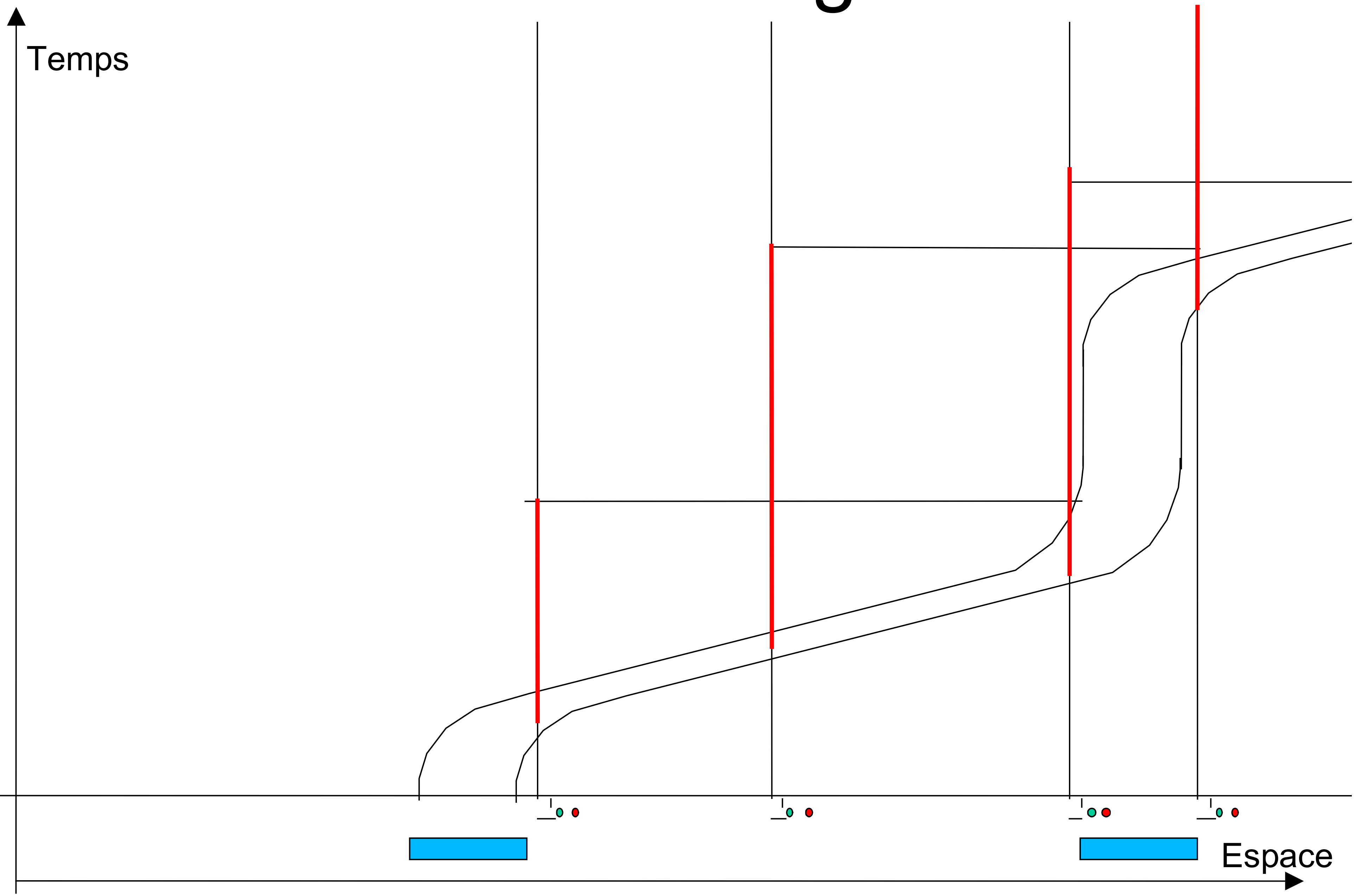
Distribution des passagers

- Disposition des accès aux quais

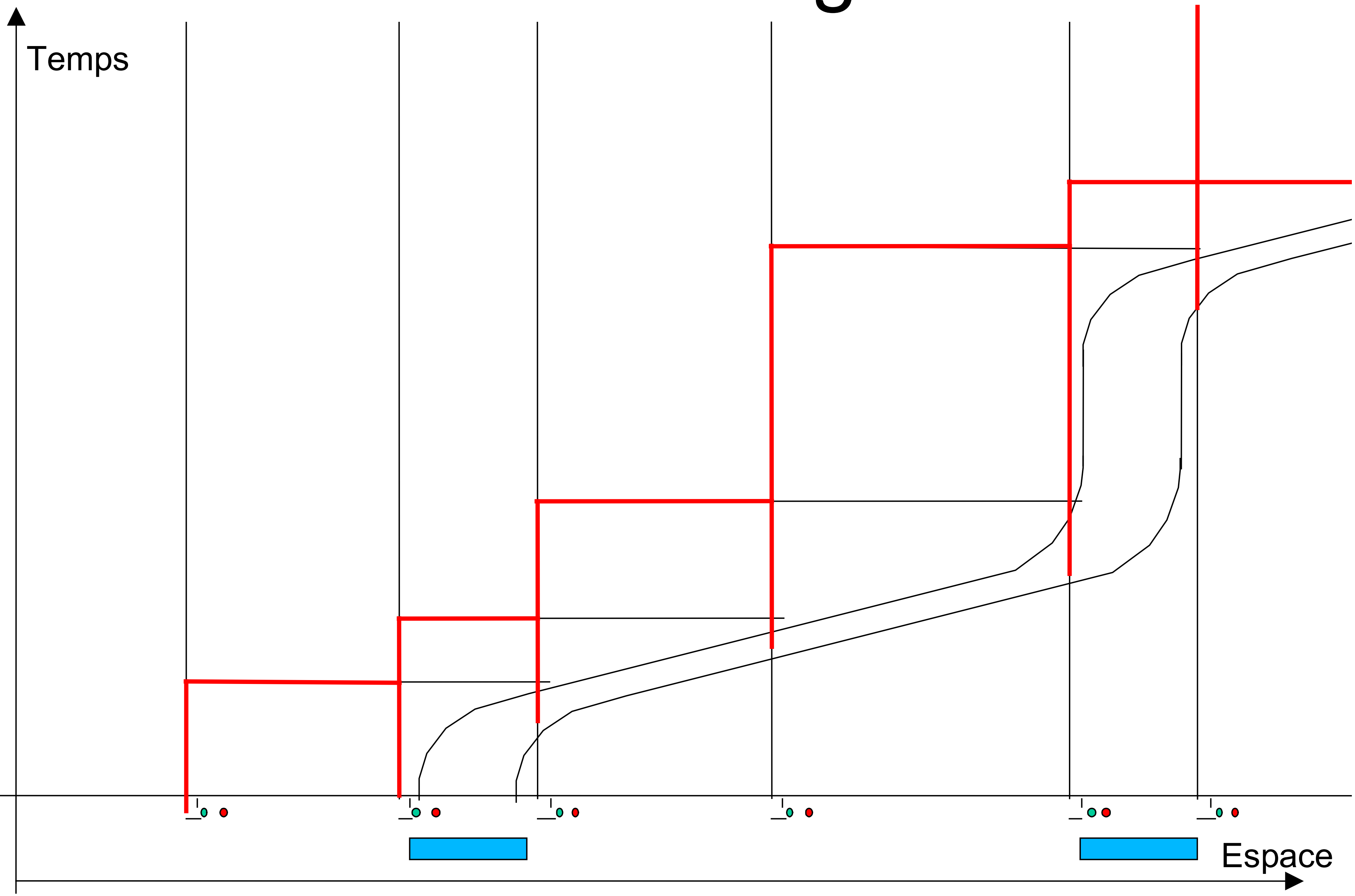
Intervalle en ligne 1



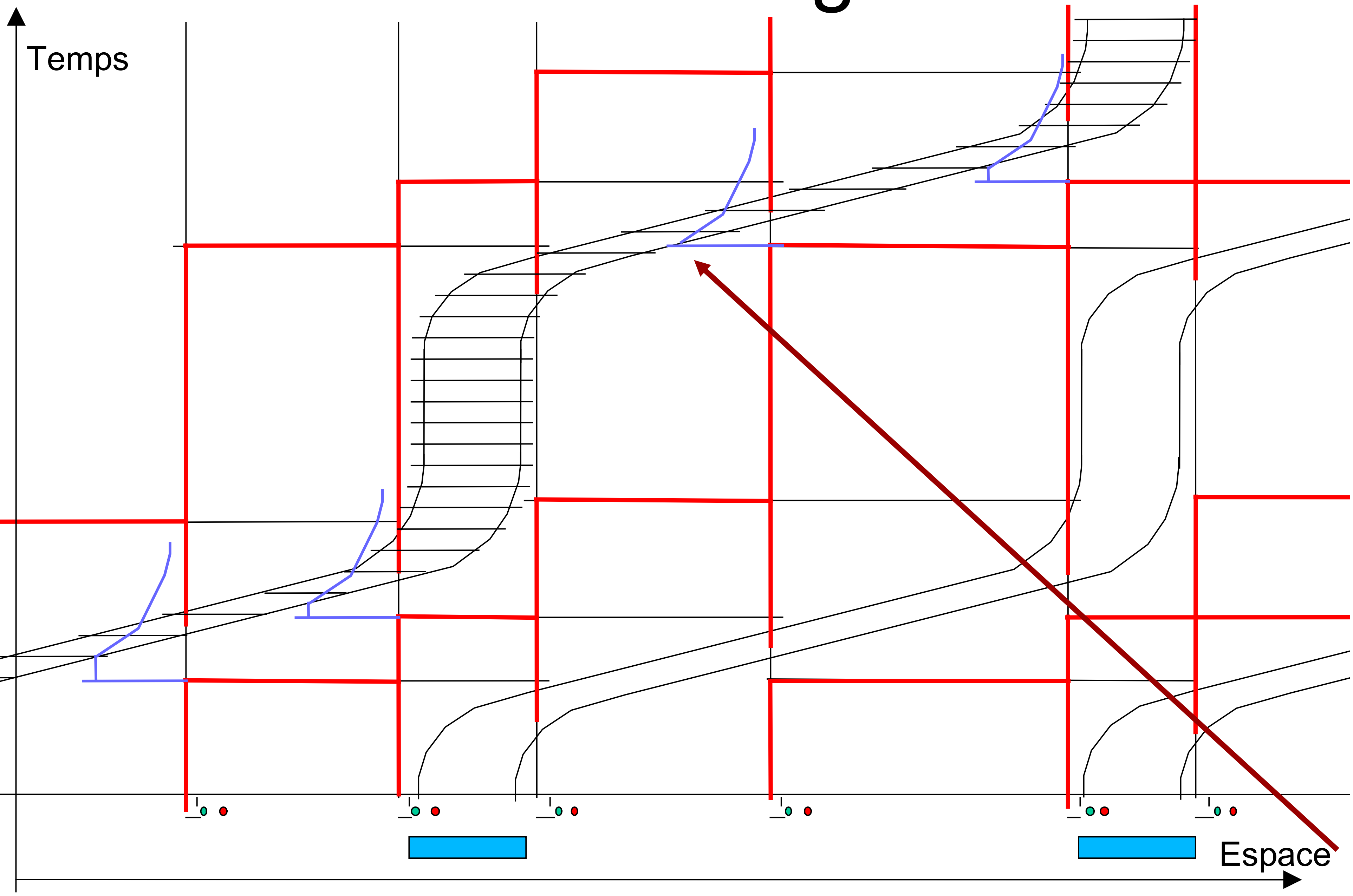
Intervalle en ligne 2



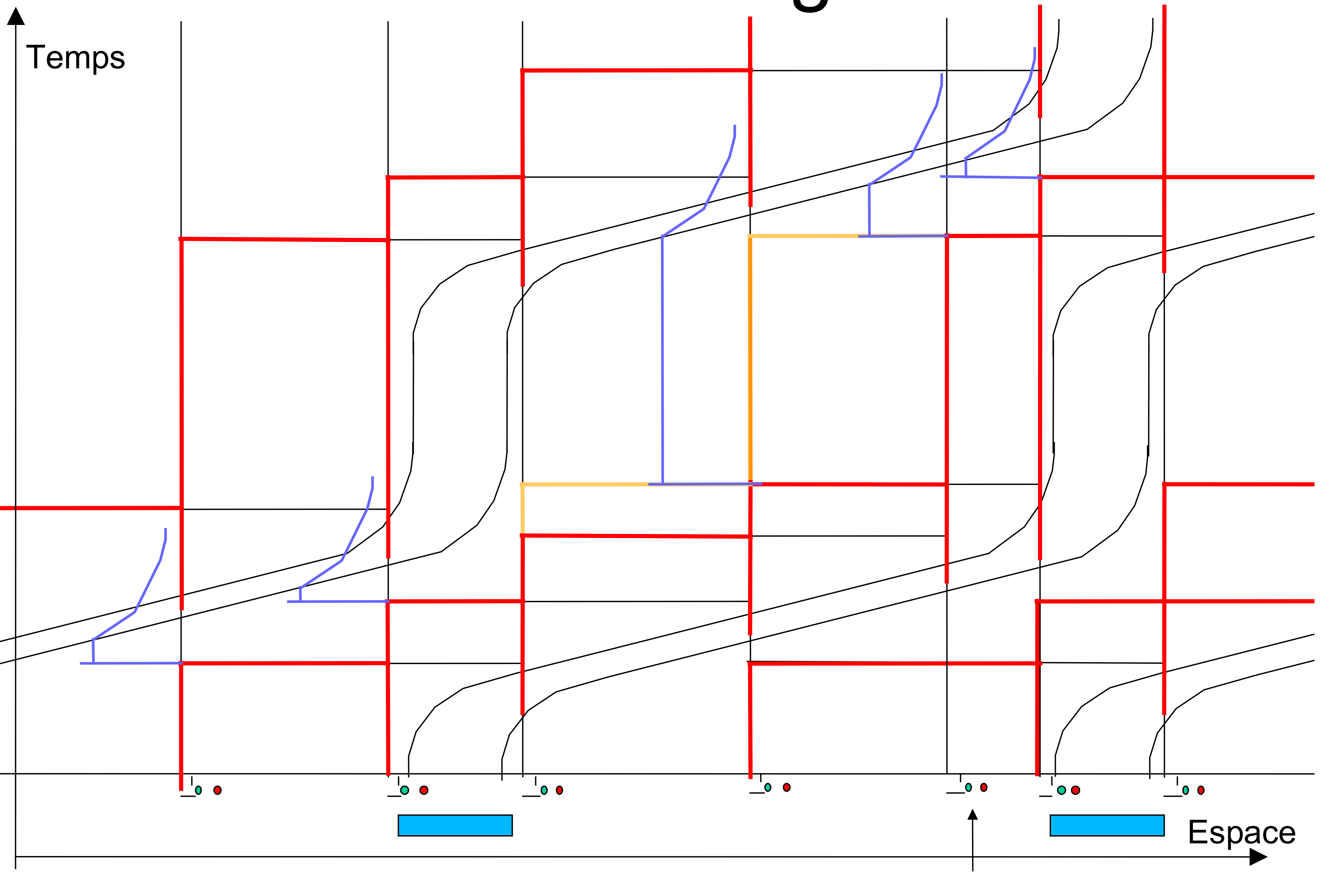
Intervalle en ligne 3



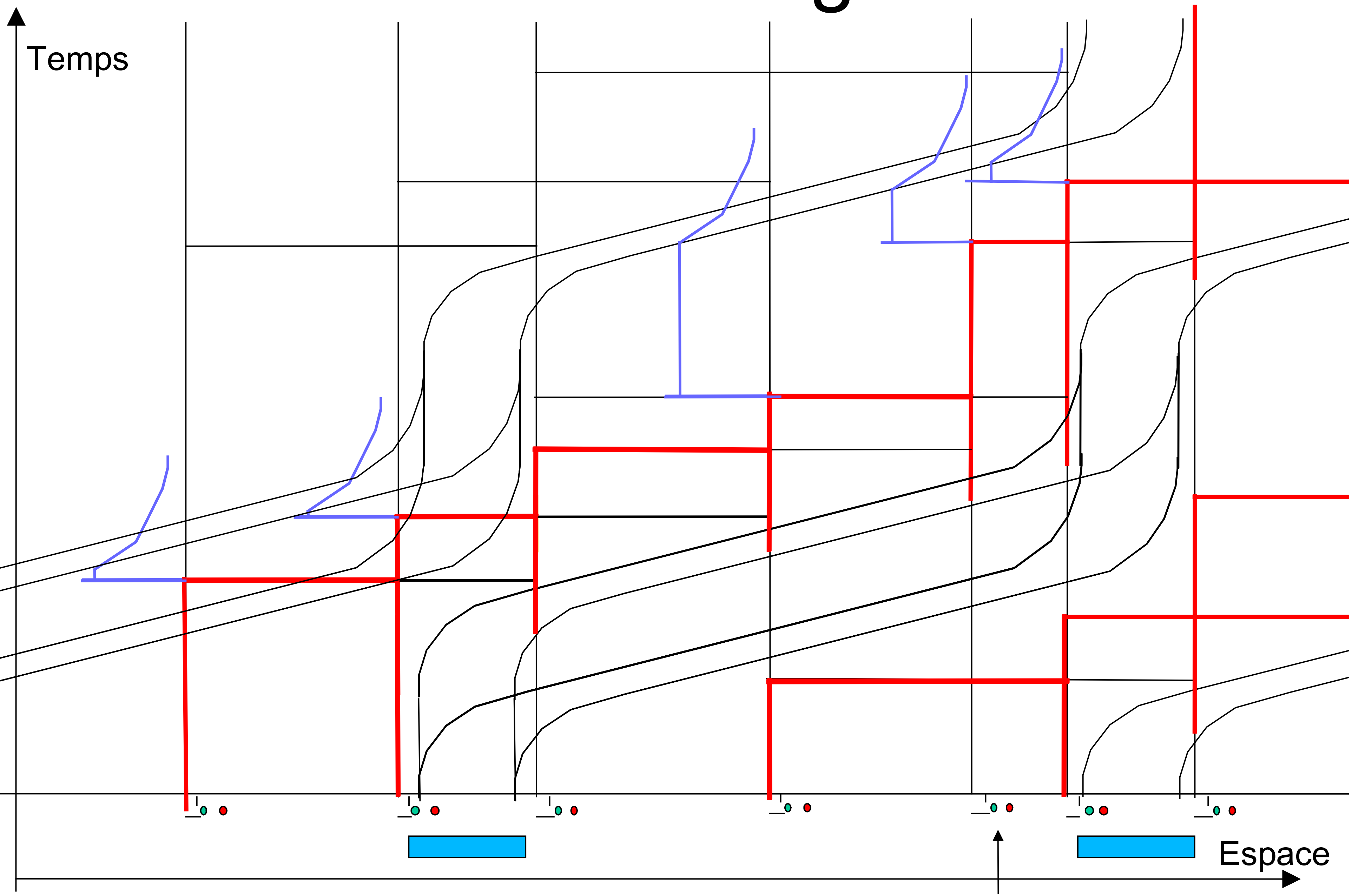
Intervalle en ligne 4



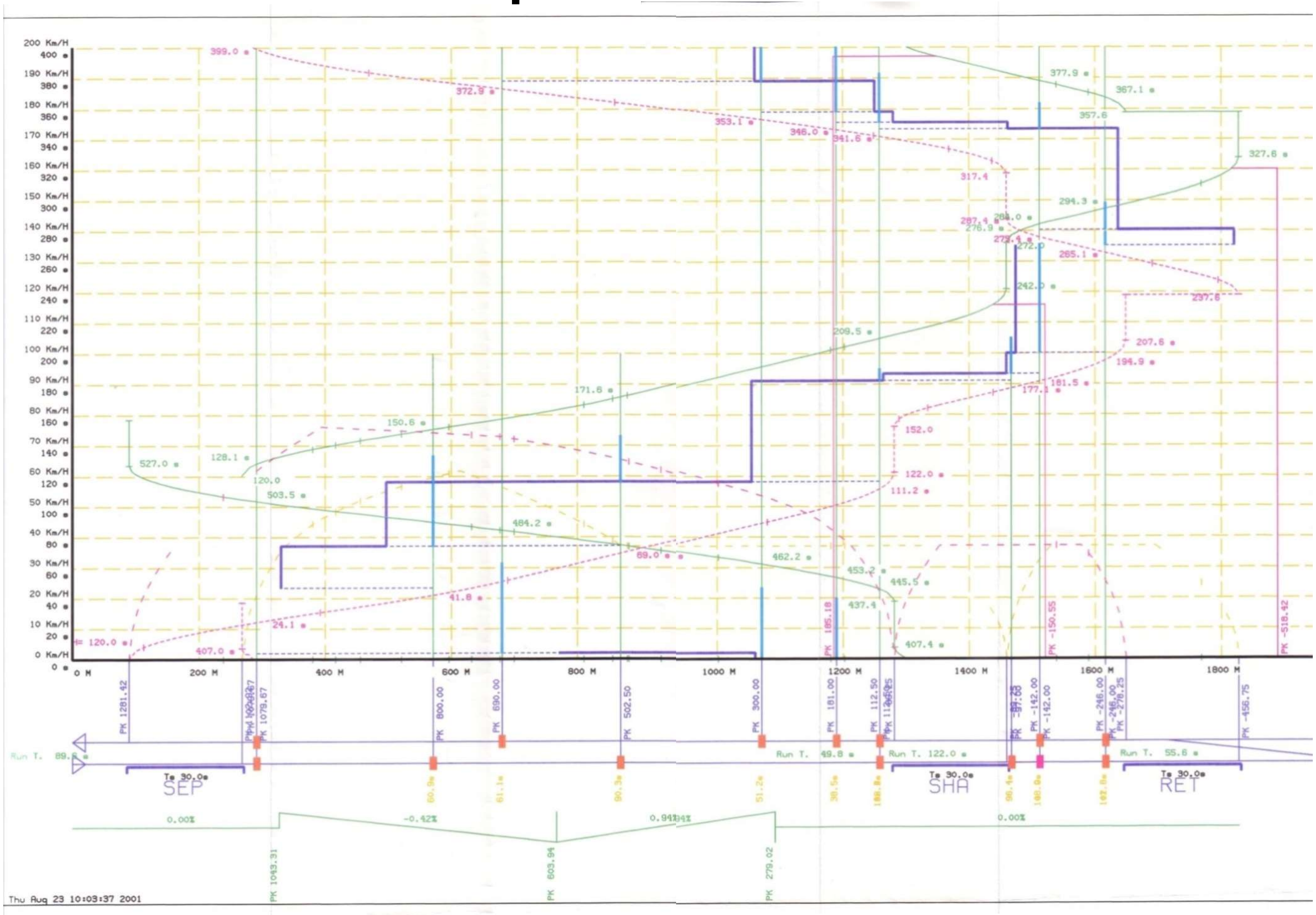
Intervalle en ligne 5



Intervalle en ligne 6

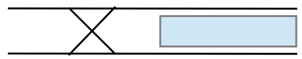


Intervalle pour retournement

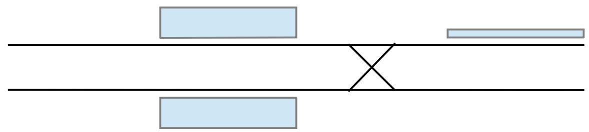


Aménagement des terminus
Principes

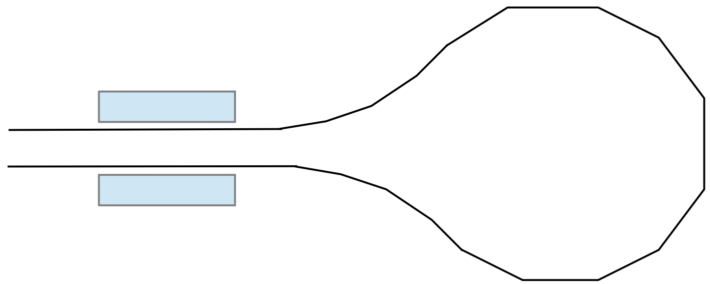
Retournement en avant-gare



Retournement en arrière-gare



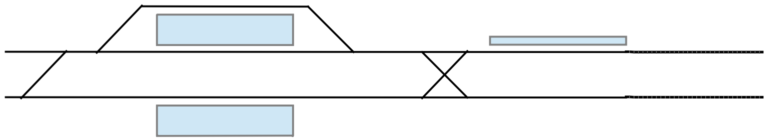
Boucle de retournement



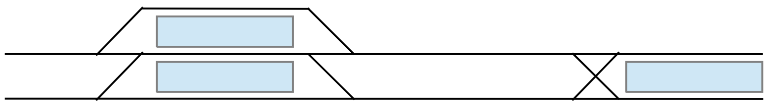
Aménagement des terminus
Exemples

Nombre de voies

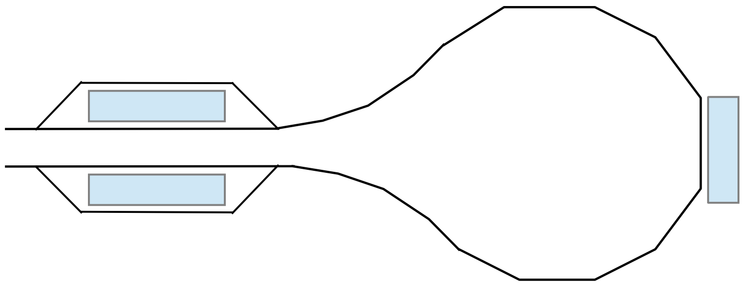
- arrivée
- départ
- remise/réserve



Terminus sur plusieurs gares



Terminus déporté



Performances des trains

Interface avec la signalisation

Adhérence

Performance en traction

Performance en freinage

Freins indépendants de l’adhérence

Interface avec la signalisation

Sans : Marche à vue

Espacement au temps

Cantonnement téléphonique (gare à gare)

Détection de passage (pédale)

Détection de présence (circuit de voie)

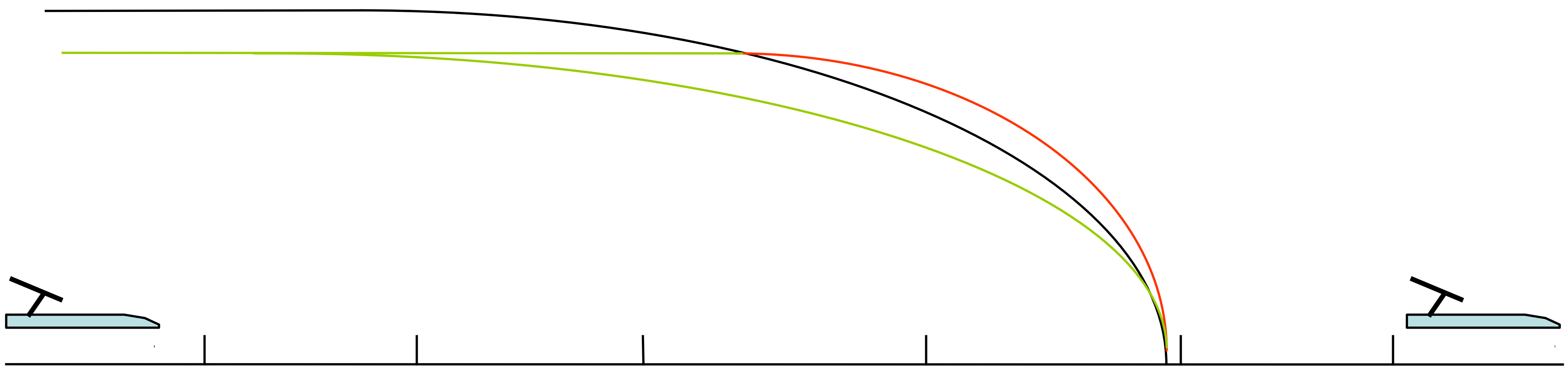
Contrôle automatique

Pilotage à distance (Ligne de Sceaux)

Pilotage automatique (PA)

Pilotage automatique integral (PAI)

Le freinage automatique




DE L'OUEST

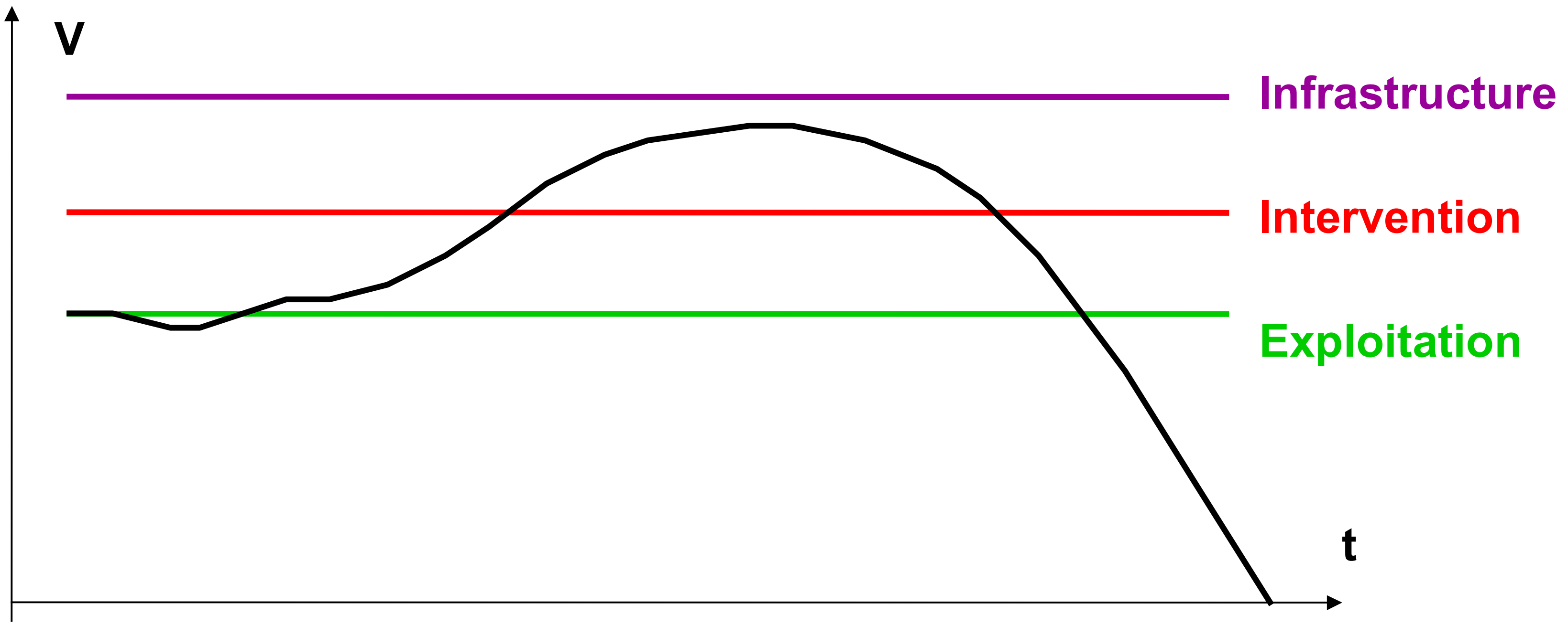
Les vitesses limites

Les trois vitesses limites

Infrastructure: celle qu'il ne faut en aucun cas dépasser

Intervention: celle qui provoque le déclenchement du freinage automatique

Exploitation: la vitesse maximale autorisée en exploitation



Les vitesses limites

Raisons des vitesses limites

Infrastructure:

- **Résistance de la voie, des appareils de voie**
- **Interaction avec l’environnement**
- **Influence sur le confort des passagers**

Matériel Roulant :

- **Sortie de voie**
- **Basculement**
- **Capacité de freinage**

Signalisation :

- **Vision des signaux**
- **Distances d’arrêt, de ralentissement**

Environnement :

- **Bruit, vibrations, infrastructure partagée, ...**

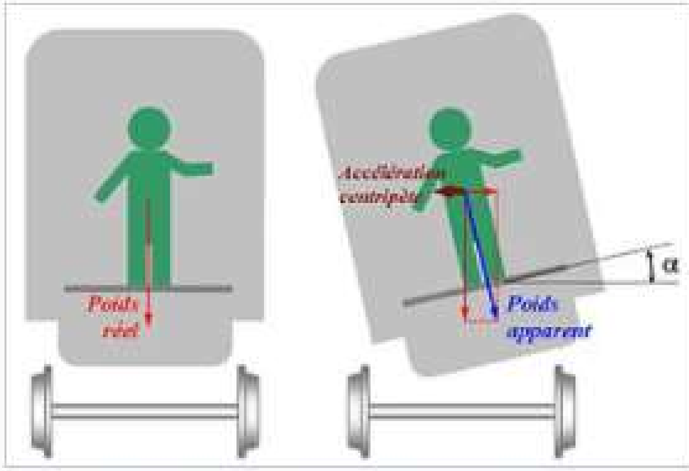
La pendulation

La pendulation permet d'améliorer la vitesse limite dans les courbes.

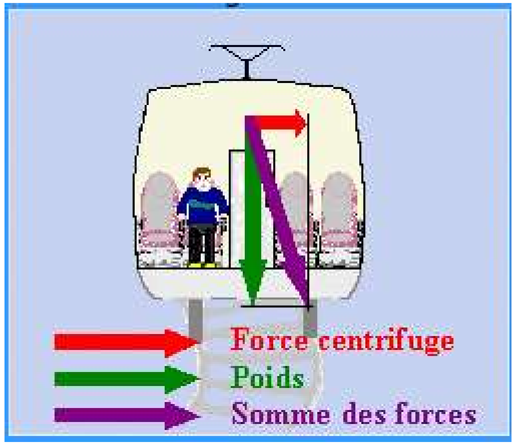
La limitation de vitesse en courbe correspond au minimum de

- **la tenue de la voie**
  - **glissement transversal**
  - **renversement du rail**
- **la tenue du véhicule**
  - **chevauchement du rail**
  - **renversement**
- **la limite de confort**
  - **insuffisance ou excès de dévers**
  - **trop forte variation de l'insuffisance de dévers**

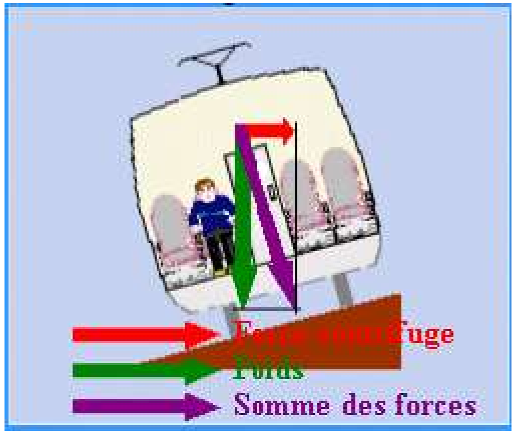
La pendulation permet uniquement d'augmenter la limitation de vitesse due au confort



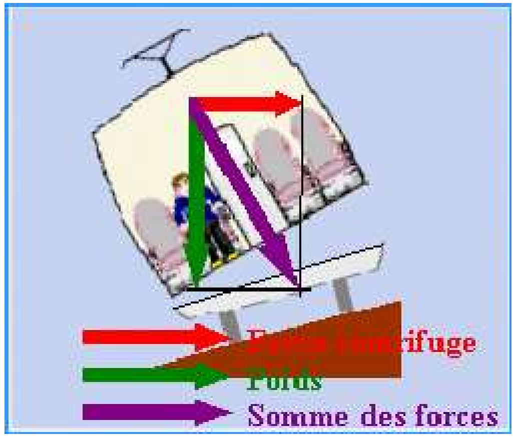
Intérêt du dispositif sur le confort des passagers



Sans dévers



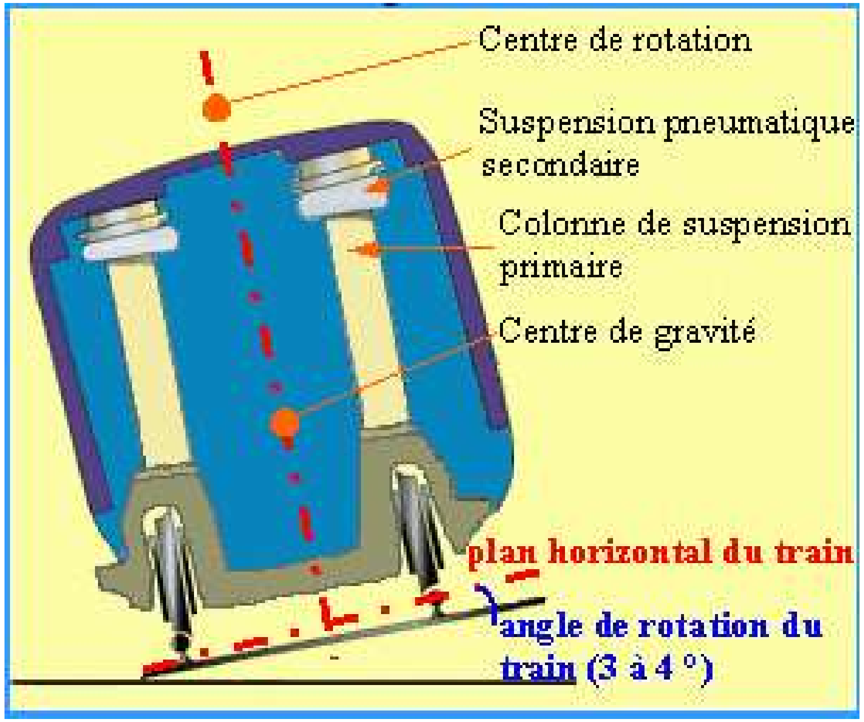
Vitesse d'équilibre



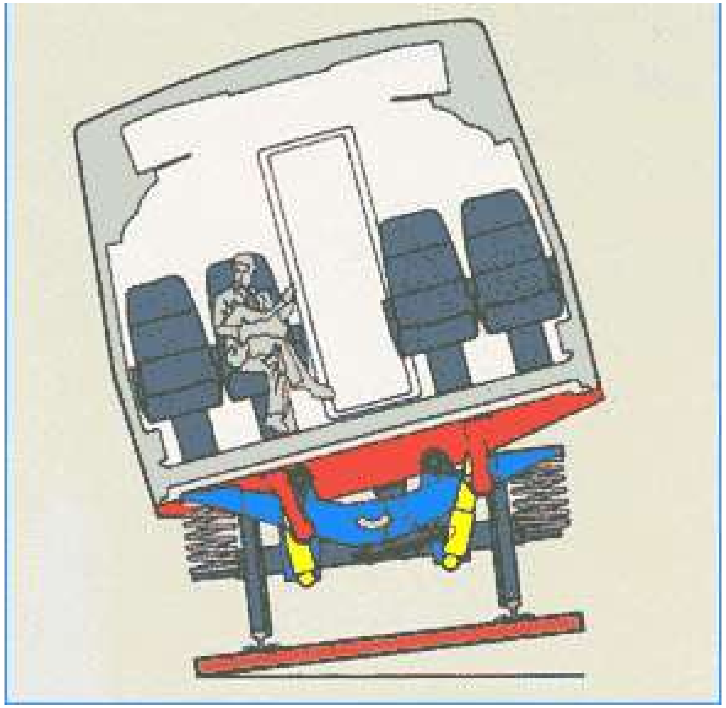
Avec Pendulation

La pendulation peut être

- Passive
- Active détectée
- Active programmée



Pendulation passive



Pendulation active

L'adhérence roue-rail

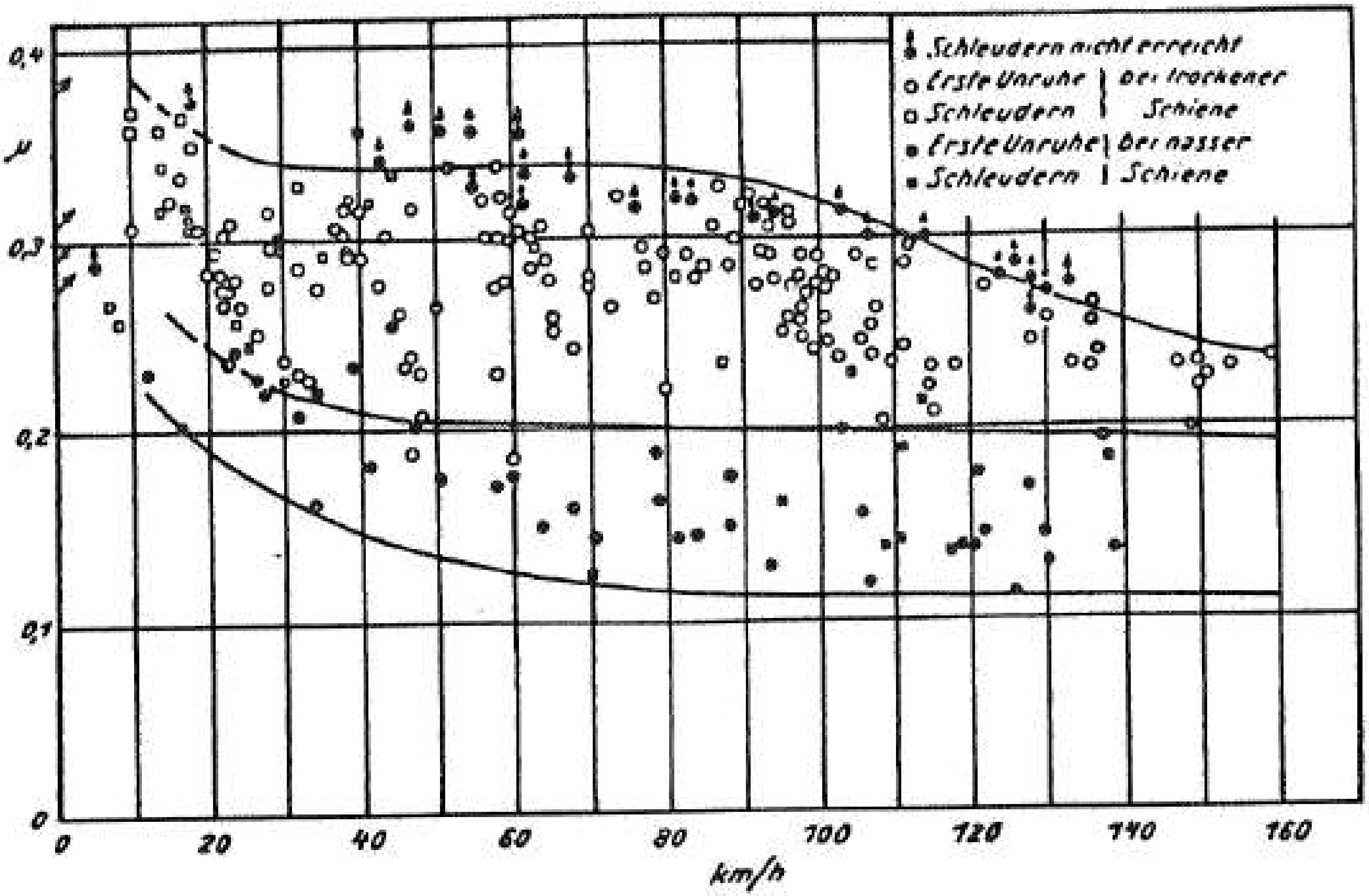


Bild 3b: Meßpunkte für Kraftschlußbeiwerte nach Curtius und Kniffler (1943)

La Traction

Taux de motorisation

Proportion d'essieux moteurs

Prise en compte de l'adhérence

Résistance à l'avancement

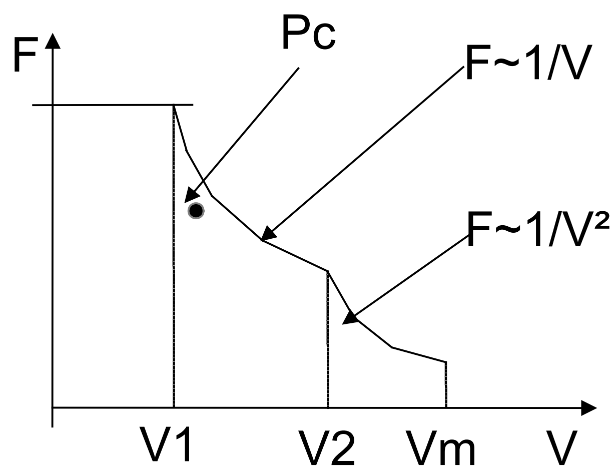
$Rav = A + B*V + C*V^2$

Accélération

$Gamma = (F-Rav-M*g*p) / (M+It)$

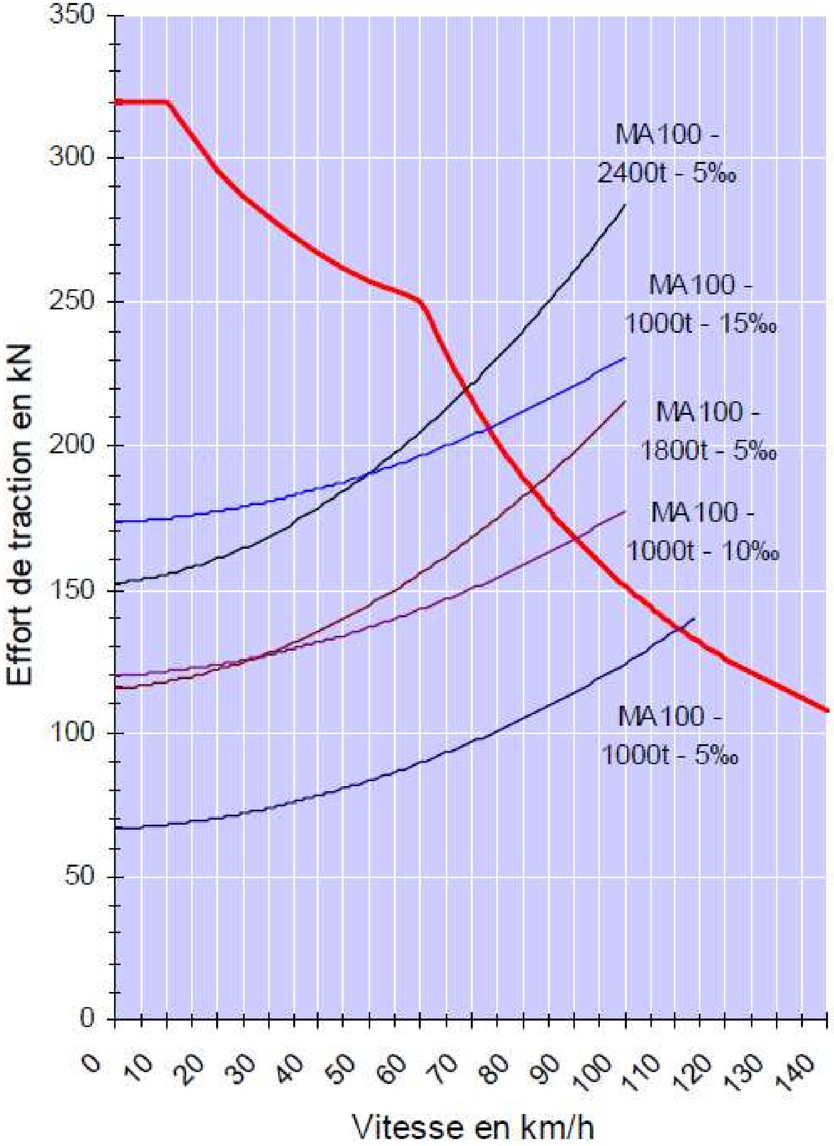
Risque de Patinage

Courbe Effort-Vitesse



SNCF BB 27000

COURBE EFFORT - VITESSE



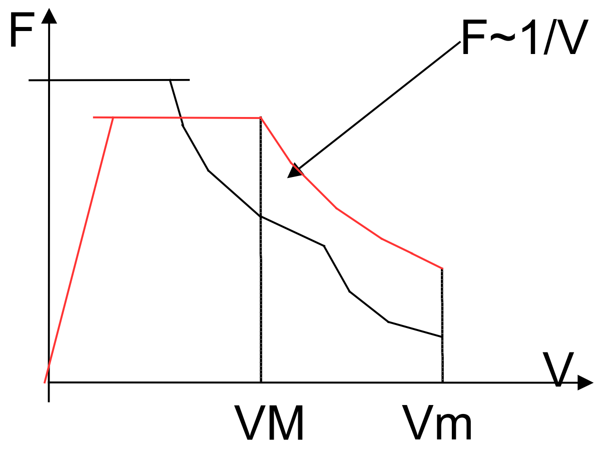
CARACTÉRISTIQUES GÉNÉRALES

Constructeur	Alstom
Date de construction	2000-2006
Système d'électrification	1,5 kV continu 25 kV 50 Hz
Puissance continue	4200 kW
Vitesse maximum	140 km/h
Effort au démarrage	320 kN
Effort au régime continu	250 kN à 57 km/h
Masse en ordre de marche	90 t
Configuration des essieux	Bo'Bo'
Gabarit	UIC 505-1
Longueur	19,720 m
Moteurs de traction	4 moteurs asynchrones
Frein électrique	À récupération et rhéostatique 2600 kW
Homologation	France, Luxembourg
Equipements de sécurité	KVB, RPS, radio GSMR, Memor II+ (Luxembourg)
Unité multiple	oui

Le Freinage

Types de freinage
- Electrique
  - Récupération
  - Rhéostatique
- Mécanique
  - Sabots
  - Disques
- Patins magnétiques
- Courant de Foucault

Courbe Effort-Vitesse
Du freinage électrique



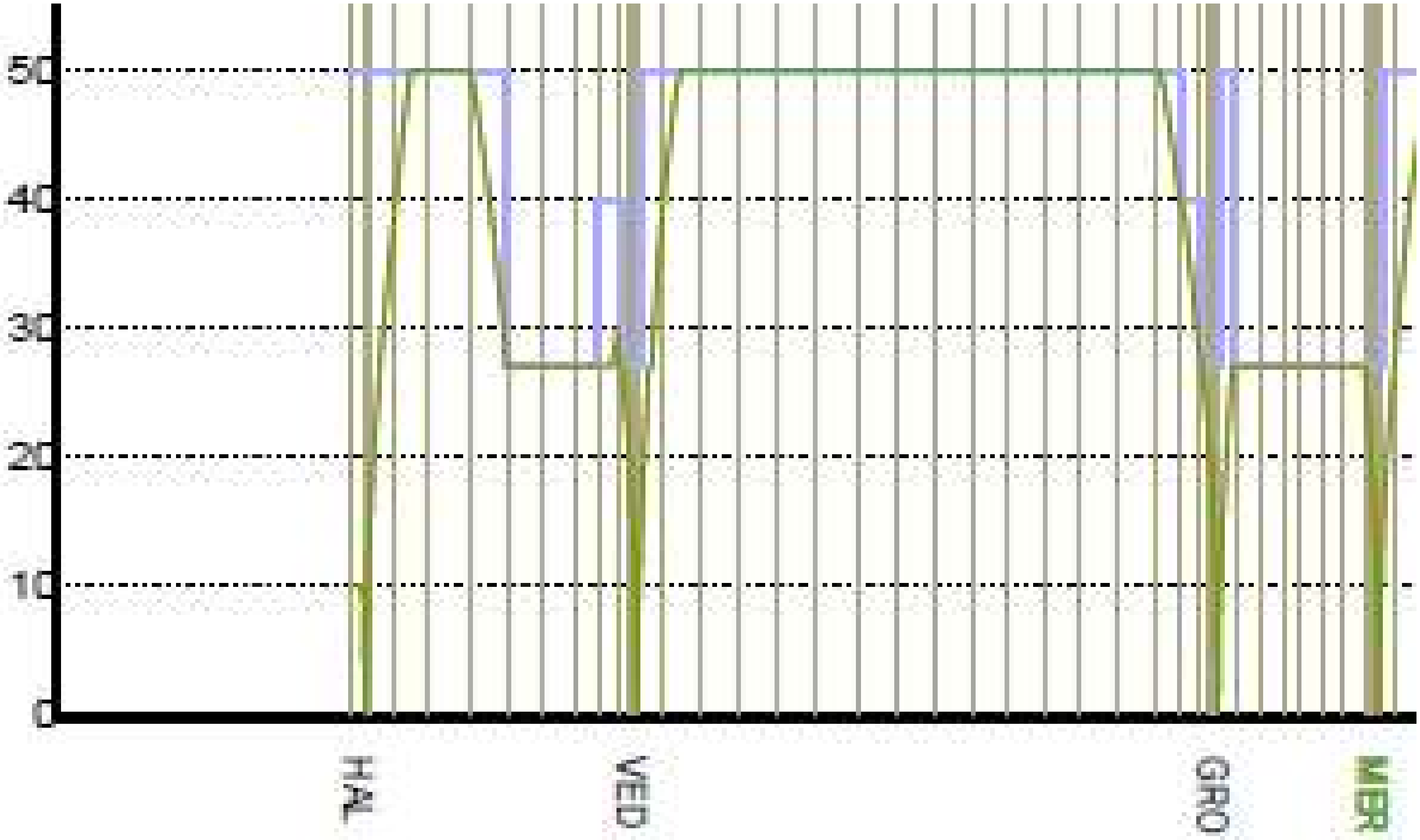
Conjugaison des freins

Décélération
- Gamma = (F+Rav+M*g*p) / (M+It)
- Risque d'enrayage

Frein d'immobilisation

Freinage de service, d'urgence, garanti - WCEB

Le diagramme espace-vitesse



La commande continue

Frein mécanique

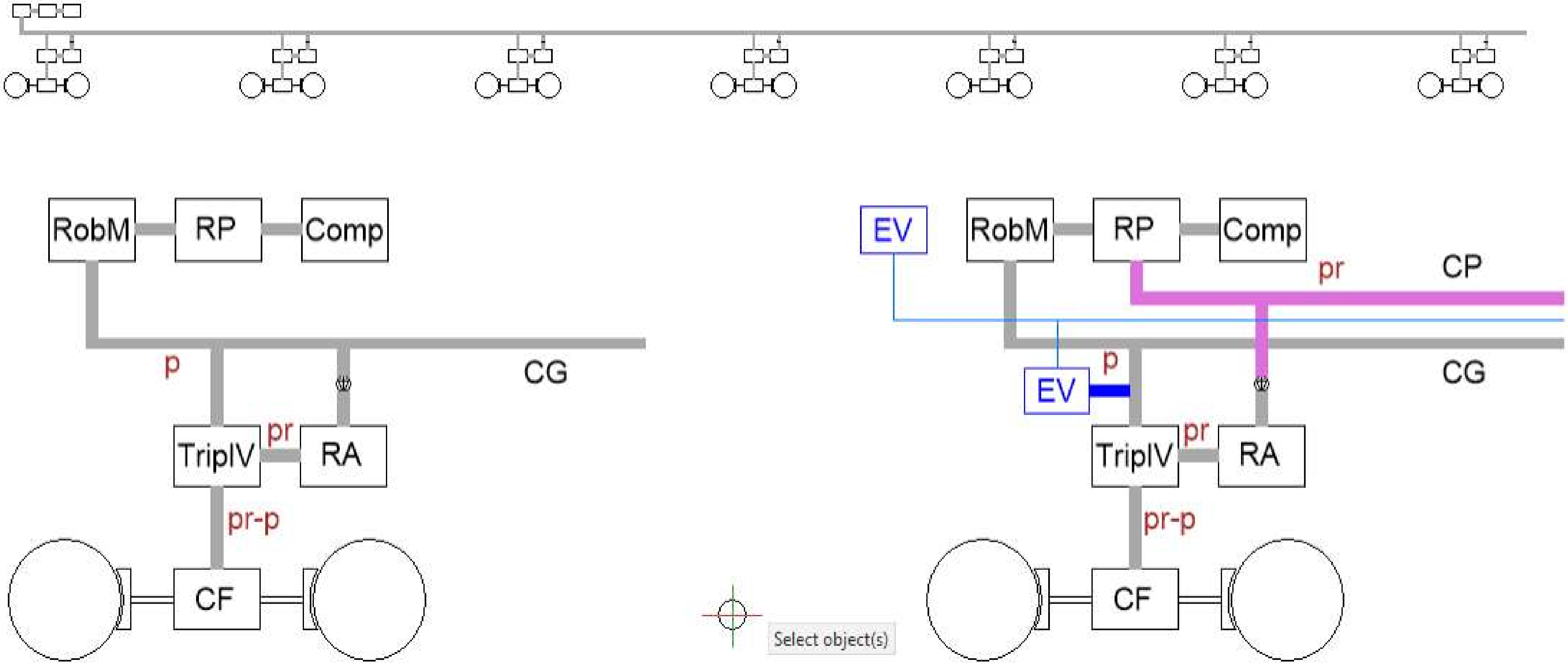
- Sifflet
- Conduite générale
- Conduite générale + principale
- Commande électro-pneumatique

Effort Traction / Freinage

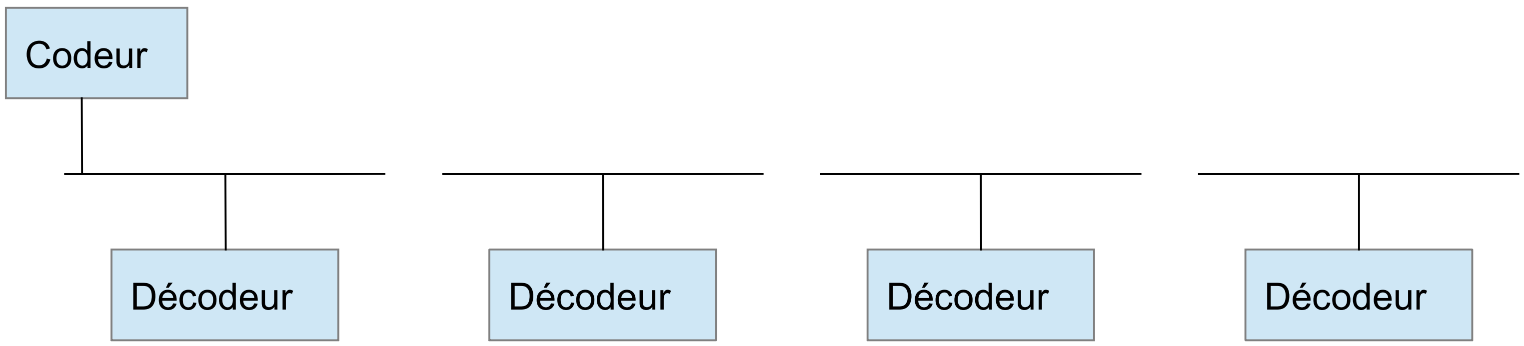
- Lignes de train par niveau
- Ligne de train codée (PWM, U, I)

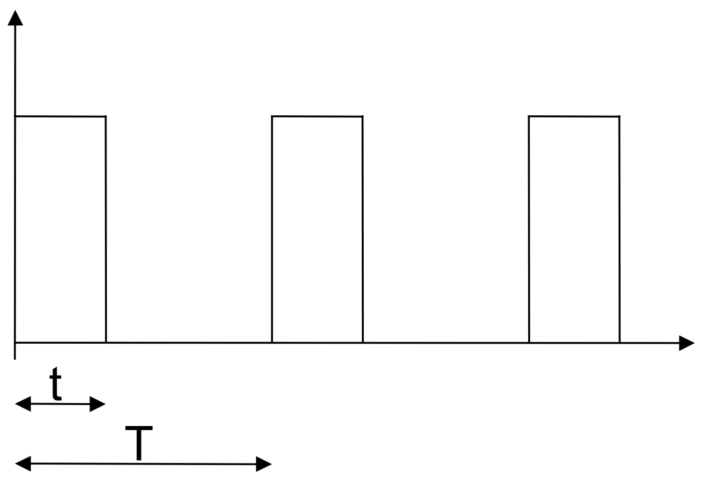
Poste de serre-frein

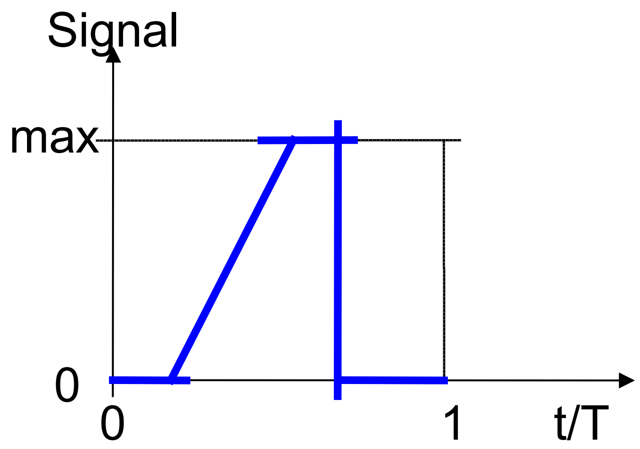
Commande pneumatique du frein



Le signal PWM







Les types de conduite

Sécurité

Second agent, homme mort, VACMA

Conduite

Manuelle, CMC, VI, PA, ATO (PAI)

Supervision

Temps, Signaux, Arrêt FU, KVB, ATP

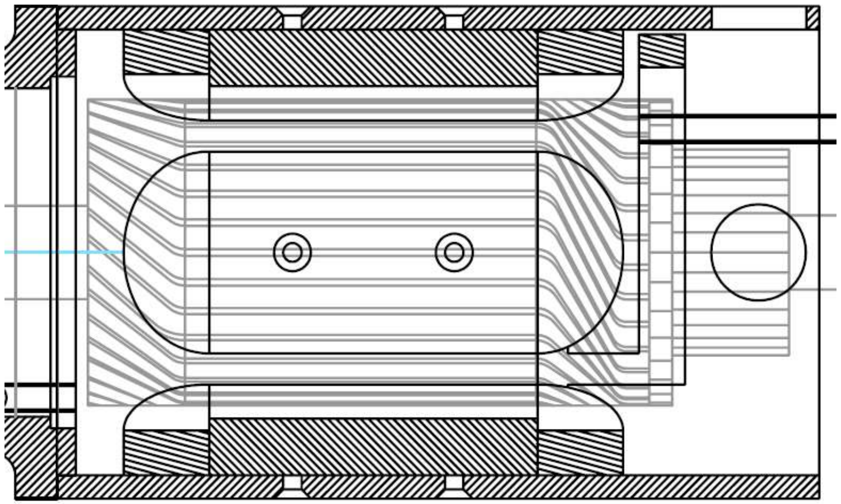
La Traction

Traction par câble

Traction à air comprimé

Traction thermique
- Transmission mécanique
- Transmission hydrostatique
- Transmission hydrodynamique
- Transmission électrique

Traction électrique
- Moteur à courant continu
  - Moteur série
  - Moteur compound
  - Limitation par le collecteur
- Moteur synchrone
- Moteur asynchrone
- Moteur à aimants permanents



Les deux formules de base

$$E = k\, N\, \Phi$$

$$C = k'\, \Phi\, I$$

La Voie

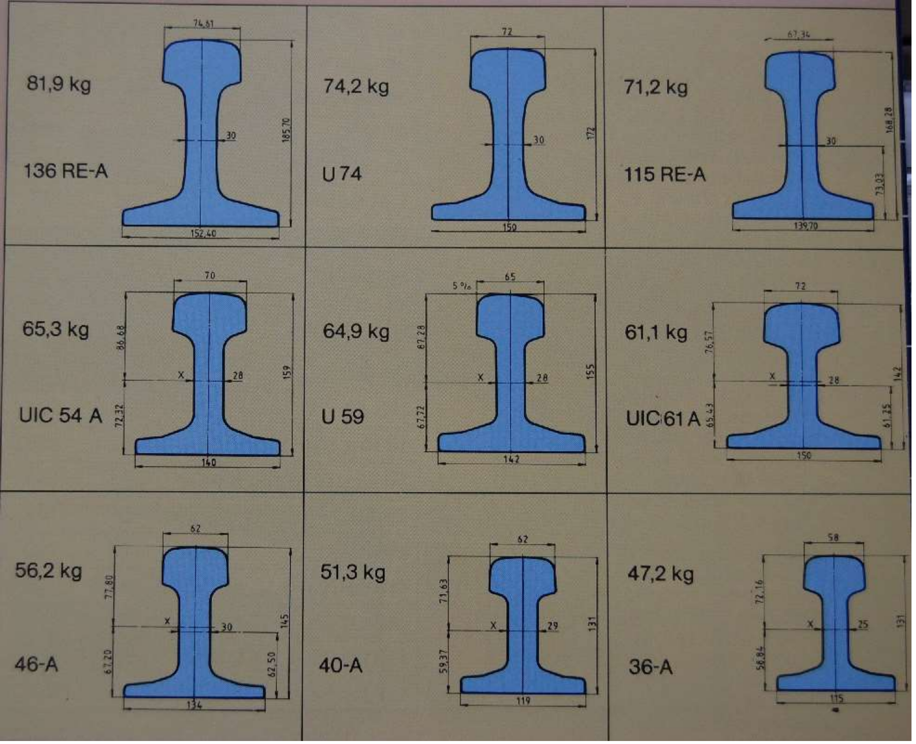
Ecartement

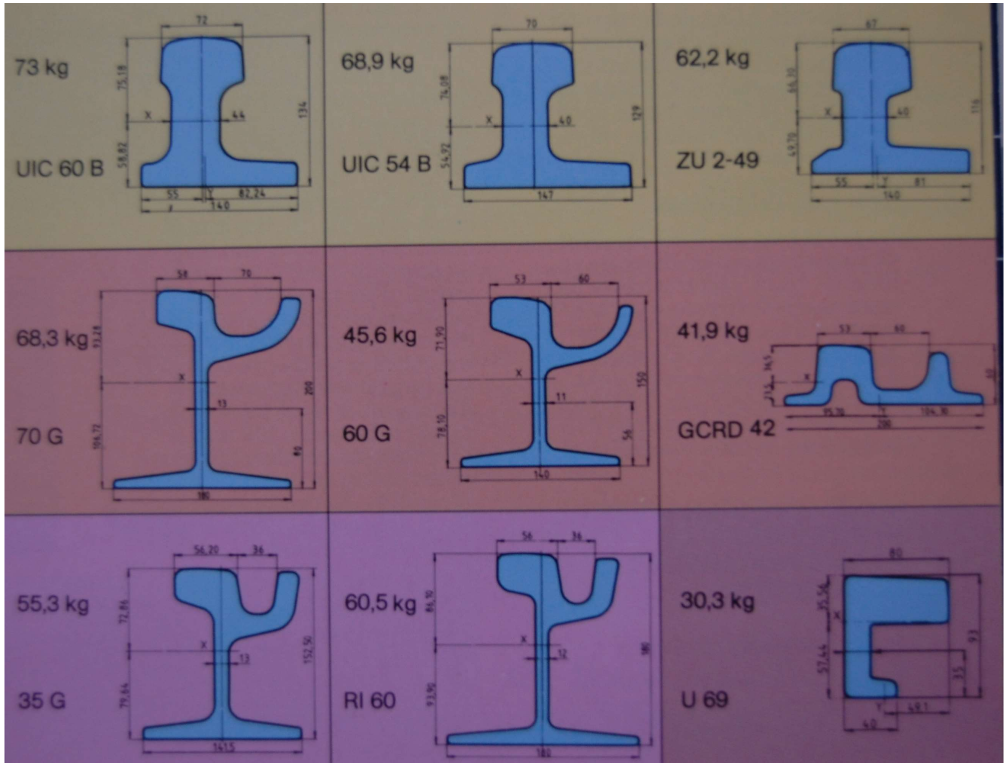
Type et Inclinaison du rail

Tolérances de pose et d’entretien

Appareils de voie

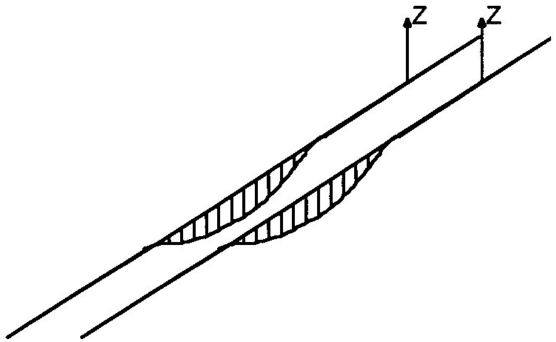
Écartement en mm	Appellation usuelle	Exemples de pays utilisateurs
2314	Voie large de Brunel	Ancien réseau du Great Western (UK)
1829	6 pieds	Moscou-Saint-Pétersbourg (Russie), lignes de l'Erie (États-Unis)
1676	5 1/2 pieds	Indes, Ceylan, Argentine, Chili
1672	6 pieds castillans	Espagne, Portugal
1600		Brésil, Irlande, Australie
1524	5 pieds	Russie, Roumanie, Chine, Finlande, Panama
1435	Voie normale	Europe, États-Unis, Uruguay, Pérou, Afrique
1300		Brésil
1270		Chili
1190		Indes orientales
1118		Espagne
1090		Suède
1067	3 1/2 pieds	Afrique, Chili, Colombie, Australie, Hongrie, Japon, Norvège, Nouvelle-Zélande, Soudan, Venezuela, Tasmanie, Russie
1050		Palestine, Algérie
1000	Voie métrique	Europe (sauf UK), Afrique, Afrique du Sud, Mexique, Pérou, La Réunion, Sénégal, Ouganda, Venezuela
950		Sicile, Sardaigne, Italie
914		Colombie, Cuba, Ouest des USA, île de Man, Mexique, Pérou, Salvador, Royaume-Uni
900		Autriche, Allemagne, Portugal
891		Suède
826		Royaume-Uni
800		Suisse, Suède
785		Finlande, Allemagne
762	2 pieds 6 pouces	Brésil, Le Cap, Ceylan, Chypre, Royaume-Uni, Japon, Mexique, Nigeria, Saint-Domingue
760		Autriche, Bulgarie, Yougoslavie, Pologne
750		Algérie, Argentine, Congo, Estonie, Hongrie, Lettonie, Norvège, Pologne, Suisse, Tanzanie
724		Royaume-Uni
711		Royaume-Uni
700		Luxembourg
686		Royaume-Uni
610	2 pieds	Indes, Japon, USA, Tasmanie, Afrique du Sud, Venezuela
600	Decauville	Algérie, Maroc, France, ouvrages militaires, réseaux industriels
500	Decauville	Réseaux industriels, forestiers, parcs
400	Decauville	Réseaux maraîchers
381	15 pouces	Royaume-Uni (Romney, Hythe & Dymchurch), parcs d'attractions


81,9 kg
136 RE-A
74,2 kg
U 74
71,2 kg
115 RE-A
65,3 kg
UIC 54 A
64,9 kg
U 59
61,1 kg
UIC 61 A
56,2 kg
46-A
51,3 kg
40-A
47,2 kg
36-A

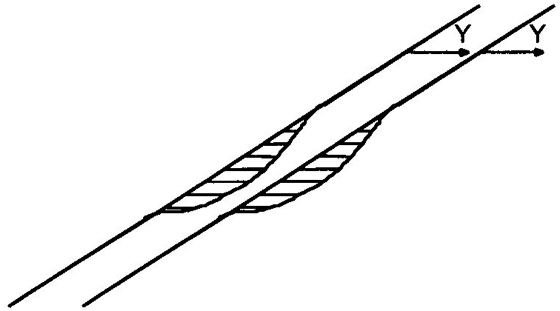

73 kg
UIC 60 B
68,9 kg
UIC 54 B
62,2 kg
ZU 2-49
68,3 kg
70 G
45,6 kg
60 G
41,9 kg
GCRD 42
55,3 kg
35 G
60,5 kg
RI 60
30,3 kg
U 69

DESCRIPTION DES DEFAUTS DE VOIE

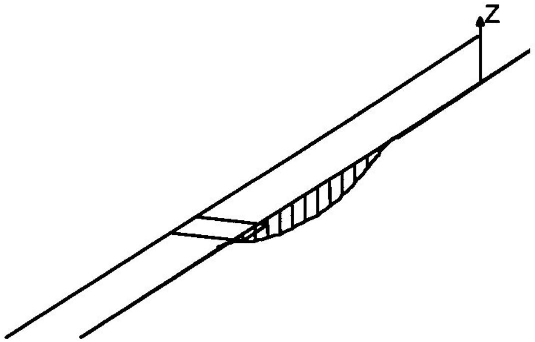
Les défauts de voie décrivent l'écart entre la voie réelle et la voie spécifiée. Les courbes, raccordements paraboliques, dévers et variations de dévers ne sont pas considérés comme des défauts.



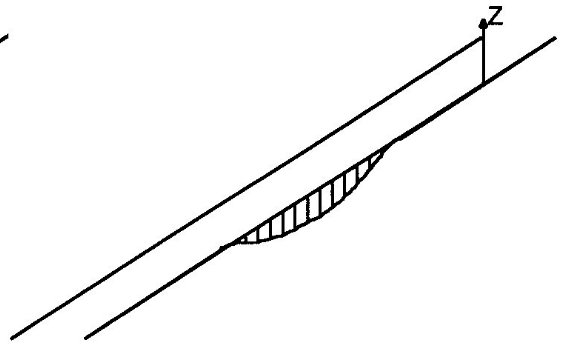
Surface
Nivellement longitudinal



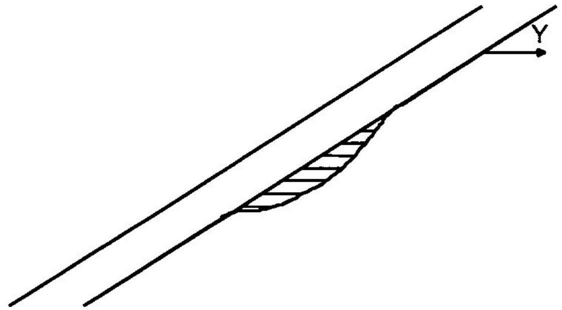
Alignment
Dressage



Warp (US), Twist (GB)
Gauche, Ecart de dévers
Variation de dévers sur
longue distance



Cant, Elevation, Superelevation
Nivellement transversal



Track gage
Ecartement

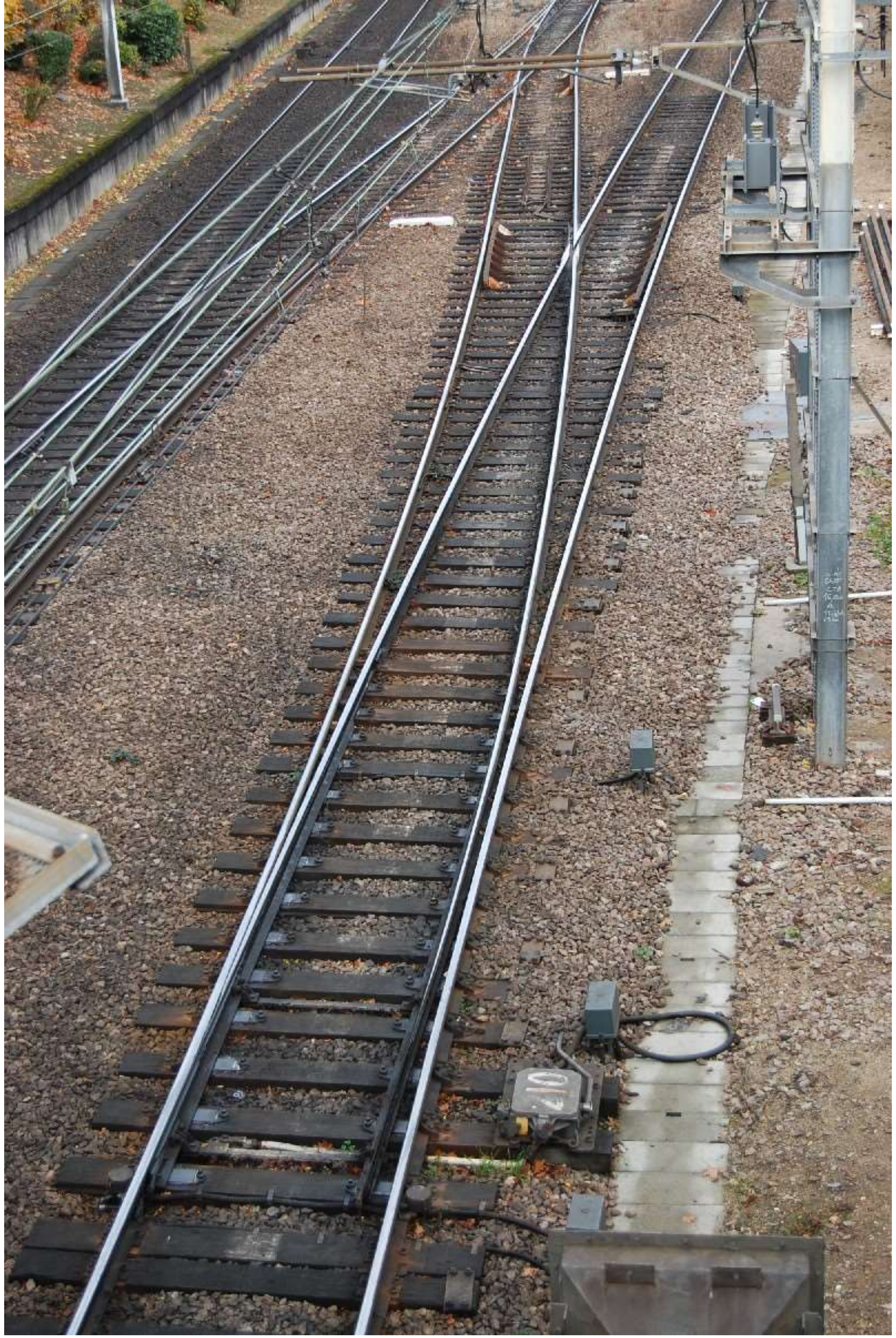
SAFETY LEVEL ONE GEOMETRY TABLE

	Max. speed km/h (mph)	322 (200)	230 (143)	170 (105)	100 (62)	80 (50)	60 (37)	40 (25)
Alignment (mm)	10	9	10	13	16	17	21	24
	20	9	10	13	16	17	21	24
	31	15	18	18	NA	NA	NA	NA
Surface (mm)	[5] 12.2	11	13	16	18	19	21	52
	31	18	22	22	NA	NA	NA	NA

SAFETY LEVEL ONE GEOMETRY TABLE

	Max. speed km/h (mph)	322 (200)	230 (143)	170 (105)	100 (62)	80 (50)	60 (37)	40 (25)
Gage (mm) [1]	minimum	−7	−9	−12	−12	−12	−12	−12
	min. mean value [2]	−4	−7	−7	−7	NA	NA	NA
	maximum [3]	+27	+27	+35	+35	+35	+35	+37
Gage Variation [4]	mm on 10 m base	15	15	15	15	NA	NA	NA
Cant (mm)	maximum	180	180	180	180	180	180	180
	Chord (m)							
Alignment (mm)	10	12	14	17	21	23	28	32
	20	12	14	17	21	23	28	32
	31	20	24	24	NA	NA	NA	NA
Surface (mm)	[5] 12.2	15	18	22	24	26	28	70
	31	24	30	30	NA	NA	NA	NA
Warp (mm)	[6] 10	15	15	18	18	18	24	24

[1] With respect to the nominal track gage, 1435 mm (56.5 in).
[2] Mean value on a 100 m (328 ft) length of track.
[3] Local defect value > +20 mm (0.79 in) has to be corrected.
[4] Gage variation is defined as the difference between the minimum and maximum gage measurements within 10 meters.
[5] The maximum values indicated on this line are not mid-chord offsets but are the difference between the average level at eight locations spaced symmetrically from the center at 0.675 m, 2.075 m, 3.64 m, and 6.11 m and a location at 0.675 m from the center. $Surface_{12.2} = \frac{1}{8}(Z_{-6.11}+Z_{-3.64}+Z_{-2.075}+Z_{-0.675}+Z_{0.675}+Z_{2.075}+Z_{3.64}+Z_{6.11}) - Z_{0.675}$
[6] Difference between the cross level value at any location and the mean value of the crosslevel over a distance of +/−5.0 m (16.4 ft).



Les aiguillages

Comportement
- Non talonnable
- Talonnable
  - Avec retour en position
  - Sans retour en position

Commande
- Manuelle
- Télécommande locale
- Télécommande à distance


VAL


10


30
8

La captation aérienne

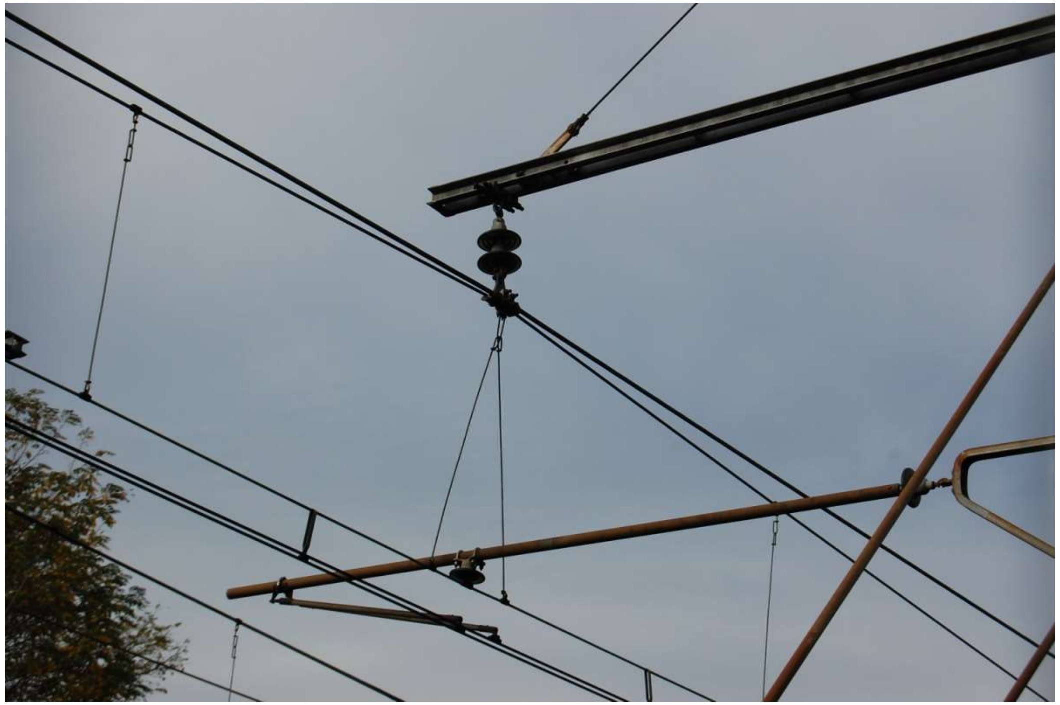
- Ligne d'alimentation
  - Caténaire
  - Fil trolley
  - Caténaire rigide
  - Point fixe d’alimentation

- Pantographe
  - Lyre
  - Traditionnel
  - Bras unique
  - Deux étages

- Perche

Tension	Fréquence	Alimentation
V	Hz	Type
160	CC	3e rail
180		
500	CC	
525	CC	ligne aérienne
550	CC	ligne aérienne
		3e rail
600	**CC**	**ligne aérienne**
		3e rail
650	CC	3e rail
725	50Hz triphasé	ligne aérienne 2 fils
750	**CC**	**caténaire**
		3e rail
825	CC	3e rail
850	CC	caténaire
		3e rail
860	CC	
900	CC	
950	CC	
1000	CC	3e rail
1125	50Hz triphasé	ligne aérienne 2 fils
1200	CC	caténaire
		3e rail

Tension	Fréquence	Alimentation
V	Hz	Type
1350	CC	
1500	**CC**	**caténaire**
2400	CC	
3000	**CC**	**caténaire**
	50Hz triphasé	ligne aérienne 2 fils
3500	CC	ligne aérienne
3600	16Hz2/3 triphasé	caténaire 2 fils
6000	CC	
6250	50Hz	
6300	25Hz	
11000	16Hz2/3	
	25Hz	
12000	16Hz2/3	caténaire
	25Hz	caténaire
12500	60Hz	
15000	**16Hz2/3**	**caténaire**
	Variable 0-50Hz	ligne aérienne 3 fils
20000	50Hz	
	60Hz	
25000	**50Hz**	
	60Hz	
50000	50Hz	




SEC
500
SEC
500


Sortie
correspondance

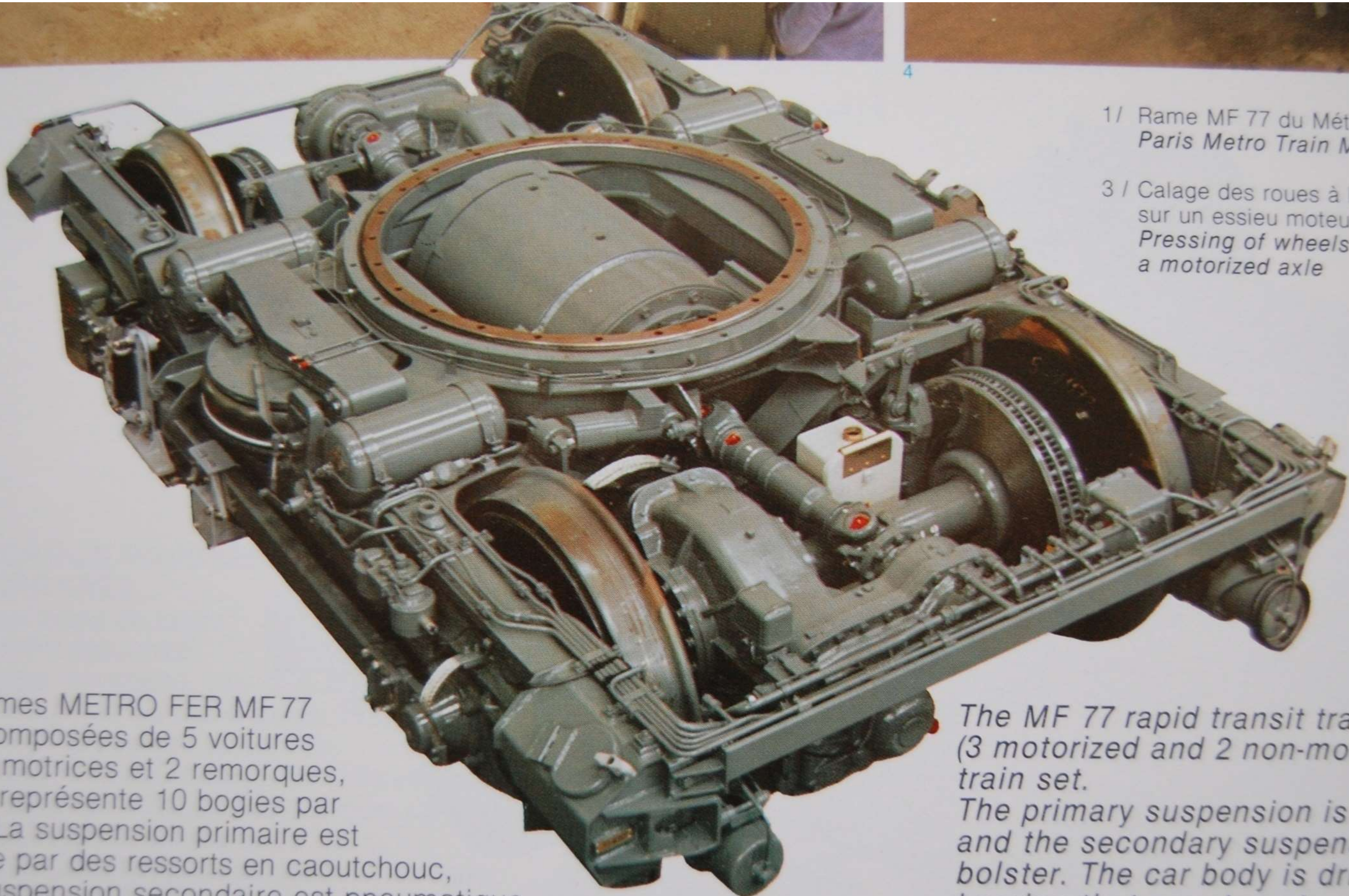
Voici sur quels réseaux étaient utilisés ces différents pantographes[1] :

	Pantographe 1	Pantographe 2		Pantographe 3	Pantographe 4		
Réseaux	**SNCF**	**SNCF**	**FS**	**CFF**	**SNCB**	**NS**	**DB** et **ÖBB**
Courant capté	continu	alternatif	continu	alternatif	continu		alternatif
Tension	1 500 V	25 kV 50 Hz	3 000 V	15 kV 16,7 Hz	3 000 V	1 500 V	15 kV 16,7 Hz
Conception palette	palette double	palette simple		palette simple	palette double		
Largeur palette	1 950 mm	1 450 mm		1 320 mm	1 950 mm		
Matière palette	cuivre-fer	cuivre-fer		aluminium	carbone		
Panto de réserve pour	FS	—		FS	SNCF (CA 25 kV 50 Hz)		

Le Bogie

Eléments du bogie

- Chassis
- Roues – Essieux – Boîtes d'essieu
- Freins
- Moteurs – transmission
- Suspensions primaire et secondaire (ressorts / air)
- Liaison caisse-bogie
- Captage de courant 3ème rail



4

1/ Rame MF 77 du Métro c
Paris Metro Train MF 7

3 / Calage des roues à la p
sur un essieu moteur
Pressing of wheels on
a motorized axle

rames METRO FER MF 77
composées de 5 voitures
3 motrices et 2 remorques,
ui représente 10 bogies par
e. La suspension primaire est
sée par des ressorts en caoutchouc,
suspension secondaire est pneumatique,
une traverse de charge. L'entraînement de la caisse est

The MF 77 rapid transit train
(3 motorized and 2 non-motor
train set.
The primary suspension is m
and the secondary suspensio
bolster. The car body is drive
bearing that counteracts a s
rotation and minimizes wear

La Caisse

Chaudron
- Gabarit
- Résistance (charge, déformation, compression)
- Ouvertures (porte, fenêtres)
- Ancrage des équipements

Portes

Fenêtres, points d'appui

Intercirculation

Eclairage

Ventilation / Climatisation

Information passagers (y compris système d'alarme voyageurs)

Les Auxiliaires

Convertisseur d'alimentation des auxiliaires
- Eclairage
- Ventilation / Climatisation
- Portes
- Information des voyageurs

Groupe compresseur et réservoir d'air
- Freinage mécanique
- Portes

Batterie et son chargeur
- Eclairage secouru
- Commande continue (y compris portes)
- Alarme voyageurs


FERNET-BRANCA
3
TISSOT
Union de
1


115
M1 115


PASSAGE APS
LAURIERS
30


626


Pyramides
Pyramides
M 14
DIRECTION
Saint-Lazare
M 7
Sortie


RER
1541

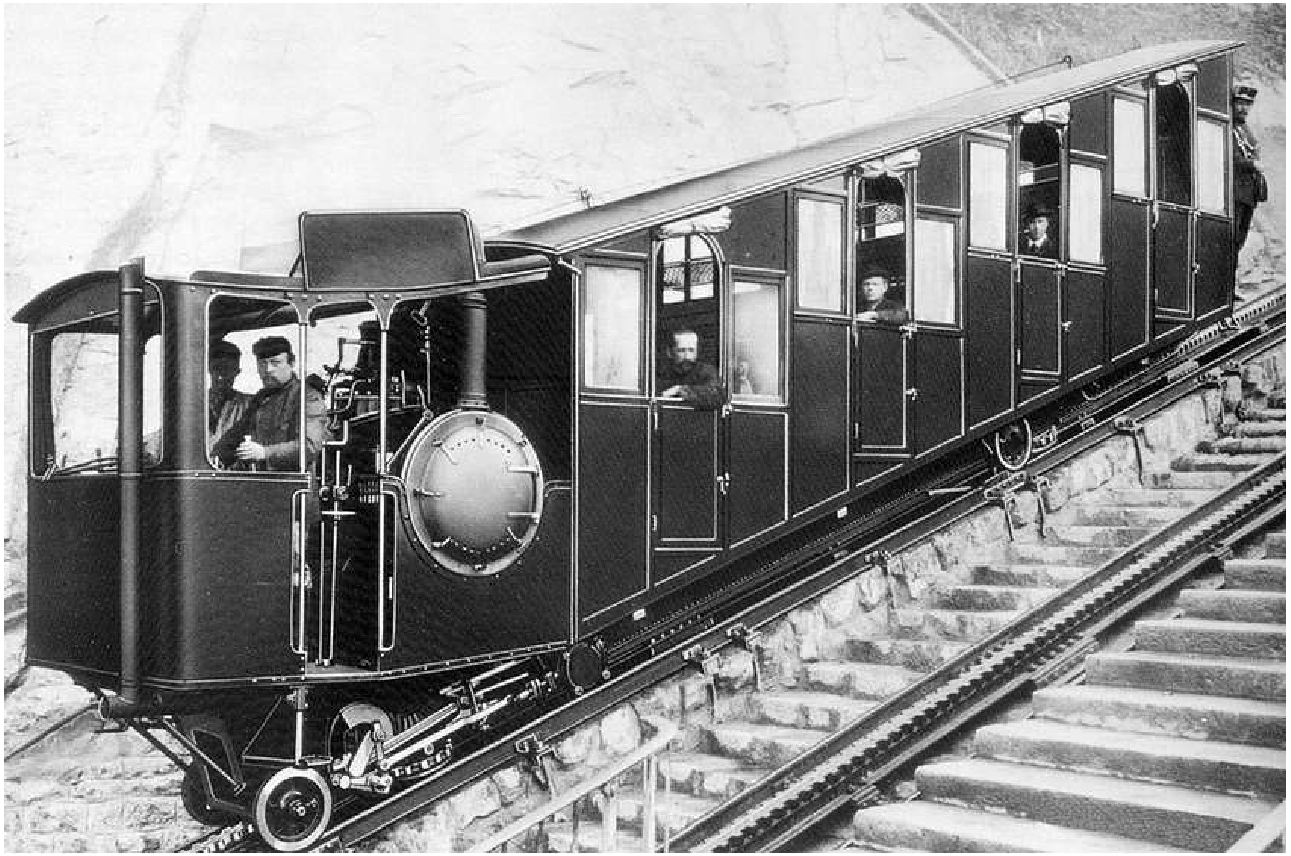

ACTON TOWN
EALING COMMON


Nf
70
30
Nf


213


Train à crémaillère sur le Pilate
DONNÉES TECHNIQUES
PLUS


Mai à novembre
TRAJET AU POSTE DU CONDUCTEUR
PLUS



La maintenance préventive

- Visite (préparation du train, quotidien)
  - Nettoyage, contrôle visuel
- Inspection en Service (atelier, hebdomadaire)
  - Contrôle des équipements, vidange des toilettes
- Révision (atelier, mensuel)
  - Vérification des équipements
- Révision Générale (atelier, annuel)
  - Remplacement d'équipements
- Grande Révision Générale (atelier, pluriannuel)
  - Reprise partielle du véhicule
- Mi-Vie (environ 20 ans)
  - Reprise totale du véhicule

La maintenance curative

Contrairement à la maintenance préventive cette maintenance ne peut pas être planifiée

Maintenance accidentelle

- Panne, dysfonctionnement
- Accident, choc

Maintenance prédictive

- Détection de signes avant-coureurs de panne

Installations de Maintenance

Machines outils (tour, fraise, scie, meule, ...)

Machine à laver

Voie sur fosse

Passerelles d’accès toiture

Tour à roues

La marche des trains

Marche tendue

Pleine performance en traction, vitesse, freinage

Marche détendue (ou commerciale)

Réserve de temps fonction de t ou de x

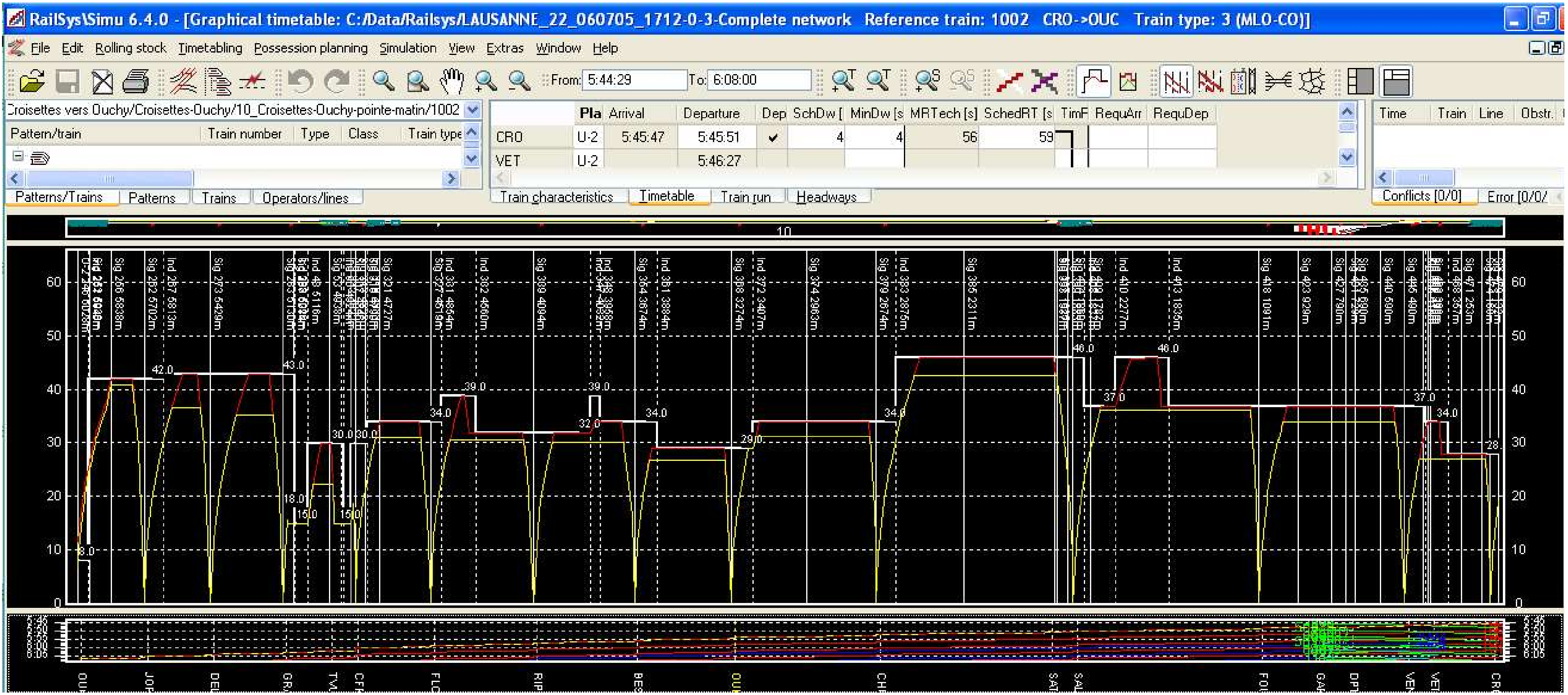
Marche contractuelle

Performance exigée au cahier des charges

Spécification des pénalités

Marche dégradée

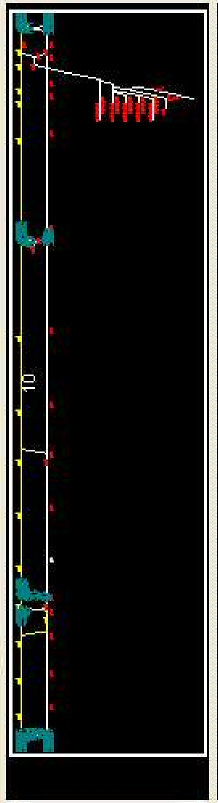
Un équipement de traction et/ou freinage hors service

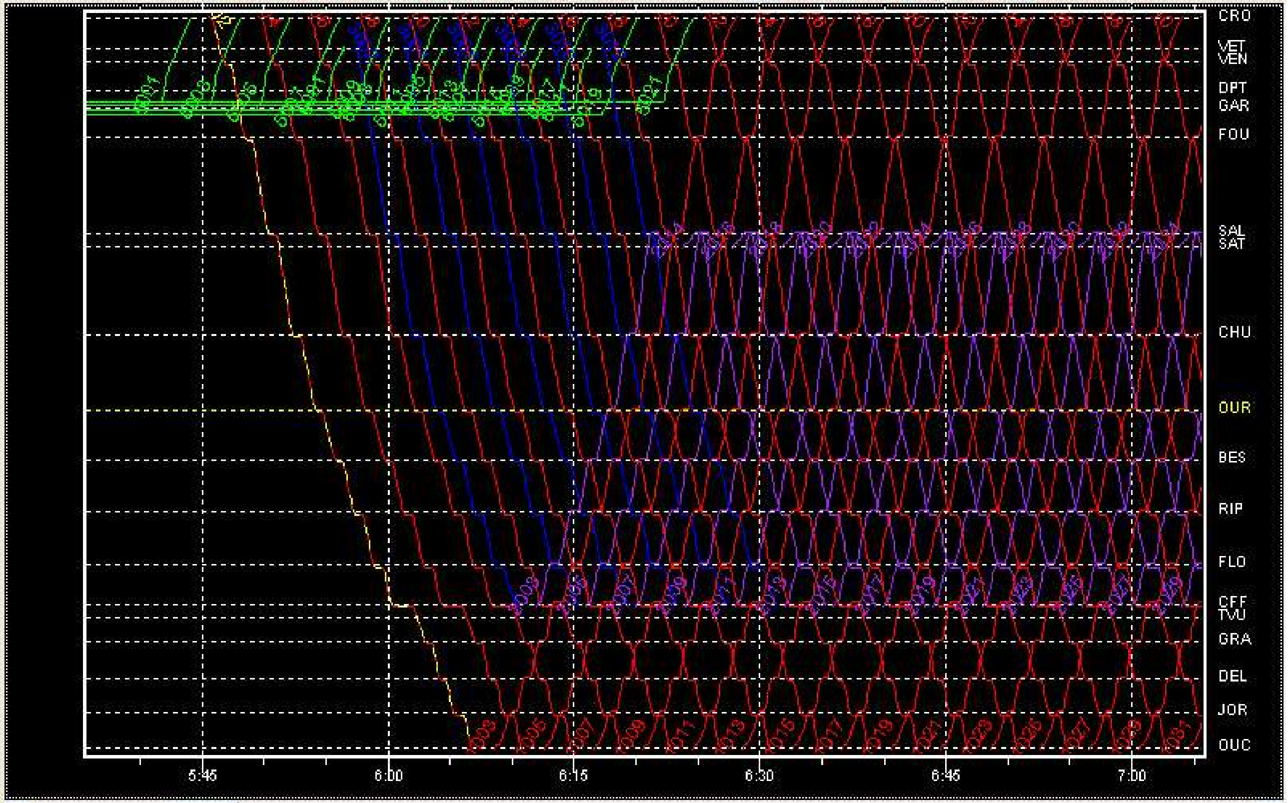

RailSys\Simu 6.4.0 - [Graphical timetable: C:/Data/Railsys/LAUSANNE_22_060705_1712-0-3-Complete network Reference train: 1002 CRO->OUC Train type: 3 (MLO-CO)]
File Edit Rolling stock Timetabling Possession planning Simulation View Extras Window Help
From: 5:44:29
To: 6:08:00
Croisettes vers Ouchy/Croisettes-Ouchy/10_Croisettes-Ouchy-pointe-matin/1002
Pattern/train Train number Type Class Train type
Patterns/Trains Patterns Trains Operators/lines
Pla Arrival Departure Dep SchDw MinDw MRTech [s] SchedRT [s TimF RequArr RequDep
CRO U-2 5:45:47 5:45:51 4 4 56 59
VET U-2 5:46:27
Train characteristics Timetable Train run Headways
Time Train Line Obstr.
Conflicts [0/0] Error [0/0/
OUC JOR DEL GR TV CF FLO RIP BES OUI CHI SAT SAL FOI GAI DPI VEN VET CR

	Pla	Arrival	Departure
CRO	U-2	5:45:47	5:45:51
VET	U-2		5:46:27
VEN	U-2	5:46:50	5:47:18
DPT	U-2		5:47:43
GAR	U-2		5:47:54
FOU	U-2	5:48:36	5:49:00
SAL	U-2	5:50:31	5:51:00
CHU	U-2	5:52:28	5:52:56
OUR	U-2	5:54:18	5:54:46
BES	U-2	5:55:51	5:56:19
RIP	U-2	5:57:23	5:57:56
FLO	U-2	5:59:00	5:59:34
CFF	U-2	6:00:24	6:02:00
TVU	U-1		6:02:26
GRA	U-2	6:03:10	6:03:34
DEL	U-2	6:04:19	6:04:44
JOR	U-2	6:05:26	6:06:11
OUC	U-2	6:06:48	6:06:49

Train characteristics | Timetable | Train r

Time	Train	Line	Obstr.	Obstr.	Location





Le roulement des trains

Attribution des journées

- Horaires
- Retournements

Créneaux pour révision

- Petites révisions
- Grandes révisions
- GRG (grande révision générale)

Trains en réserve

Parc de matériel roulant

```
  5001    1    0      4
TAKT: /Ouchy vers Croisettes/Degarage/5001
OPDAY 127   0
      GAR    5:00:00    1    5:00:00    4:02:31    5:41:46    D-3 5955 X       1
      VEN                               5:42:42    5:42:42    D-3              1
      VET                               5:43:07    5:43:07    D-1              1
      CRO               1               5:44:15    5:44:16    D-2    1         1

  5003    1    0      4
TAKT: /Ouchy vers Croisettes/Degarage/5003
OPDAY 127   0
      GAR    5:04:00    1    5:04:00    4:02:13    5:45:35    E-3 6202 X       1
      VEN                               5:46:42    5:46:42    D-3              1
      VET                               5:47:07    5:47:07    D-1              1
      CRO               1               5:48:15    5:48:16    D-2    1         1

  1002    3    0     18 1002
TAKT: /Croisettes vers Ouchy/Croisettes-Ouchy/10_Croisettes-Ouchy-pointe-matin/1002
OPDAY 127   0
      CRO               4               5:45:47    5:45:51    U-2    4 X       3
      VET                                                     U-2              3
      VEN              28               5:46:50    5:47:18    U-2   28         3
      DPT                                                     U-2              3
      GAR                                                     U-2              3
      FOU              24               5:48:36    5:49:00    U-2   24         3
      SAL              28               5:50:31    5:51:00    U-2   29         3
      CHU              28               5:52:28    5:52:56    U-2   28         3
      OUR              28               5:54:18    5:54:46    U-2   28         3
      BES              28               5:55:51    5:56:19    U-2   28         3
      RIP              33               5:57:23    5:57:56    U-2   33         3
      FLO              34               5:59:00    5:59:34    U-2   34         3
      CFF              46               6:00:24    6:02:00    U-2   96         3
      TVU                                                     U-1              3
      GRA              24               6:03:10    6:03:34    U-2   24         3
      DEL              25               6:04:19    6:04:44    U-2   25         3
      JOR              25               6:05:26    6:06:11    U-2   45         3
      OUC               1               6:06:48    6:06:49    U-2    1         3
```

Le roulement des trains

Minimum turn back time for TOK threshold is:
240 sec in general except as follows
35 sec for CFF TVU SAT VET
46 sec for OUC CRO

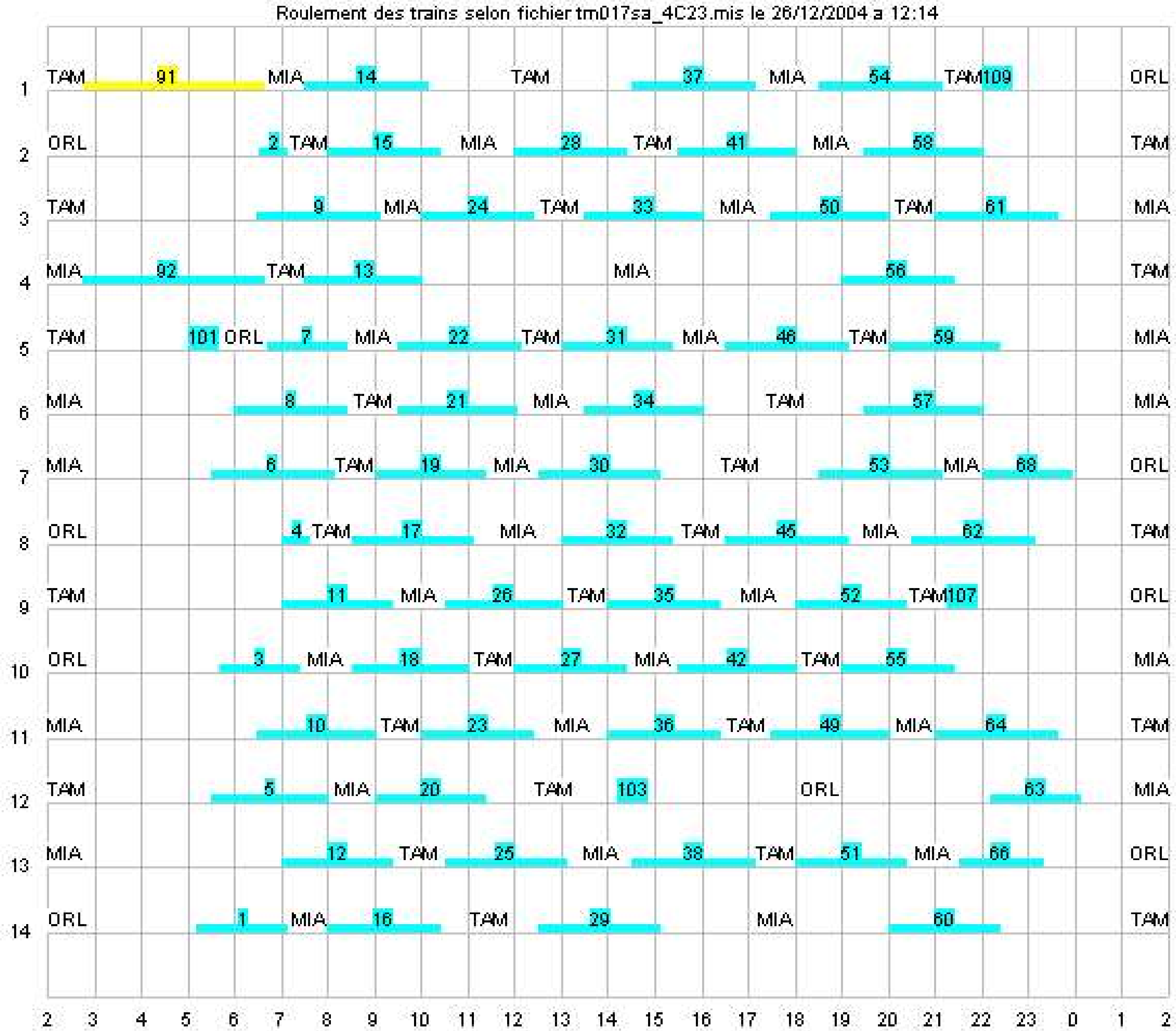
No	Day	Train	Deptime	Depstat	Arrtime	Arrstat	Turnback	TOK
1	1	5001	05:41:46	GAR3	05:44:15	CRO2	00:01:36	---
2	1	1002	05:45:51	CRO2	06:06:48	OUC2	00:02:02	---
3	1	1003	06:08:50	OUC2	06:28:10	CRO2	00:01:41	---
4	1	1024	06:29:51	CRO2	06:50:48	OUC2	00:02:02	---
5	1	1025	06:52:50	OUC2	07:12:10	CRO2	00:01:41	---
6	1	1046	07:13:51	CRO2	07:34:48	OUC2	00:02:02	---
7	1	1047	07:36:50	OUC2	07:56:10	CRO2	00:01:41	---
8	1	1068	07:57:51	CRO2	08:18:48	OUC2	00:02:02	---
9	1	1069	08:20:50	OUC2	08:40:10	CRO2	00:02:25	---
10	1	1224	08:42:35	CRO2	09:03:35	OUC2	00:04:05	---
11	1	1227	09:07:40	OUC2	09:27:00	CRO2	00:03:35	---
12	1	1240	09:30:35	CRO2	09:51:35	OUC2	00:04:05	---
13	1	1243	09:55:40	OUC2	10:15:00	CRO2	00:03:35	---
14	1	1256	10:18:35	CRO2	10:39:35	OUC2	00:04:05	---
15	1	1259	10:43:40	OUC2	11:03:00	CRO2	00:03:35	---
16	1	1272	11:06:35	CRO2	11:27:35	OUC2	00:04:05	---
17	1	1275	11:31:40	OUC2	11:51:00	CRO2	00:03:35	---
18	1	1288	11:54:35	CRO2	12:15:35	OUC2	00:04:05	---
19	1	1291	12:19:40	OUC2	12:39:00	CRO2	00:03:35	---
20	1	1304	12:42:35	CRO2	13:03:35	OUC2	00:04:05	---
21	1	1307	13:07:40	OUC2	13:27:00	CRO2	00:03:35	---
22	1	1320	13:30:35	CRO2	13:51:35	OUC2	00:04:05	---
23	1	1323	13:55:40	OUC2	14:15:00	CRO2	00:03:35	---
24	1	1336	14:18:35	CRO2	14:39:35	OUC2	00:04:05	---
25	1	1339	14:43:40	OUC2	15:03:00	CRO2	00:03:35	---
26	1	1352	15:06:35	CRO2	15:27:35	OUC2	00:04:05	---
27	1	1355	15:31:40	OUC2	15:51:00	CRO2	00:03:35	---
28	1	1368	15:54:35	CRO2	16:15:35	OUC2	00:04:05	---
29	1	1371	16:19:40	OUC2	16:39:00	CRO2	00:00:51	---
30	1	1510	16:39:51	CRO2	17:00:48	OUC2	00:02:02	---
31	1	1515	17:02:50	OUC2	17:22:10	CRO2	00:01:41	---
32	1	1532	17:23:51	CRO2	17:44:48	OUC2	00:02:02	---
33	1	1537	17:46:50	OUC2	18:06:10	CRO2	00:01:41	---
34	1	1554	18:07:51	CRO2	18:28:48	OUC2	00:02:02	---
35	1	1559	18:30:50	OUC2	18:51:46	CRO2	00:03:49	---
36	1	1722	18:55:35	CRO2	19:17:11	OUC2	00:03:39	---
37	1	1727	19:20:50	OUC2	19:40:00	CRO2	00:03:35	---
38	1	1738	19:43:35	CRO2	20:05:11	OUC2	00:03:39	---
39	1	1743	20:08:50	OUC2	20:28:00	CRO2	00:03:35	---
40	1	1754	20:31:35	CRO2	20:53:11	OUC2	00:03:39	---
41	1	1759	20:56:50	OUC2	21:16:00	CRO2	00:03:35	---
42	1	1770	21:19:35	CRO2	21:41:11	OUC2	00:03:39	---
43	1	1777	21:44:50	OUC2	22:04:00	CRO2	00:03:35	---
44	1	1786	22:07:35	CRO2	22:29:11	OUC2	00:03:39	---
45	1	1793	22:32:50	OUC2	22:52:00	CRO2	00:03:35	---
46	1	1802	22:55:35	CRO2	23:17:11	OUC2	00:03:39	---
47	1	1809	23:20:50	OUC2	23:40:00	CRO2	00:01:15	---
48	1	5526	23:41:15	CRO2	23:43:36	GAR3		
49	2	5003	05:45:35	GAR3	05:48:15	CRO2	00:01:36	---
50	2	1004	05:49:51	CRO2	06:10:48	OUC2	00:02:02	---
51	2	1005	06:12:50	OUC2	06:32:10	CRO2	00:01:41	---
52	2	1026	06:33:51	CRO2	06:54:48	OUC2	00:02:02	---
53	2	1027	06:56:50	OUC2	07:16:10	CRO2	00:01:41	---
54	2	1048	07:17:51	CRO2	07:38:48	OUC2	00:02:02	---
55	2	1049	07:40:50	OUC2	08:00:10	CRO2	00:01:41	---
56	2	1070	08:01:51	CRO2	08:22:48	OUC2	00:02:02	---
57	2	1071	08:24:50	OUC2	08:44:46	CRO2	00:03:49	---
58	2	1226	08:48:35	CRO2	09:09:35	OUC2	00:04:05	---
59	2	1229	09:13:40	OUC2	09:33:00	CRO2	00:03:35	---
60	2	1242	09:36:35	CRO2	09:57:35	OUC2	00:04:05	---
61	2	1245	10:01:40	OUC2	10:21:00	CRO2	00:03:35	---
62	2	1258	10:24:35	CRO2	10:45:35	OUC2	00:04:05	---
63	2	1261	10:49:40	OUC2	11:09:00	CRO2	00:03:35	---
64	2	1274	11:12:35	CRO2	11:33:35	OUC2	00:04:05	---
65	2	1277	11:37:40	OUC2	11:57:00	CRO2	00:03:35	---
66	2	1290	12:00:35	CRO2	12:21:35	OUC2	00:04:05	---
67	2	1293	12:25:40	OUC2	12:45:00	CRO2	00:03:35	---
68	2	1306	12:48:35	CRO2	13:09:35	OUC2	00:04:05	---
69	2	1309	13:13:40	OUC2	13:33:00	CRO2	00:03:35	---
70	2	1322	13:36:35	CRO2	13:57:35	OUC2	00:04:05	---

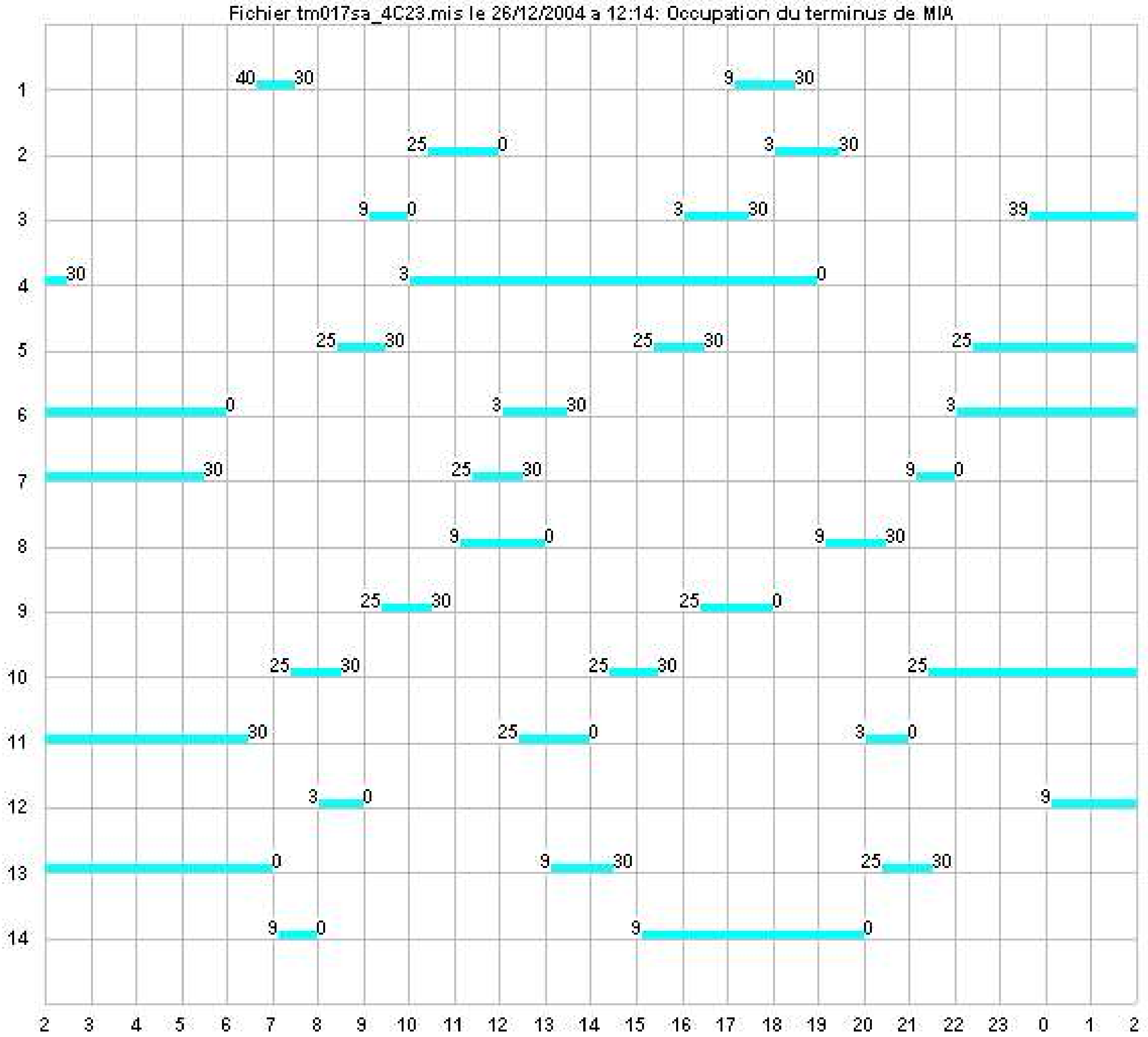
Le roulement des trains

Analysis of overnight storage

1	5001	05:41:46	GAR3	GAR3	23:43:36	5526	+
2	5003	05:45:35	GAR3	GAR3	23:49:25	5528	+
3	5005	05:49:24	GAR3	GAR6	19:07:57	5510	+
4	5007	05:53:14	GAR3	GAR3	23:55:15	5530	+
5	6001	05:55:05	GAR4	GAR5	21:13:30	6518	+
6	5009	05:57:35	GAR4	GAR4	23:13:46	5516	+
7	6003	05:58:43	GAR4	GAR7	19:02:38	6510	+
8	5011	06:01:14	GAR4	GAR6	19:18:10	5512	+
9	6005	06:03:05	GAR5	GAR6	20:55:19	6512	+
10	5013	06:05:35	GAR5	GAR4	23:19:36	5518	+
11	6007	06:06:43	GAR5	GAR5	21:07:40	6516	+
12	5015	06:09:14	GAR5	GAR4	23:25:25	5520	+
13	6009	06:11:05	GAR6	GAR6	21:01:09	6514	+
14	5017	06:13:35	GAR6	GAR4	23:31:15	5522	+
15	6011	06:14:43	GAR6	GAR5	21:19:19	6520	+
16	5019	06:17:14	GAR6	GAR3	23:37:46	5524	+
17	5021	06:22:14	GAR7	GAR5	21:31:11	5514	+

Le roulement des trains




Fichier tm017sa_4C23.mis le 26/12/2004 a 12:14: Occupation du terminus de MIA
1
2
3
4
5
6
7
8
9
10
11
12
13
14
40 30
9 30
25 0
3 30
9 0
3 30
39
30
3 0
25 30
25 30
25
0
3 30
3
30
25 30
9 0
9 0
9 30
25 30
25 0
25 30
25 30
25
30
25 0
3 0
3 0
9
0
9 30
25 30
9 0
9 0
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1 2

Le roulement des trains

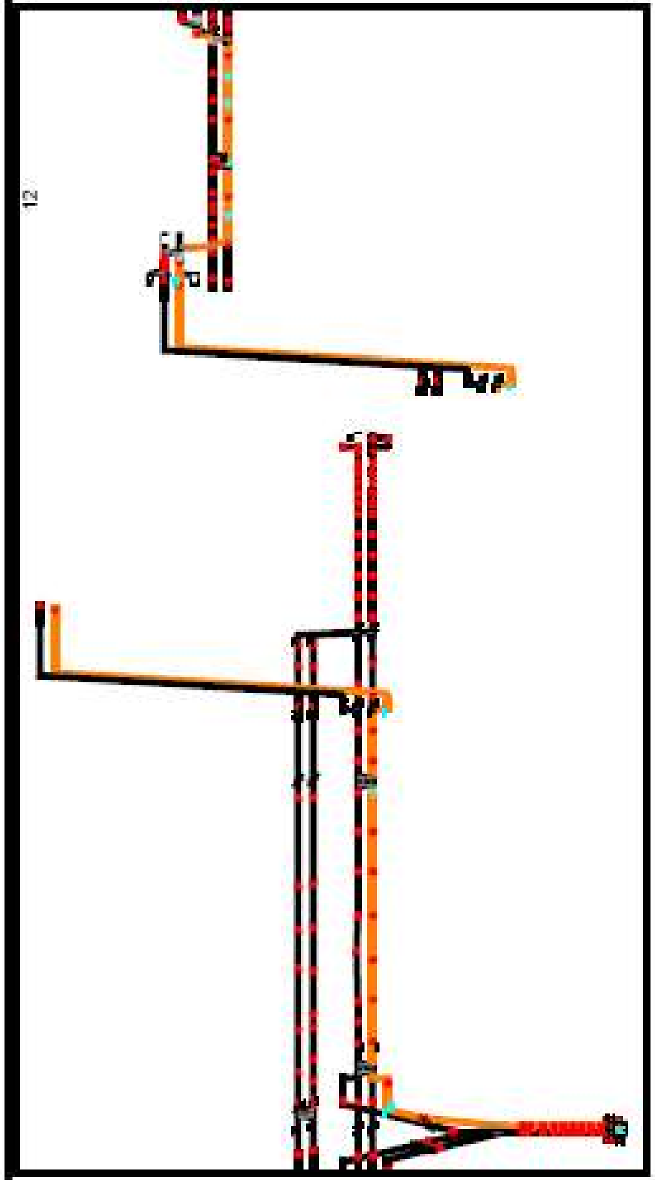
Roster No	Mon.	Tue.	Wen.	Thu.	Fri.	Sat.	Sun.
19	Back Up Train						
18	Overhauls						
17	R	Major Inspection			R	R	R
16	R	General Inspection			R	R	R
15	R	Major Cleaning			R	R	R
14	R	R	Minor Inspection		R	R	R
13	R	R	A	A	R	R	R
12	R	R	R	R	R	R	R

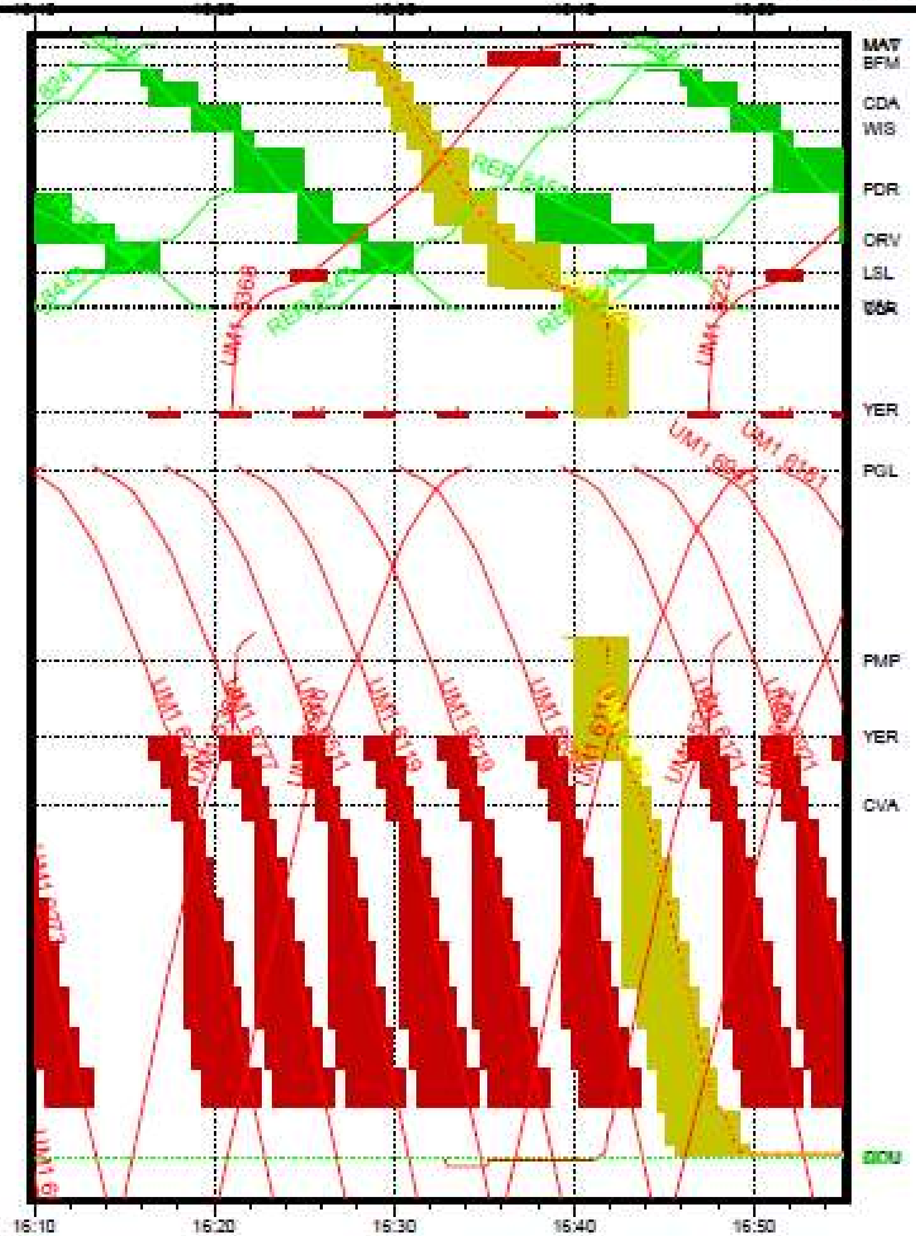
A: Available as additional back-up train,
R: In service according to train roster,

Graphical timetable

Project : TGV_Massy_Lyon_2 Editor:
Variant : 01 Date : 17/05/2014 15:46:18
Timetable variant: 02
Line : Complete network

RailSys\Simu 6.4.0





Accords internationaux

UIC (Union internationale des Chemins de Fer, 1922)

- Voie
- Tension d’alimentation
- Matériel roulant

STI (Spécifications Techniques Interopérabilité, 1996, 2001)

- Infrastructure
- Signalisation
- Interface entre Matériel roulant et Installations fixes
- Trains à grande vitesse, puis conventionnels

Développements récents 1/2

Supervision du trafic

- Ajustement des horaires
- Insertion de sillons en cas de retard
- Rétention de rames devant une rame avariée

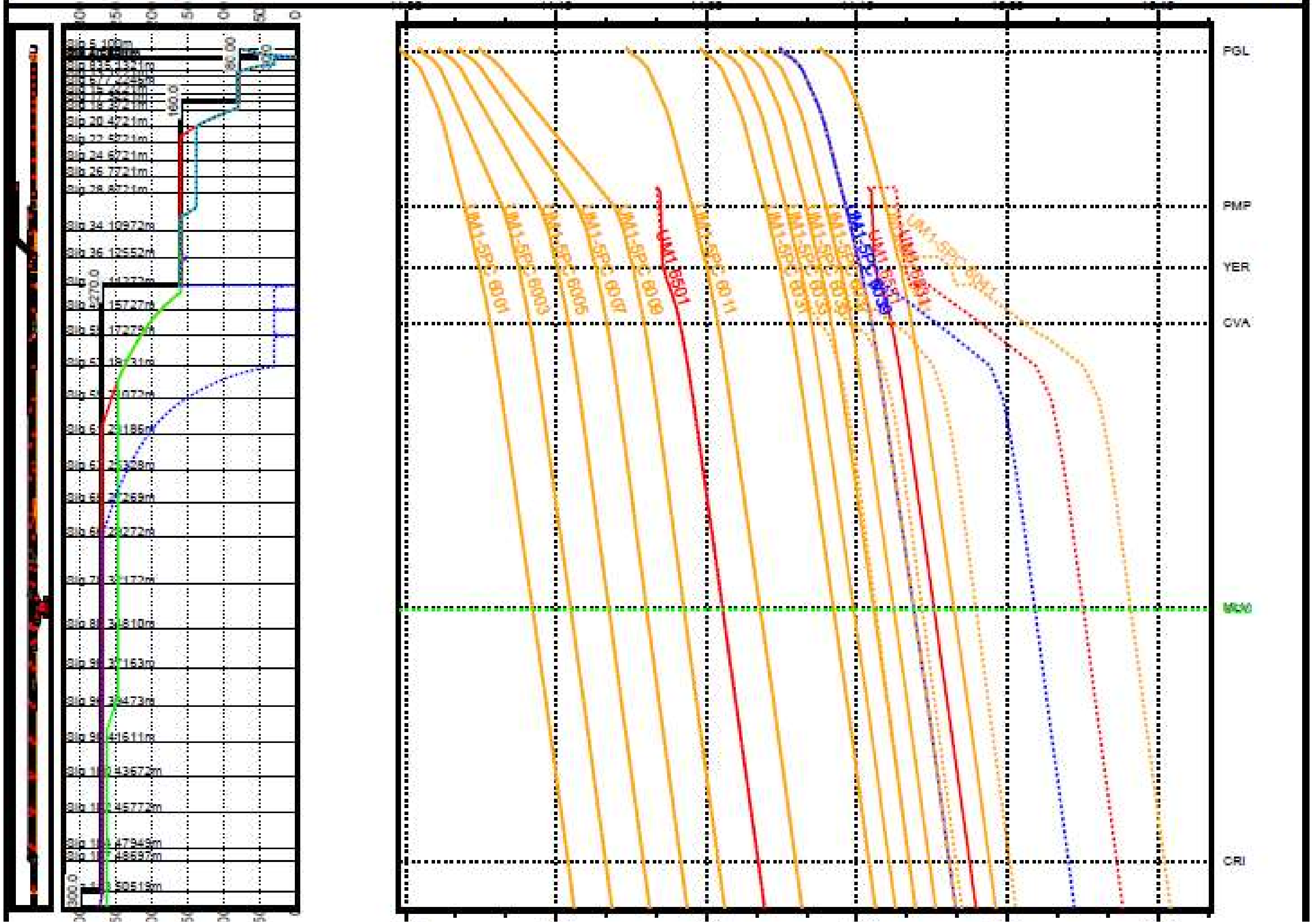
Trains autonomes

- Régularité des circulations
- Lissage des marches et des consommations réseaux
- Maintien des circulations en cas de retard

Graphical timetable

Project : TGV_Massy_Lyon_2 Editor:
Variant : 01 Date : 09/06/2014 19:04:42
Timetable variant: 2 / conflits resolus
Line : Complete network

RailSys\Simu 6.4.0



Développements récents 2/2

Alimentations alternatives

- Accumulateurs
- Supercondensateurs
- Volants d’inertie
- Piles à combustible (piles à hydrogène)

Cybernétique

- Sécurité des installations fixes
- Meilleure détection des circuits de voie
- Meilleure protection des passages à niveau

Train à hydrogène

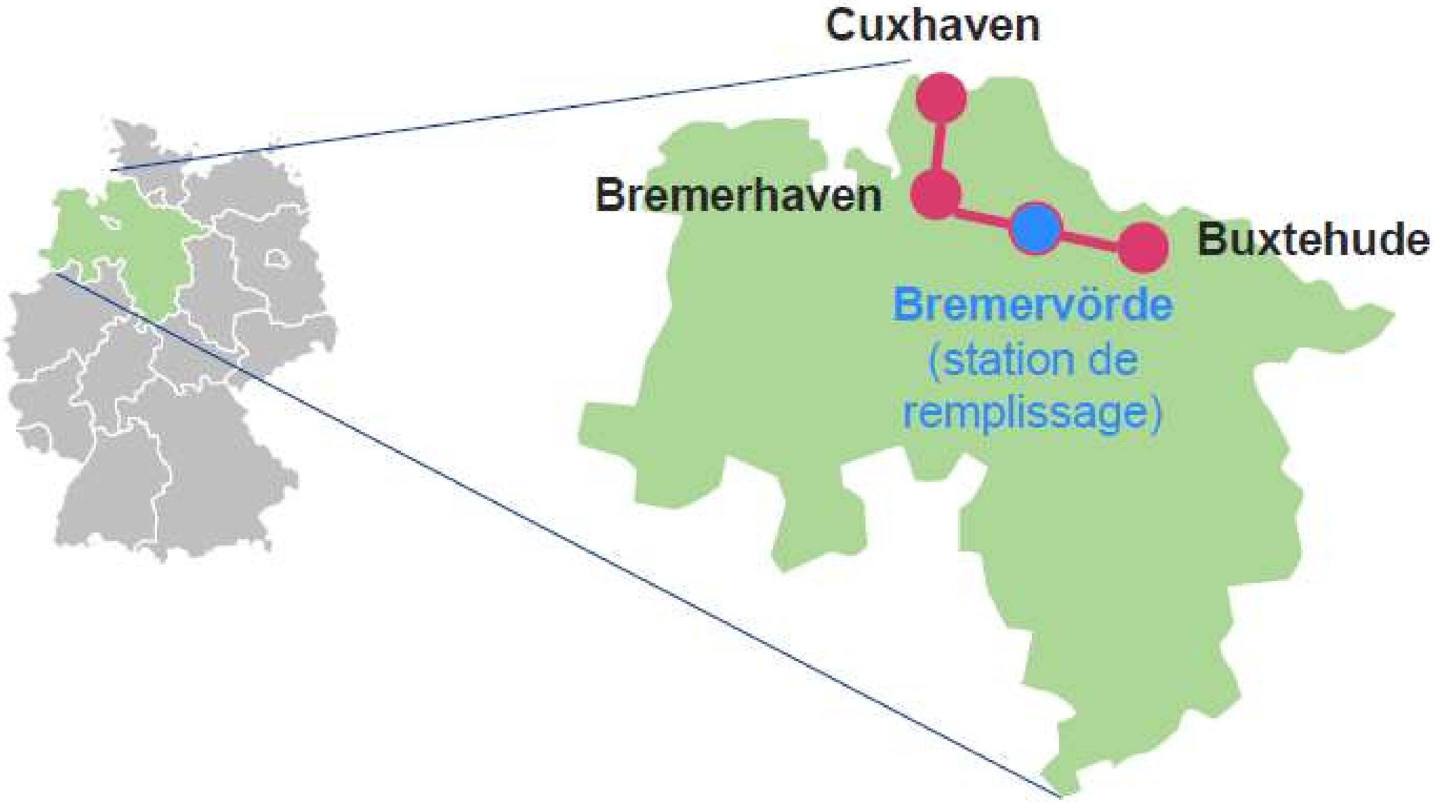
Intérêt

- Plus de 40 % des réseaux F et D non électrifiés
- En Allemagne environ 20 % du trafic opéré en Diesel
- Coût de l'éléctrification entre 1 et 3 M€ par km

Caractéristiques

- Rame ALSTOM Coradia iLINT
- Alimentation par pile à hydrogène
- Accumulateurs-tampon
- Propulsion électrique
- Service commercial depuis le 17 septembre 2019

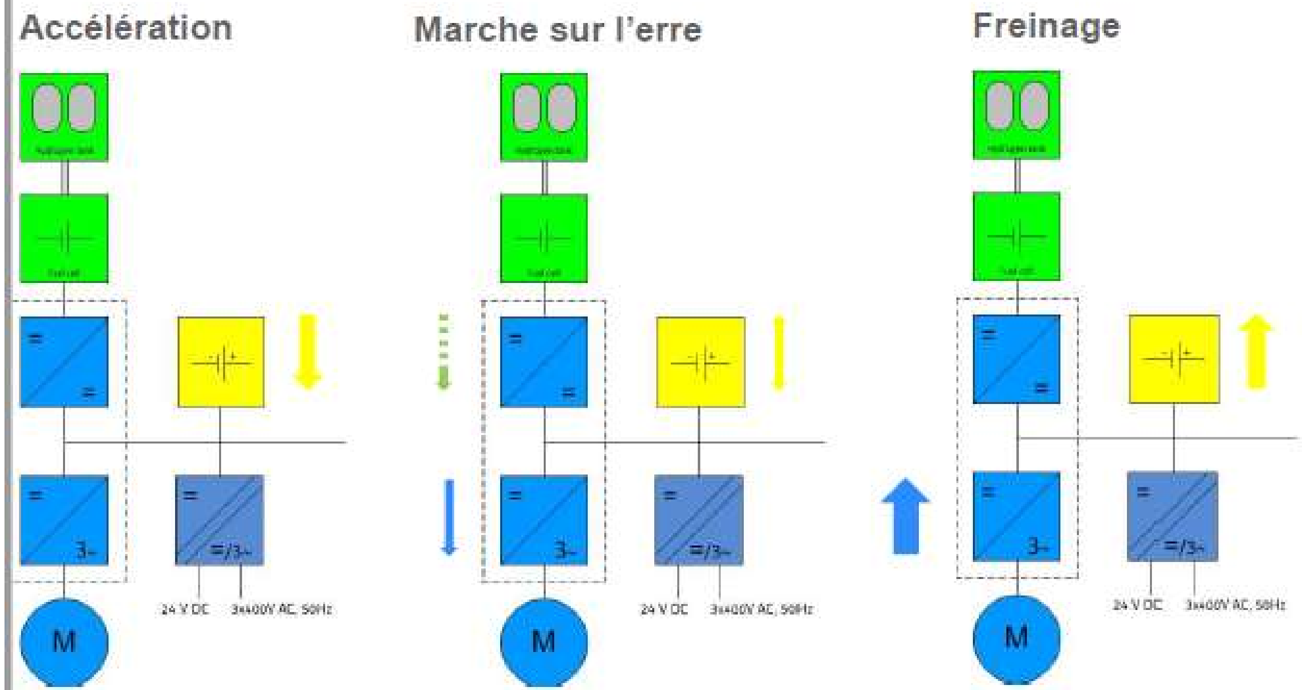
CORADIA iLint: Le service commercial avec passagers



Elément Coradia iLINT

ALSTOM
Designing fluidity

.e Coradia iLINT : les basiques technologiques : Le management de l'énergie



- Eviter les zones de fonctionnement de la pil faible rendement
- Management optimisé d sollicitation de la PAC e marche sur l'erre
- Récupération de l'énerg cinétique en freinage

ALSTO


ALSTOM
Coradia iLint: getting ready for commercial s...
À regarder ...
Partager
PLUS DE VIDÉOS
0:15 / 1:18
YouTube

Rame TGV-M

Rame TGV-M

Composition : 7 à 9 voitures
Alimentation bi/tri/quadri-courant
Puissance : 7800 kW sous 25 kV
Moteurs asynchrones
Capacité : 600 à 740 voyageurs
Vitesse maximale : commerciale 320 km/h, conception 360 km/h
Consommation réduite de 20 % par rapport au TGV Duplex
Maintenance prédictive
Modification en atelier de l'aménagement intérieur
Wifi 5g pour les passagers
Greffon permettant

- Une alimentation de la rame en cas d'arrêt prolongé sans HT
- Un déplacement en autonomie sur quelques km

Développements pour redynamiser les petites lignes

Telli
- 2029
- interopérable
- 80 places assises
- -30 % de coûts globaux

Draisy
- 2027
- pour les lignes à faible trafic
- 30 places assises
- -60 % par rapport à un train classique

Flexy
- 2025
- l’alliance du rail et de la route
- 14 places assises
- -50 % de coûts globaux


UN TRAIN PEUT
EN CACHER
UN AUTRE
TABAC
CHAMPAGNE
2
AVRIL
SALON
TOUTES
COLLECTIONS
2017
20

MASTÈRE SPÉCIALISÉ MANAGEMENT DE PROJETS DE CONSTRUCTION – OPTION TRANSPORTS FERROVIAIRES, URBAINS ET NOUVELLES MOBILITÉS

SOUTIEN LOGISTIQUE / MAINTENANCE DU SYSTÈME DE TRANSPORT FERROVIAIRE

Cyril VERDUN
SNCF Voyageurs / Matériel
Directeur de l'Ingénierie de Maintenance

Version 09 – avril 2024

Ingénierie du Matériel | SNCF VOYAGEURS

Diffusable

1

SOMMAIRE

- LE GROUPE SNCF, LE MATÉRIEL, LE FERROVIAIRE EN FRANCE
- L'OUVERTURE À LA CONCURRENCE
- LA MAINTENANCE (DÉFINITION, CONCEPT, ORGANISATION)
- SOUTIEN LOGISTIQUE DES MATÉRIELS ROULANTS FERROVIAIRES
- LES ECE / ECM
- LA MAINTENANCE PRÉDICTIVE
- LES BANCS DE MAINTENANCE
- LES INNOVATIONS POUR DEMAIN

Ingénierie du Matériel | SNCF VOYAGEURS

Diffusable

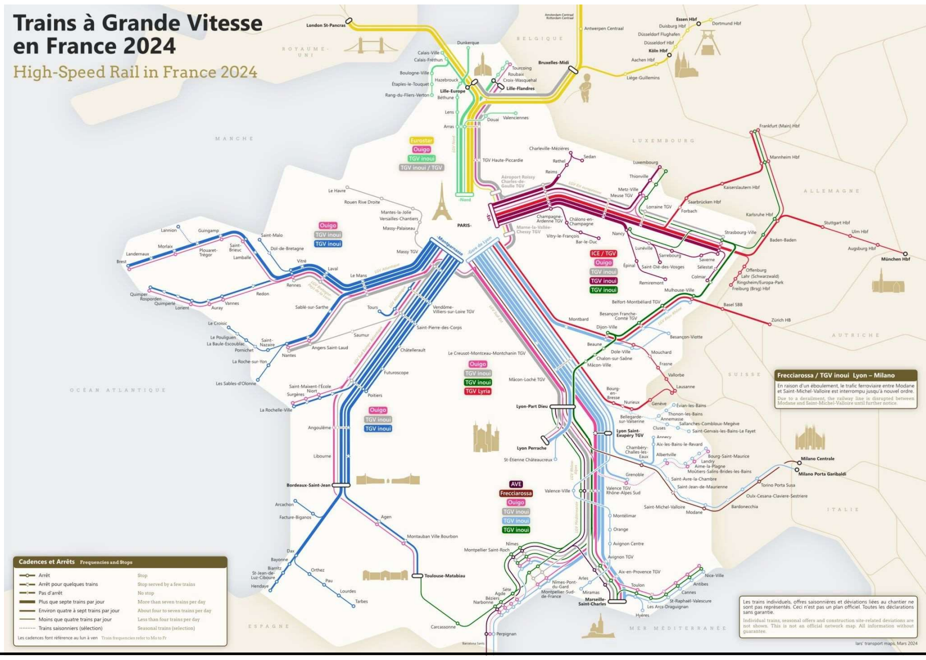
2

Groupe SNCF
Quelques repères

CHIFFRES DE FIN 2019

	TRANSPORT DE VOYAGEURS				TRANSPORT DE MARCHANDISES		GESTIONNAIRES D'ACTIFS				
	TRANSILIEN, TER, INTERCITÉS	VOYAGES	OUI.sncf	KEOLIS	GEODIS	FRET	SNCF RÉSEAU	GARES & CONNEXIONS	SNCF IMMOBILIER	ERMEWA	MATÉRIEL
MÉTIER	Transport ferroviaire conventionné de voyageurs régional et grande distance classique	Transport de voyageurs à grande vitesse Comprend TGV (Inoui ou Ouigo), Eurostar, Thalys, Lyria…	Distribution sur internet	Transport public urbain, périurbain et régional	Solutions logistiques et transports de marchandises en France et dans le monde	Transport ferroviaire de marchandise (chimie, sidérurgie, automobile, céréales…)	Gestion, exploitation, maintenance du réseau et ingénierie ferroviaire	Services fournis de façon non discriminatoire à l'ensemble des entreprises ferroviaires Gestion de pôles d'échanges	Gestion et valorisation des actifs fonciers et immobiliers du Groupe	Location de wagon de fret ferroviaire ; installations et prestation d'entretien de wagons	Ingénierie, achat, entretien et maintenance du matériel pour le compte des activités du Groupe
ZONE	France	France et Europe	France et international	France et 13 pays à travers le monde	120 pays sur les 5 continents	France et Europe	France	France	France	France et international	France
MARCHÉ	Conventionné ; ouverture à la concurrence possible dès décembre 2019 et obligatoire dès 2023	Marché international : ouvert depuis 2009 Domestique : à compter de décembre 2020	Ouvert	Conventionné	Ouvert	Ouvert	Monopolistique	Monopolistique pour les services ferroviaires	Ouvert	Ouvert	Ouvert
CA 2019	9,2 Mds€	8,4 Mds€	0,5 Md€	6,6 Mds€	8,1 Mds€	0,8 Md€	6,6 Mds€	1,5 Md€	0,6 Md€	0,4 Md€	1,4 Md€
% MOP aux bornes	6,5%	16,8%	30,0%	5,3%	4,1%	-13,6%	33,5%	15,4%	8,1%	61,7%	4,0%
			5 Md€ de volume d'affaires (billets vendus)	50% du CA à l'international	1er transporteur national 5e européen 8e mondial				4e opérateur de logement 2e bailleur en France		

Le train en France



Diffusable

SNCF Voyageurs, SNCF Réseau, FRET

Groupe international multimodal

Chiffre d'affaires 2023

41,7 Mds€

Dont 3/4 sur le ferroviaire

Réseau :	7,551 Mds€
Voyageurs[1] :	19,172 Mds€
Gare et CO :	1,856 Mds€
KEOLIS :	6,984 Mds€
GEODIS :	11,640 Mds€
FRET / Logistique :	1,712 Mds€

15 millions
de voyageurs/jour dans le monde dont 5 millions dans les trains en France

283 000
collaborateurs dont 160 000 à SNCF et 250 000 en France

15 000
Trains / jour

190 000 000
Billets vendus en 2022

15 800 M€
D'achats (97% à des ent. Françaises)

30 000 Km
de lignes (2e réseau d'Europe)
dont 2 600 Km à grande vitesse

10,6 Mds€ d'investissements
dont 97% en France et dont 33%financés en propre

1/3 du CA
à l'international

Taux de MOP/CA

Transport ferroviaire Non conventionné[1]	15%
Conventionné[2]	7%
Logistique	5%

[1] Voyageurs dont filiales (TGV, Eurostar, Thalys, Lyria….)

780 Sociétés (KEOLIS, GEODIS, EFFIA, EUROSTAR, THALYS….)

Diffusable

Ingénierie du Matériel

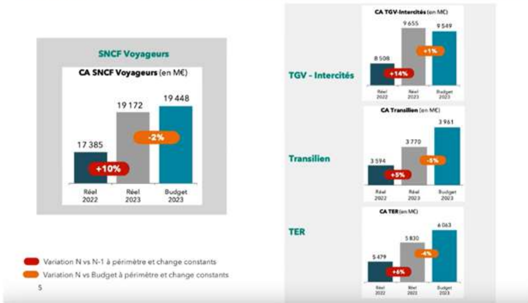
5

SNCF Voyageurs

Chiffres 2023 :

- **19,172 Milliards d'€** de CA
- **66 000** collaborateurs / collaboratrices
- **2,540 Milliards €** de EBITDA

UN CHIFFRE D'AFFAIRES EN HAUSSE DE 10% VERSUS 2022



Les trafics de 2019 de TER et Intercités sont corrigés du transfert des lignes de Normandie réalisé en 2020

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Ingénierie du Matériel

6

SNCF Voyageurs / Matériel

- **1,7 Milliards d'€** de CA 2023 avec les Activités SNCF
- **580 M€** de CA à l'externe en 2023 (400 OPTER) via MASTERIS, filiale 100 % SNCF Matériel
- **22 000** agents du métier dont :
  - **6 000** agents en Technicentres Industriels
  - **2 000** à l'ingénierie
  - **14 000** agents en Technicentres de maintenance
- **2 métiers structurants : INGENIERIE et INDUSTRIEL** qui interviennent sur la totalité du cycle de vie de tous les matériels roulants.
- **17 000 matériels roulants** maintenus par an par SNCF

Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

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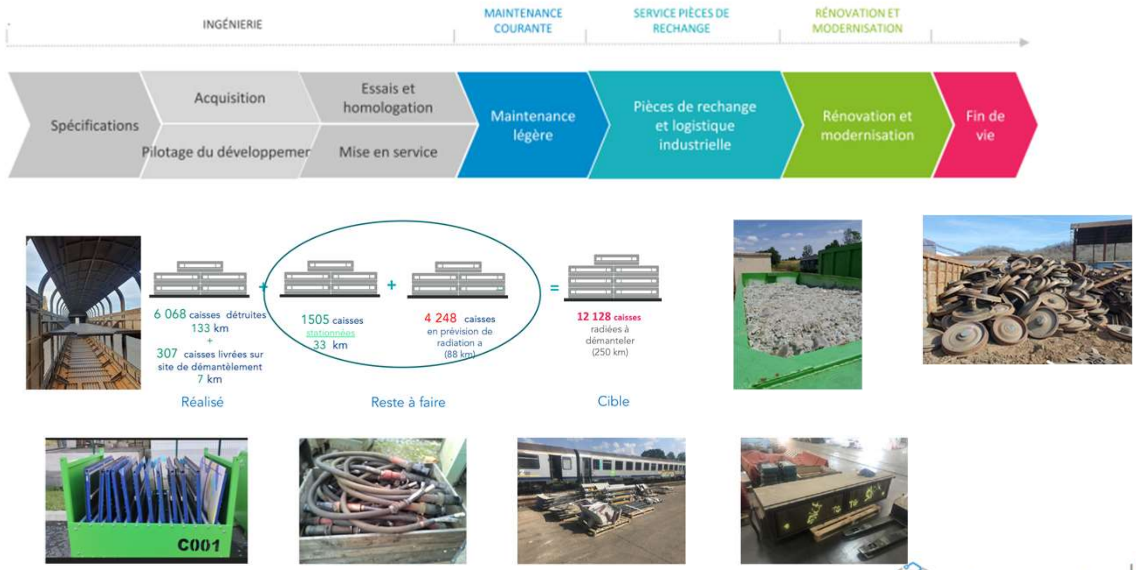
Sur toute le cycle de vie du matériel



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Ingénierie du Matériel | SNCF VOYAGEURS

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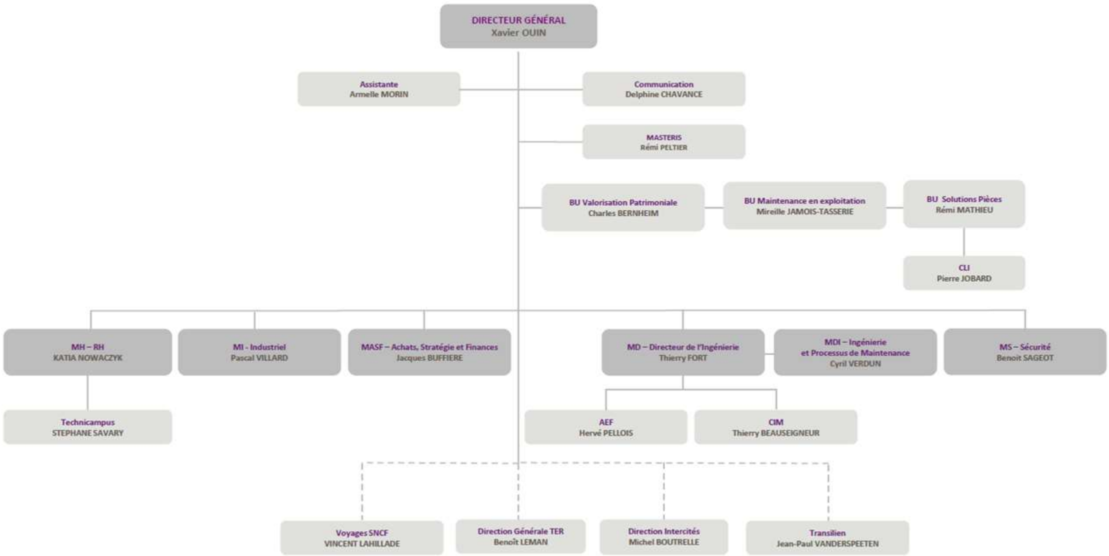
SNCF Voyageurs / Matériel



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Ingénierie du Matériel | SNCF VOYAGEURS

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La maintenance du matériel roulant en quelques chiffres (en France)

- **22 000** agents
- **39** établissements
- **7** Clusters Ingénierie
- **70** lieux de production
- **2,7** Mds euros sont consacrés chaque année à la maintenance des matériels SNCF
- **25** Mds euros d'actif (Assets)
- **1er** donneur d'ordre et acteur majeur de la filière industrielle ferroviaire française

KNORR-BREMSE · ALSTOM · FerdeFrance FRENCH RAIL EXCELLENCE · CAF · SIEMENS Ingenuity for life · masteris WE MAINTAIN YOUR EXCELLENCE · Faiveley Transport A Wabtec Company

Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

10

Les performances : la Sécurité des circulations

- 1050 matériels Transilien font des trains tous les jours : 3,2 millions voyageurs/j
- 350 TGV (un vendredi en pointe, cette flotte assure plus de 1000 circulations)
- 2000 rames TER (yc. Locomotives et Voitures)
- 200 rames Intercités (yc. Locomotives et Voitures)

TRANSILIEN SNCF : un parc en mutation

Le parc MR TRANSILIEN au 1er janvier 2024

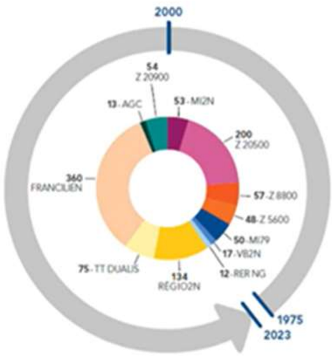
Quelques chiffres

1073 rames composent le parc SNCF Transilien

1 056 rames automotrices dont 558 à 2 niveaux, dont 13 bimodes (électrique + diesel)

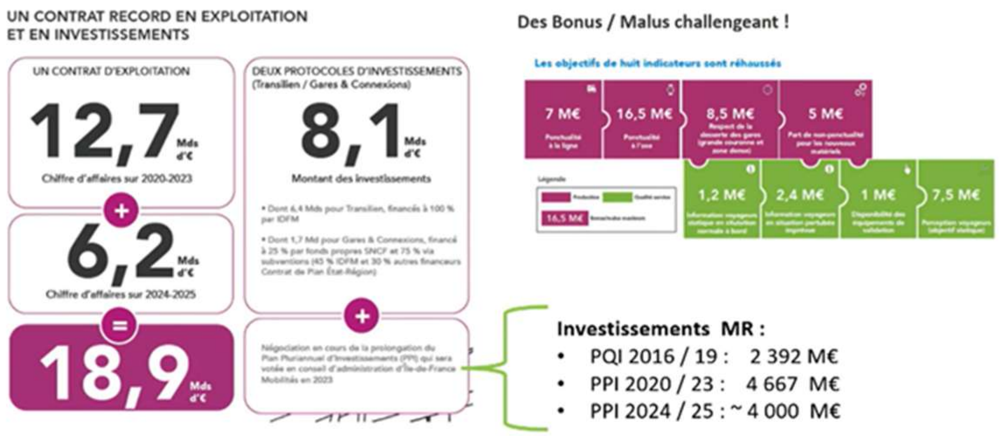
17 rames remorquées toutes à 2 niveaux, tractées par **23 locomotives**

Le parc SNCF Voyageurs Transilien
Au 1er janvier 2024 (locomotives exclues)



TRANSILIEN SNCF : un contrat très important

TRANSILIEN, un contrat 2020/23 prolongé jusqu'en 2025



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Ingénierie du Matériel | SNCF VOYAGEURS

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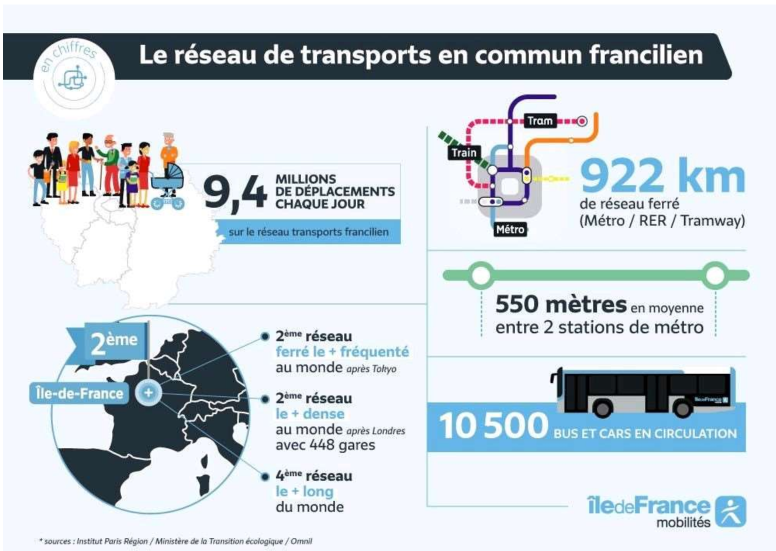
TRANSILIEN SNCF 2ème réseau au monde

(après Tokyo)

- 17 LIGNES
  (dont 8 TN, 5 RER et 4 tram-Trains)
- 3,4 MILLIONS DE VOYAGEURS
  (70% des voyageurs SNCF)
- + DE 6200 TRAINS / JOUR
- 1 train entre ou sort en gare par seconde
- 1280 KM DE VOIES
- 392 GARES
- Les 2 plus grosses gares d'Europe (GdN et PSL)
- 13 000 AGENTS
- JO en 2024 : 11 Millions de spectateurs



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Ingénierie du Matériel | SNCF VOYAGEURS

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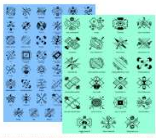
LES JEUX DE PARIS 2024 : DEUX ÉVENEMENTS SPORTIFS HORS NORMES

DU SPORT !

32 Sports en compétition pour les JO*
22 sports en compétition pour les JP

37 sites d'épreuves pour les JO
20 sites d'épreuves pour les JP

878 épreuves sur près d'1 mois
Plus de 40 championnats du monde en simultané



LES JEUX OLYMPIQUES
Du 26 juillet – 11 août

LES JEUX PARALYMPIQUES
Du 28 août - 8 septembre

Le relais de la flamme du 8 mai au 26 juillet 2024

UN ÉVÈNEMENT TRÈS MÉDIATISÉ !

4 MDS de téléspectateurs

350 000 heures de diffusion
(TV et plateformes confondues)

40 000 journalistes et représentants de médias de tous les pays

Une couverture médiatique internationale
Un intérêt des médias qui a déjà commencé :

*28 sports « titulaires » + 4 sports additionnels (breaking, escalade sportive, skateboard, surf)

2

Interne

Sources : Paris 2024 - paris2024.org/fr (2023)

PARIS 2024 SNCF SUPPORTEUR OFFICIEL PARIS 2024

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Ingénierie du Matériel SNCF VOYAGEURS

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Planning de l'ouverture à la concurrence des lignes TER

RÉGIONS	LOTS EN CONCURRENCE	AVIS DE PRÉ-INFORMATION (API)	AVIS DE CONCESSION	INFOS DES SALARIÉS (n°1)	CAHIER DES CHARGES (DCE)	REMISE DE L'OFFRE FINALE	NOTIFICATION NOUVEL ATTRIBUTAIRE + INFO DES SALARIÉS (N°2)	LANCEMENT APPEL À VOLONTARIAT* (au plus tard ou déjà planifié)	MEX TRANSFERT **
HAUTS-DE-FRANCE	**Lot 1 :** Etoile d'Amiens **(464 ETP)**	✓	✓	✓	✓	✓	✓ Mars 2023	*Août 2023*	*Janv. 2025*
	Lot 2 : Dessertes parisiennes*** **(1181 ETP)**	✓ Fév. 2023	-	-	-	-	-	*Août 2024*	*Déc. 2026*
	Lot 3 : Etoile de Lille	-	-	-	-	-	-	-	-
	Lot 4 : TER - GV	-	-	-	-	-	-	-	-
PAYS DE LA LOIRE	Lot - Sud Loire **(270 ETP) +** Tram Train **(116 ETP)**	✓	✓	✓	✓	En cours Mai. 2023	*Été 2023*	*Août 2023*	*Tram-train - Déc. 2024 Sud-Loire – Mi SA 2026*
	Lot – Boucle	-	-	-	-	-	-	-	
	Lot – Etoile mancelle	-	-	-	-	-	-	-	
	Lot – Axe loire	-	-	-	-	-	-	-	
GRAND EST	**Lot 1 :** Nancy-Contrexéville **(39 ETP)**	✓	✓	✓	En cours Avril 2023	-	*T1-2025*	-	*SA 2028*
	Lot 2 : Bruche-Piémont-Vosges **(189 ETP)**	✓	✓	✓	✓ Déc. 2022	-	*T4-2024*	-	*Mi-2027*
	Transfrontalier Lot n°1 Est – Strasbourg **(79 ETP)**	✓	✓	✓	En cours Mars. 2023	-	-	-	-
	Transfrontalier Lot n°2 Ouest – Metz **(119 ETP)**	✓	✓	✓	En cours Mars. 2023	-	-	-	-

RÉGIONS	LOTS EN CONCURRENCE	AVIS DE PRÉ-INFORMATION (API)	AVIS DE CONCESSION	INFOS DES SALARIÉS (n°1)	CAHIER DES CHARGES (DCE)	REMISE DE L'OFFRE FINALE	NOTIFICATION NOUVEL ATTRIBUTAIRE + INFO DES SALARIÉS (N°2)	LANCEMENT APPEL À VOLONTARIAT* (au plus tard ou déjà planifié)	MEX TRANSFERT **
SUD	**Lot 1 :** Intermétropoles (Marseille Nice) **(163 ETP)**	✓	✓	✓	✓	✓	✓	En cours Mars à Juin 2023	*Juin 2025*
	Lot 2 : Azur (Etoile de Nice) **(511 ETP)**	✓	✓	✓	✓	✓	✓	En cours Mars à Juin 2023	*Déc. 2024*
	Lot 3 : Interurbain– Marseille-Aubagne-Toulon-Hyères Marseille-Toulon-Les Arcs Draguignan Marseille-Aix-En-Provence-Pertuis Marseille-Gap-Briançon Briançon-Gap-Valence-Romans	✓ Fév. 2023	*Fév. 2024*	-	-	-	*S2-2025*	-	*Déc.. 2028 (au plus tôt)*
	Lot 4 : Interurbain– Marseille-Miramas, via Rognac et via la Côte Bleue Marseille-Avignon, via Arles et via Cavaillon Marseille-Avignon-Valence-Lyon Marseille-Nimes-Montpellier Avignon-Carpentras	✓ Fév. 2023	*Fév. 2024*	-	-	-	*Fin-2025-2027*	-	*Déc.. 2028 (au plus tôt)*
BOURGOGNE – FRANCHE – COMTÉ	4 à 8 lots	✓ Mars 2022	-	-	-	-	*T4-2024*	*Sept 2024*	*Début 2026*
NORMANDIE	**Lot 1 :** Etoile de Caen	En cours (AMI) Fév. 2023	-	-	-	-	*S1 2025*	*Août 2025*	*Déc. 2026*
	Lot 2 : Etoile de Rouen	-	-	-	-	-	*Printemps 2027*	*Août 2028*	*Déc. 2029*
	Lot 3 : Paris Granville	-	-	-	-	-	*Déc. 2027*	*Août 2028*	*Déc. 2029*
	Lot 4 : Normandie / Saint-Lazare	-	-	-	-	-	*Printemps 2028*	*Août 2028*	*Déc. 2029*
	Lot 5 : Etoile Mancelle (avec Pays de la Loire)	-	-	-	-	-	*Déc. 2025*	*Août 2028*	*Déc. 2029*
OCCITANIE	-	-	-	-	-	-	-	-	*2033 - 100% du périmètre*
CENTRE VAL-DE-LOIRE	-	-	-	-	-	-	-	-	*2030- 45% du périmètre 2031- 75% du périmètre 2032- 100% du périmètre*

Mise à jour : avril 2023

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Ingénierie du Matériel | SNCF VOYAGEURS

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Planning de l'ouverture à la concurrence des lignes TN et IC

RÉGIONS	LOTS EN CONCURRENCE	AVIS DE PRÉ-INFORMATION (API)	AVIS DE CONCESSION	INFOS DES SALARIÉS (n°1)	CAHIER DES CHARGES (DCE)	REMISE DE L'OFFRE FINALE	NOTIFICATION NOUVEL ATTRIBUTAIRE + INFO DES SALARIÉS (N°2)	LANCEMENT APPEL À VOLONTARIAT* (au plus tard ou déjà planifié)	MEX TRANSFERT **
ILE-DE-FRANCE MOBILITE	**Lot n°1 :** T4 / T11 / Branche Esbly <> Crécy **(417 ETP)**	✓	✓	✓	✓	En cours Mars. 2022	*Juin 2023*	*Juin 2023*	*Déc. 2024*
	Lot n°2 : T12 et T13 **(191 ETP)**	✓	✓	✓	✓	En cours Mars. 2023	*Fév/Mars 2024*	-	-
	Lot N°3 : Ligne L **(929 ETP)**	✓	✓	En cours Fév. 2023	-	-	*Avril 2024*	*Sept 2024*	*Déc. 2025*
	Lot N°4 : Ligne J **(858 ETP)**	✓ Déc. 2022	-	-	-	-	-	*Sept 2026*	*Déc. 2026*
	Lot N°5 : Ligne N **(916 ETP)**	✓ Déc. 2022	-	-	-	-	-	*Sept 2026*	*Déc 2026*

RÉGIONS	LOTS EN CONCURRENCE	AVIS DE PRÉ-INFORMATION (API)	AVIS DE CONCESSION	INFOS DES SALARIÉS (n°1)	CAHIER DES CHARGES (DCE)	REMISE DE L'OFFRE FINALE	NOTIFICATION NOUVEL ATTRIBUTAIRE + INFO DES SALARIÉS (N°2)	LANCEMENT APPEL À VOLONTARIAT* (au plus tard ou déjà planifié)	MEX TRANSFERT **
TRAINS D'ÉQUILIBRE DU TERRITOIRE	**Lot A :** Nantes-Lyon et Nantes-Bordeaux	✓	✓	✓	✓ Déc. 2022	-	*Juin 2024*	*Août 2025*	*Fin 2026*
	Lot B : PALITO et Paris-Clermont-Ferrand	-	-	-	-	-	-	*Fin 2026*	*2027*
	Lot C : Trains de nuit Paris-Briançon-Nice Trains de nuit SO	-	-	-	-	-	-	-	*2026-2028*
	Lot D : Bordeaux - Marseille Metz-Grenoble Lyon-Toulouse	-	-	-	-	-	-	*Fin 2026*	*2029*

Mise à jour : avril 2023

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Ingénierie du Matériel | SNCF VOYAGEURS

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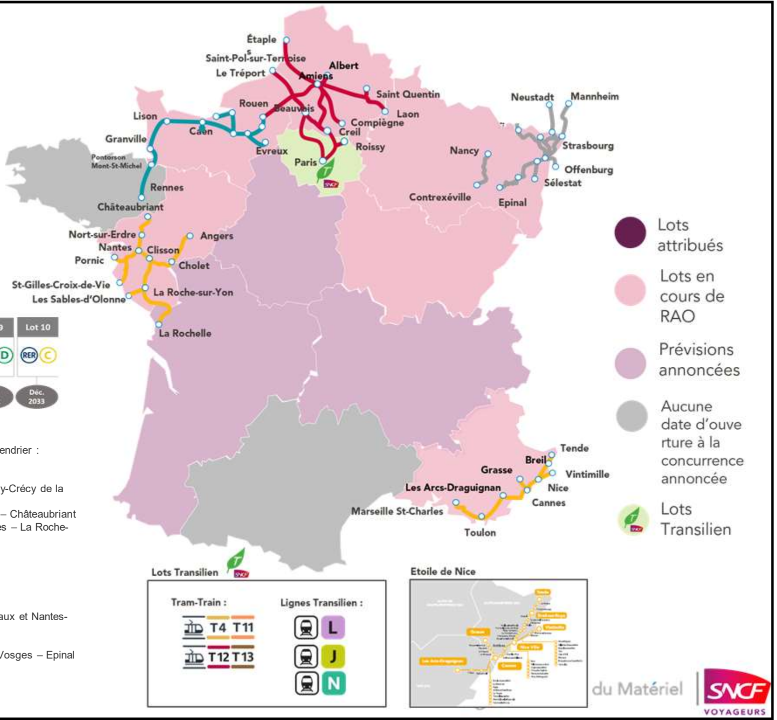
Planning Récapitulatif



Les prochaines attributions devraient être les suivantes, les AOT étant susceptibles de modifier ce calendrier :

2023
- **Juin** - Île-de-France Mobilités : lot composé des lignes de trams-trains T4, T11 et de la branche Esbly-Crécy de la ligne P
- **Mi-2023** - Région Pays de la Loire : lot unique composé des périmètres «tram-train» (lignes Nantes – Châteaubriant et Nantes – Clisson) et «sud Loire» (lignes Nantes – Pornic, Nantes – Saint-Gilles-Croix-de-Vie, Nantes – La Roche-sur-Yon, Nantes - Les Sables d'Olonne, Nantes – La Rochelle, Nantes – Cholet et Angers – Cholet)
- **Fin 2023** – Région Grand-Est : lot composé de la ligne Nancy – Contrexéville
- **Fin 2023** – Région Sud : lot fonctionnel Système d'Information Billettique Régional (SIBR) Sud

2024
- **Février-mars** - Île-de-France Mobilités : trams-trains T12 et T13
- **Juin 2024** - État (trains d'équilibre du territoire, actuellement exploités par Intercités) : Nantes-Bordeaux et Nantes-Lyon
- **Mi-2024** - Île-de-France Mobilités : lot composé de la ligne L
- **Dernier trimestre** – Région Grand Est : lot «Bruche-Piémont-Vosges» (Strasbourg – Saint-Dié-des-Vosges – Epinal et Strasbourg – Molsheim – Sélestat)

Diffusable

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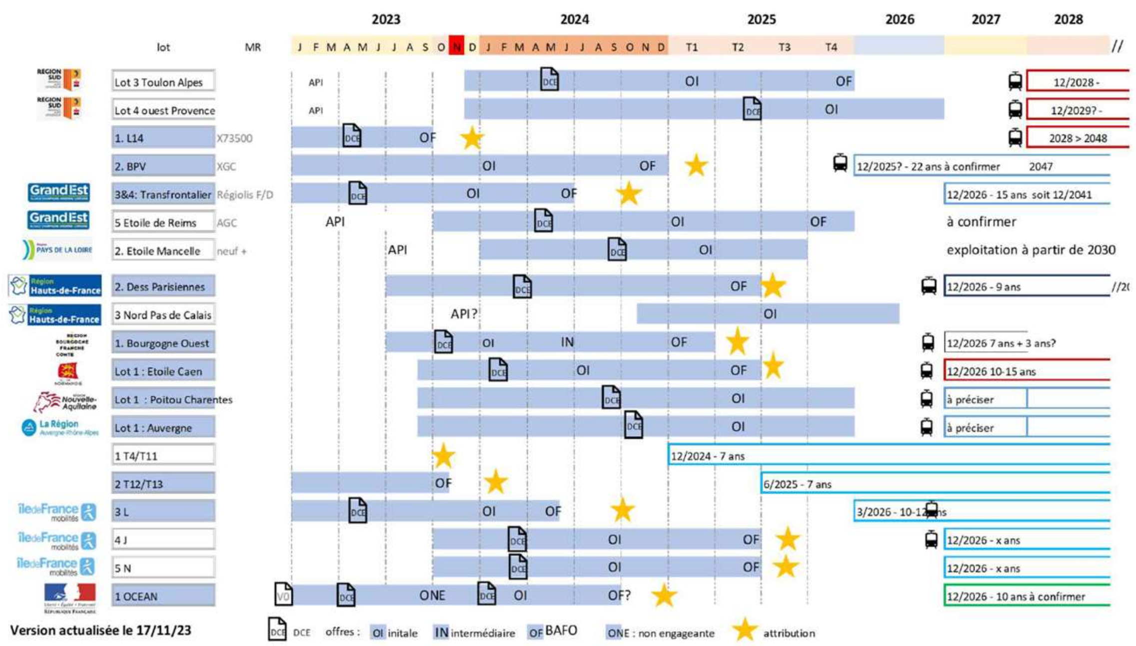
Planning Récapitulatif



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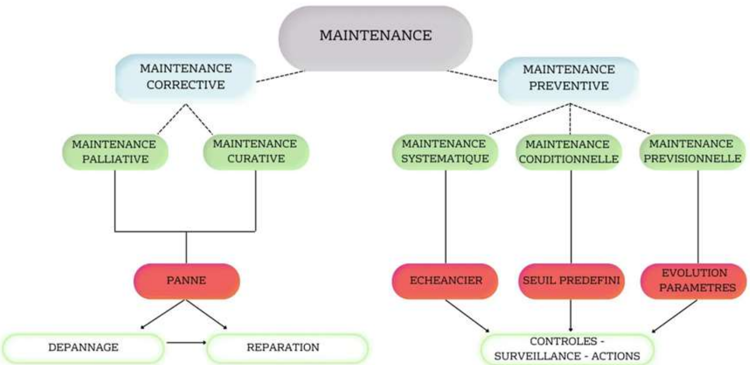
Définition de la maintenance

- Selon la norme **NF-X 60 000**, la **maintenance** est « *l'ensemble des activités ayant pour objectif de maintenir ou rétablir un bien dans un état spécifié de fonctionnement pour établir une fonction requise.* ».
- La maintenance rassemble donc l'ensemble des actions techniques (prévention, dépannage, révision et vérification, réparation, contrôle et diagnostic), mais aussi administratives et de management, permettant de conserver le bon fonctionnement des équipements et d'assurer la production.
- Les objectifs fixés par la direction permettent de mettre en place une **stratégie de maintenance** (prise en compte des enjeux humains, techniques, de sécurité, financiers, etc…). De cette stratégie découle ensuite les **types de maintenance** à déployer.
- La norme NF-X 60 000 différencie deux grandes familles : la **maintenance corrective** et la **maintenance préventive**



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La maintenance

- LES 2 TYPES DE MAINTENANCE

Maintenance Préventive

- Toute action de maintenance planifiée permettant de remettre le système dans un certain état. Les actions comprennent les inspections périodiques, les remplacements des éléments à usure critique, les étalonnages, etc.
- Action de maintenance réalisée sur le système alors que celui-ci est en état de fonctionnement (sans panne)
- On conçoit ce type de maintenance si la défaillance n'est pas acceptable

Maintenance Corrective

- Toute action de maintenance non planifiée permettant de remettre le système en état suite à une défaillance ou un incident. Les actions comprennent les localisations de pannes, les démontages, les déposes, les échanges, les réparations, les remontages, les tests de bon fonctionnement, etc.
- Action de maintenance réalisée sur le système pour palier à une panne qui est intervenue
- On conçoit ce type de maintenance si la défaillance est jugée acceptable

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Le concept de maintenance

- MAINTENANCE PRÉVENTIVE VS MAINTENANCE CORRECTIVE

Le système est défaillant avant l'intervention

Maintenance Corrective

- Maintenance curative
- Maintenance palliative

Le système est opérationnel avant l'intervention

Maintenance Préventive

- Maintenance systématique
- Maintenance conditionnelle
- Maintenance prédictive

Attention : La maintenance « Évolutive » n'est pas considérée comme de la maintenance car l'intervention touche directement la configuration de définition du matériel

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Le concept de maintenance

- L'ORGANISATION DE LA MAINTENANCE

Niveau de maintenance AFNOR (complexité tâche) SNCF	*Tâches*	*Candidats à la maintenance*	*Code niveaux logistiques*
Niveau 1	**Tâche opérateur (tractionnaire)**	**MATERIEL (système)**	**Niveau organisationnel NTI 1**
Niveau 2	**Examen**		
Niveau 3	**Réparation légère, Visite, Modules**		
Niveau 4	**Réparation URL / URA**	**URL / URA**	**Niveau Atelier NTI 2**
	Révision des matériels	**MATERIEL (système)**	**Niveau industriel NTI3**
Niveau 5	**Grande Réparation / Modernisation**		

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Ingénierie du Matériel | SNCF VOYAGEURS

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Niveau 1 de la maintenance

Il comprend les opérations de surveillance en service

(tests, essais, Détection Boite Chaude, Examen Carnet de Bord, Station Service…).

Concept de maintenance : Test bon Fonctionnement Essais, …

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Ingénierie du Matériel | SNCF VOYAGEURS

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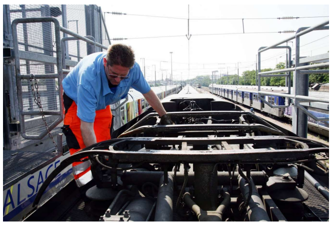
Niveau 2 de la maintenance

Concept de maintenance : Vérifications test Echange rapide

Il comprend des vérifications, tests, échanges d'équipements remplaçables en rames, dans des intervalles convenus entre deux circulations.

Interventions de durée limitée sur chantiers spécialisés :

- Chantiers de préparation : matériel voyageur
- Grill : engins moteurs
- Visite de l'archet
- Sites de visites techniques : trains Fret



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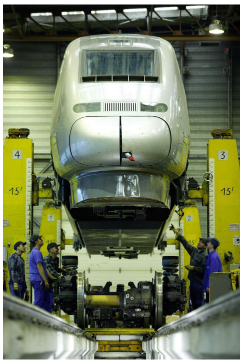
Niveau 3 de la maintenance

Concept de maintenance : Inspection et réparation si nécessaire Echange d'organes

Opérations effectuées en Technicentre de maintenance.
Visites périodiques préventives et des déposes d'organes.

Le retrait du véhicule du service commercial est nécessaire

- Visite légère
- Modules de maintenance à réaliser sur une nuit
- Opérations de 1 à 4 jours d'immobilisation
- Echanges d'organes (URL réparables)



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Ingénierie du Matériel SNCF VOYAGEURS

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Niveau 4 de la maintenance

Concept de maintenance :
Révisions générales
Réparation organes déposés

Le niveau 4 comprend les opérations réalisées en Technicentre industriel

- Les opérations de maintenance majeures, appelées généralement révisions, Opérations Caisses ou Opérations mi-vie
- Les Réparations d'URL et d'URA réalisées en Technicentre industriel




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Ingénierie du Matériel | SNCF VOYAGEURS

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Niveau 5 : modernisation

Le niveau 5 comprend les opérations réalisées en Technicentre industriel

- de modifications fonctionnelles et techniques
- des réparations lourdes des matériels


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Ingénierie du Matériel | SNCF VOYAGEURS

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Dispositif opérationnel de maintenance

Niveau 1 } EXPLOITANTS

Niveau 2
Niveau 3 } 25 TECHNICENTRES de MAINTENANCE

Niveau 4
Niveau 5 } 10 TECHNICENTRES INDUSTRIELS

- **10** Technicentres Industriels (TI)
- **1** plate forme logistique (CLI)
- **1** direction de l'Ingénierie avec :
  - **5** Clusters ingénierie
  - **1** Agence d'Essai Ferroviaire (AEF)
  - **1** Centre d'Ingénierie du Matériel (CIM)
- **1** Technicampus

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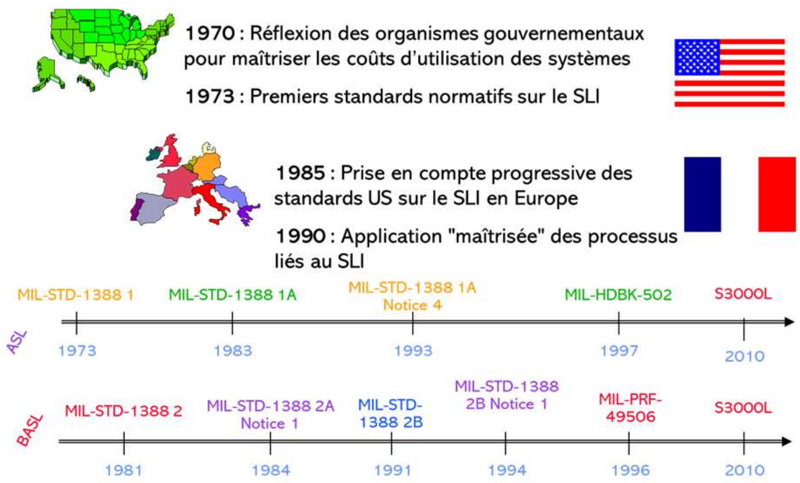
Le Soutien Logistique Intégré

Le Soutien Logistique Intégré (SLI) ou *Integrated Logistic Support (ILS)* est une approche globale et itérative des activités de management et des activités d'ingénierie permettant :

- de concevoir un système en prenant en compte les besoins et les contraintes en matière de soutien,
- d'acquérir le système de soutien requis,
- d'harmoniser les éléments de soutien entre eux et de les harmoniser avec la conception du système,
- d'assurer le soutien nécessaire durant la phase opérationnelle, à un coût maîtrisé, en fonction des besoins des utilisateurs.



Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

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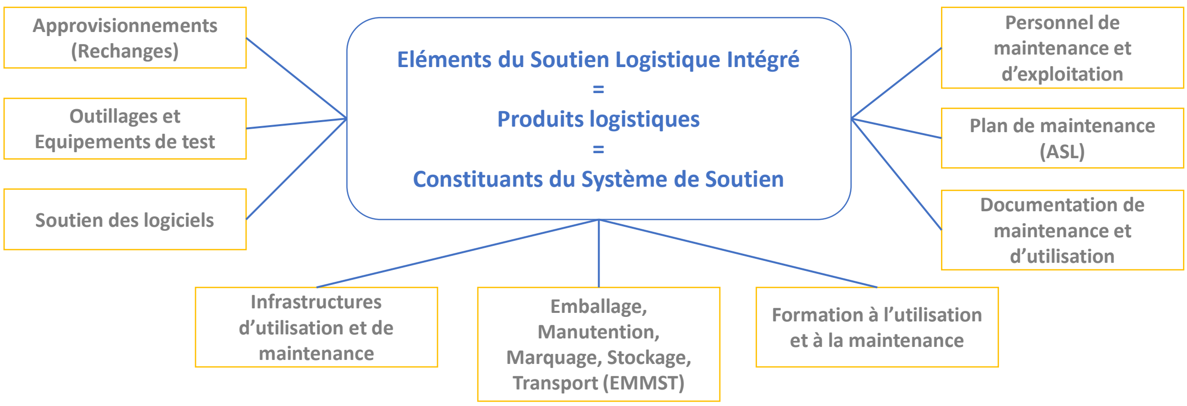
Les éléments du soutien

- NEUFS ÉLÉMENTS DU SOUTIEN…

Le SLI traite de l'ensemble des constituants du SdS



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Les éléments de soutien

- LE PLAN DE MAINTENANCE : « L'ÉLÉMENT DE SYNTHÈSE DE L'ASL »

- Le plan de maintenance est une synthèse des tâches de maintenance du système à réaliser dans le cadre de la maintenance préventive et corrective.
- Les données issues des études d'analyse du soutien logistique (ASL) sont rattachées aux constituants de l'arborescence logistique en rapport avec la politique de maintenance pour identifier les opérations de maintenance (Type de tâche de maintenance, Éléments de soutien (outillage, formations nécessaires, nombre et niveau de personnels de maintenance, etc.) Durée de l'intervention, Niveau de maintenance, Criticité de l'intervention, etc.).
- C'est une synthèse des tâches et des sous-tâches destinée à décrire la maintenance d'un matériel.

- Le plan de maintenance regroupe l'ensemble des tâches de maintenance à réaliser sur un Matériel Roulant et les organise dans une arborescence logistique du Matériel. Il fait le lien entre chacune des tâches de maintenance et les éléments de soutien nécessaires à sa réalisation :
  - Combien d'agents et de quelles spécialités ?
  - Combien et quelles références d'outillages ?
  - Combien et quelles référence d'articles de rechange ?
  - Etc.

Le schéma de maintenance répond à la question : comment organiser les tâches de maintenance en opérations planifiables dans un dépôt, cohérentes avec l'exploitation locale à un coût maitrisé ?

Diffusable

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Conclusion : Le Transport Ferroviaire est un système complexe

- Une organisation large avec de multiples acteurs (acquéreurs, exploitants, mainteneurs, régulateurs, autorités gouvernementales, …)
- Des référentiels réglementaires et normatifs internationaux, européens et nationaux
- Des exigences fortes de sécurité
- Des exigences de qualité, régularité, disponibilité et de coût

Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

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SOMMAIRE

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Ingénierie du Matériel | SNCF VOYAGEURS

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C'est quoi un actif ?

« Un actif est un élément identifiable du patrimoine d'une entité ou d'un agent économique ayant une valeur économique positive, c'est-à-dire un élément générant une ressource que l'entité contrôle du fait d'évènements passés et dont elle attend des avantages économiques futurs »

Pour une entreprise ferroviaire, le Matériel Roulant peut constituer un des actifs stratégiques

Pour SNCF Voyageurs, **c'est** l'actif stratégique

Sa **gestion** devient alors une condition importante vis-à-vis du Business Plan

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Véhicule vs matériel roulant

Véhicule

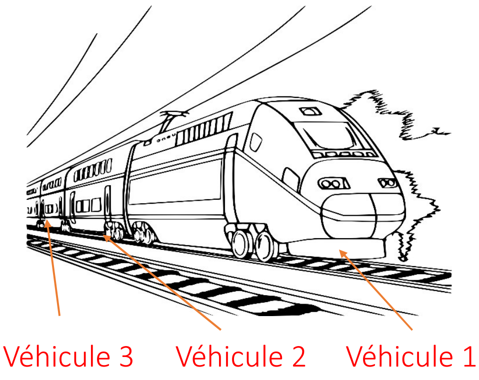
Actif qui dispose d'un numéro d'immatriculation (European Vehicle Number) et enregistré dans un registre des véhicules. Un véhicule peut donc être :

- Une caisse
- Une voiture
- Un wagon
- Une remorque
- Une locomotive
- Un locotracteur
- Une motrice

Matériel Roulant

Actif conforme à un type autorisé (disposant d'un numéro RETVA) et qui est composé d'un ou de plusieurs véhicules. Un matériel roulant peut donc être :

- Un automoteur
- Un tram-train
- Un wagon
- Une voiture
- Une locomotive
- Un locotracteur



Diffusable

Ingénierie du Matériel SNCF VOYAGEURS

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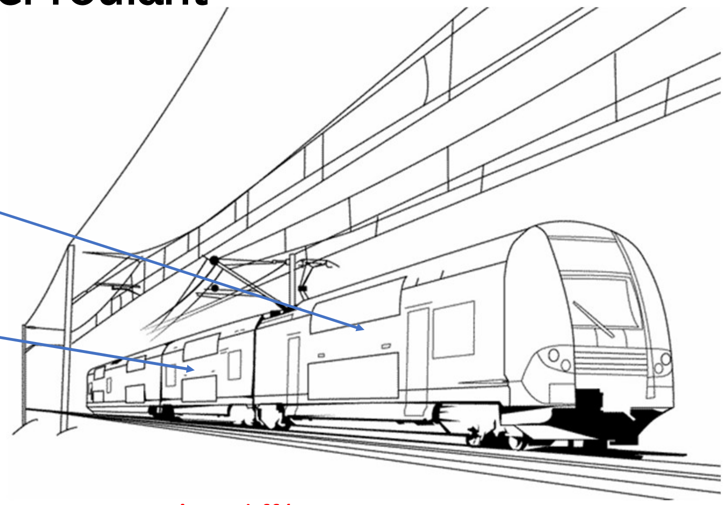
Véhicule vs matériel roulant

Véhicule 1
- Propriétaire 1
- Détenteur 1
- ECE 1

Véhicule 2
- Propriétaire 2
- Détenteur 2
- ECE 2

…



Pour SNCF Voyageurs :
- Propriétaire de chaque caisse peut être différent
- Détenteur unique pour toutes les caisses
- ECE unique pour toutes les caisses

Diffusable

Ingénierie du Matériel SNCF VOYAGEURS

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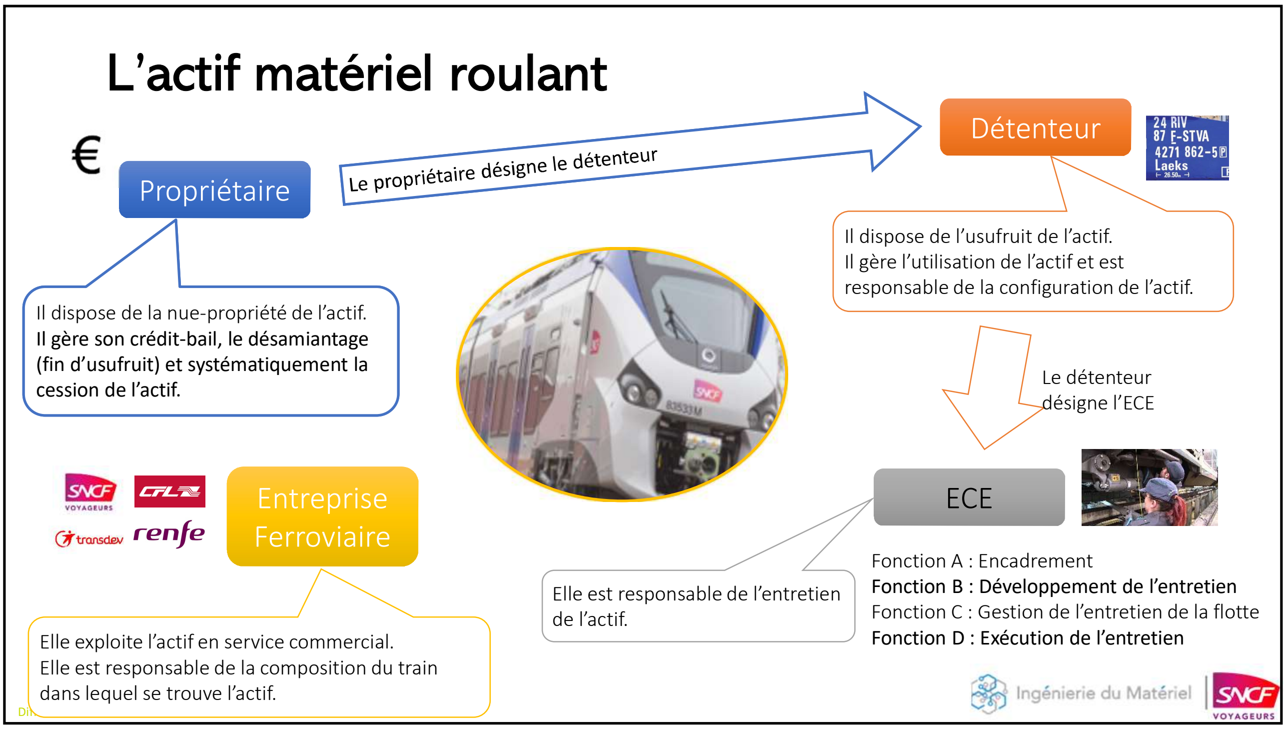
L'actif matériel roulant
€
Propriétaire
Le propriétaire désigne le détenteur
Détenteur
24 RIV
87 F-STVA
4271 862-5
Laeks
Il dispose de l'usufruit de l'actif.
Il gère l'utilisation de l'actif et est responsable de la configuration de l'actif.
Il dispose de la nue-propriété de l'actif.
Il gère son crédit-bail, le désamiantage (fin d'usufruit) et systématiquement la cession de l'actif.
Le détenteur désigne l'ECE
SNCF VOYAGEURS
CFL
transdev
renfe
Entreprise Ferroviaire
ECE
Elle est responsable de l'entretien de l'actif.
Fonction A : Encadrement
Fonction B : Développement de l'entretien
Fonction C : Gestion de l'entretien de la flotte
Fonction D : Exécution de l'entretien
Elle exploite l'actif en service commercial.
Elle est responsable de la composition du train dans lequel se trouve l'actif.
Ingénierie du Matériel
SNCF VOYAGEURS

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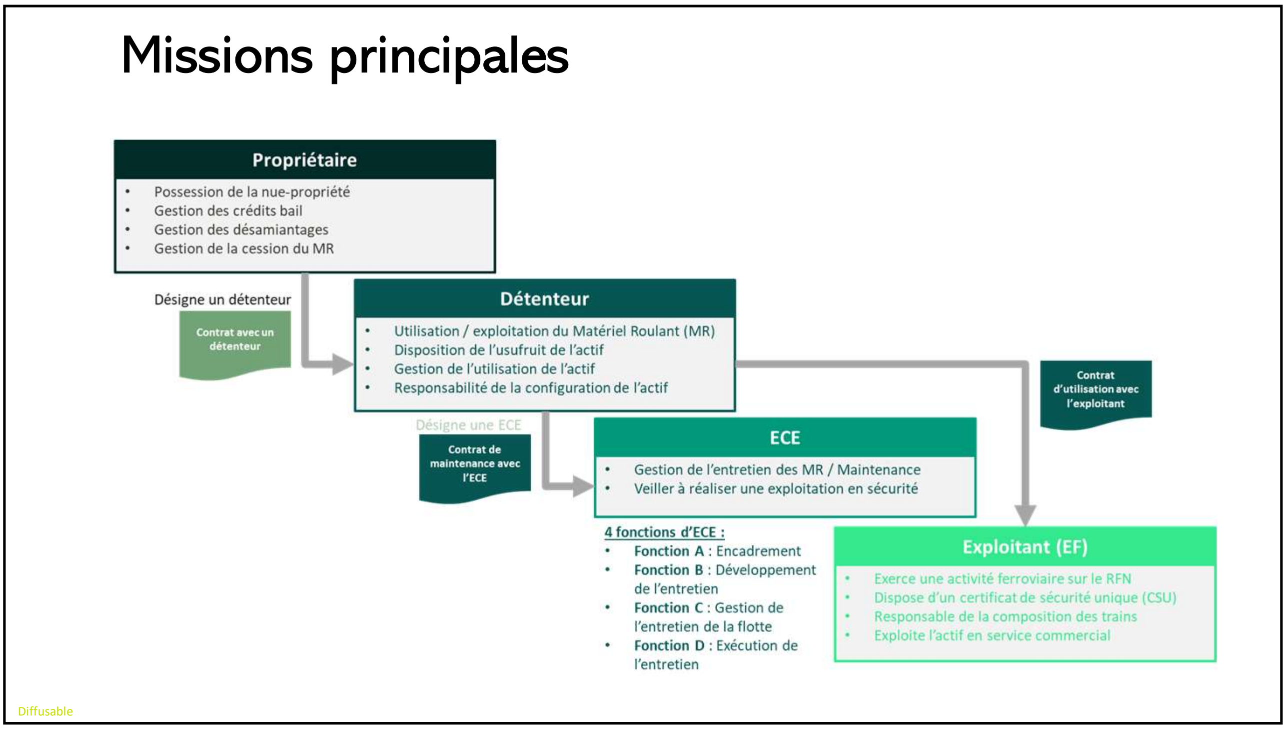
Missions principales
Propriétaire
Possession de la nue-propriété
Gestion des crédits bail
Gestion des désamiantages
Gestion de la cession du MR
Désigne un détenteur
Contrat avec un détenteur
Détenteur
Utilisation / exploitation du Matériel Roulant (MR)
Disposition de l'usufruit de l'actif
Gestion de l'utilisation de l'actif
Responsabilité de la configuration de l'actif
Contrat d'utilisation avec l'exploitant
Désigne une ECE
Contrat de maintenance avec l'ECE
ECE
Gestion de l'entretien des MR / Maintenance
Veiller à réaliser une exploitation en sécurité
4 fonctions d'ECE :
Fonction A : Encadrement
Fonction B : Développement de l'entretien
Fonction C : Gestion de l'entretien de la flotte
Fonction D : Exécution de l'entretien
Exploitant (EF)
Exerce une activité ferroviaire sur le RFN
Dispose d'un certificat de sécurité unique (CSU)
Responsable de la composition des trains
Exploite l'actif en service commercial
Diffusable

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Rôles et responsabilités des acteurs à SNCF V – exemple Transilien

Propriétaire

- Gérer le financement de l'acquisition du MR (fonds propres, crédit-bail, montage financier)
- Être le donneur d'ordre des repérages avant travaux (Amiante, Fibre Céramique Réfractaire (FCR))
- Financer des opérations de valorisation patrimoniale (modernisation, remise au potentiel – OP mi-vie)
- Gérer l'éventuelle vente du MR
- Assurer le démantèlement du MR (y compris le désamiantage)

Responsable <u>Sécurité Santé au Travail</u> *sur le repérage avant travaux et le désamiantage*

Détenteur

- Tirer des bénéfices vis-à-vis de l'utilisation du MR
- Gérer les modifications apportées sur le MR
- Gérer la configuration appliquée (configuration technique)
- Mettre à disposition les informations nécessaires à l'ECE pour mesurer les impacts éventuels sur le dossier d'entretien (dossier technique d'une modification par exemple)
- Informer l'Exploitant d'éventuels impacts de modifications sur l'utilisation du MR (conduite, …)

Responsable de la <u>configuration</u> du train
responsable de la conformité, de la configuration du MR, au type

ECE

ECE
Ingénierie du Matériel
ECE B

- Mettre en œuvre les recommandations de maintenance de la documentation d'origine dans un dossier d'entretien (PMS)
- Identifier les composants essentiels de sécurité
- Faire évoluer le dossier d'entretien au besoin
- Planifier les roulements du MR pour respecter les RDV de maintenance
- Exécuter les travaux d'entretien prévus
- Assurer une traçabilité de toutes les opérations de maintenance réalisées
- Gérer la configuration installée
- Remettre à disposition le MR à l'Exploitant

Responsable de <u>l'entretien</u> du train
Responsable du bon déroulement des opérations de maintenance et

Exploitant (EF)

- Commander les sillons et les emplacements en gare (GOV)
- Vérifier la compatibilité avec les itinéraires
- Organiser les roulements pour le personnel roulant et le personnel en gare
- Mettre à disposition tous les documents d'exploitation nécessaires (AdC, AA, GM, …)
- Préparer le train commercial (composition, essais de frein, …)
- Assurer la production ferroviaire par rapport au plan de transport prévu
- Informer l'ECE d'éventuels dysfonctionnements
- Prendre en compte les éventuelles restrictions suite à mainte…

Responsable de la <u>circulation</u> du train
Responsable de la bonne réalisation des essais avant départ et de la formation des conducteurs

Diffusable

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Les ECE ou ECM

Entité en Charge de l'Entretien / la Maintenance

- Une organisation large avec de multiples acteurs (acquéreurs, exploitants, mainteneurs, régulateurs, autorités gouvernementales, …)
- Des référentiels réglementaires et normatifs internationaux, européens et nationaux
- Des exigences fortes de sécurité
- Des exigences de qualité, régularité, disponibilité et de coût

RÈGLEMENT D'EXÉCUTION (UE) 2019/779

Diffusable

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Les ECE ou ECM
Entité en Charge de l'Entretien / la Maintenance

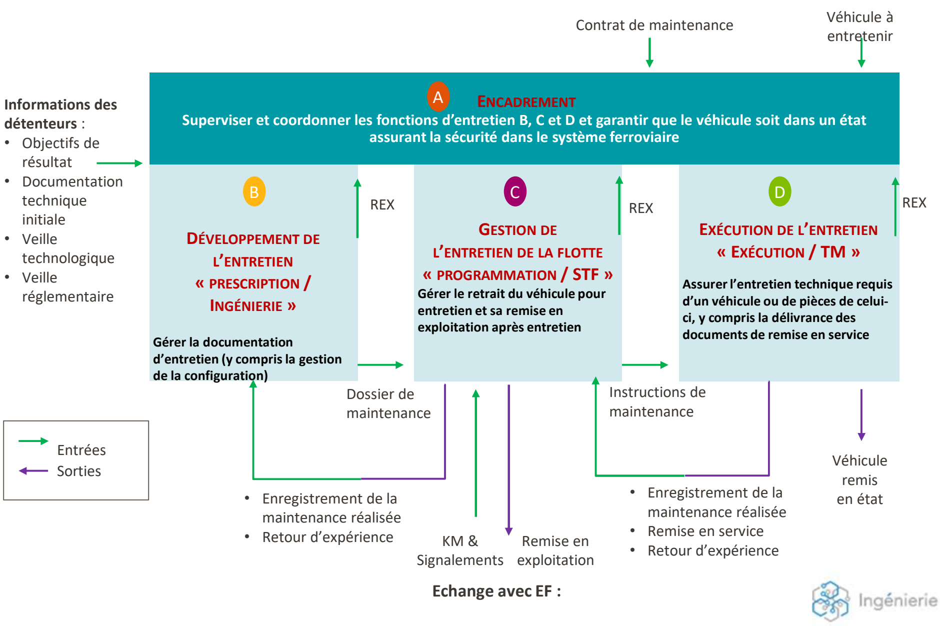
- La notion d' « entité » chargée de la maintenance (ECM) dans la plupart des textes français, « entité chargée de l'entretien » (ECE) dans les textes européens traduits, est apparue avec la **directive 2004/49/CE** (aujourd'hui remplacée par la directive 2016/798) qui définissait les responsabilités suivantes :
  - **Veiller** à ce que le véhicule soit dans un état de marche assurant la sécurité
  - **Veiller** à la bonne application du plan de maintenance du véhicule et tient à jour son « carnet d'entretien
  - **Préciser,** en fonction de l'état du véhicule, les restrictions temporaires d'utilisation
- Le règlement européen 445/2011 en définissait le domaine d'application : uniquement les wagons
- le nouveau règlement d'exécution 2019/779 **du 16 mai 2019 de l'UE s'applique depuis 06/2020 :**
  - Il **renforce les obligations** par rapport à la législation précédente notamment en ce qui concerne la mise en œuvre de mesures de maîtrise des risques.
  - Ce règlement **élargit notamment les exigences ECE à tous les véhicules pour 2020**.

Une certification établissant le respect des exigences, reprises dans le règlement 2019/779, est obligatoire pour toute entité chargée de la maintenance. Elle est délivrée par un organisme accrédité (CERTIFER en France, BELGORAIL en Belgique, etc.)

Les 4 responsabilités des ECE / ECM

- L'**ECE A** ou ECM 1, qui assure l'entière responsabilité de l'entretien et qui encadre les 3 autres fonctions.
- L'**ECE B** ou ECM 2, qui assure le développement de l'entretien (Ingénierie de Maintenance). Pour SNCF Voyageurs, l'ECE B est unique pour toutes les ECE A de SNCF Voyageurs : SNCF Matériel, dont l'Ingénierie du Matériel assure la majorité des responsabilités.
- L'**ECE C** ou ECM 3, qui assure la gestion de l'entretien de la flotte. Pour SNCF Voyageurs, l'ECE C est assurée par les STF (Supervisions Techniques de Flotte) dans les Activités. Son rôle, entre autres, est de programmer et d'organiser les roulements des Matériels Roulants en respectant les rendez-vous de maintenance imposés par l'ECE B.
- L'**ECE D** ou ECM 4, qui assure l'exécution de l'entretien. Pour SNCF Voyageurs, l'ECE D est assurée par les TM (Technicentres de Maintenance) pour la maintenance de niveau 2 et 3 et par les TI (Technicentres Industriels) pour la maintenance de niveau 4 (le niveau 5 est considéré comme de la maintenance uniquement sur le périmètre des grosses réparations).

Les 4 responsabilités des ECE / ECM



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Ingénierie du Matériel | SNCF VOYAGEURS

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SOMMAIRE

- LE GROUPE SNCF, LE MATÉRIEL, LE FERROVIAIRE EN FRANCE
- L'OUVERTURE À LA CONCURRENCE
- LA MAINTENANCE (DÉFINITION, CONCEPT, ORGANISATION)
- SOUTIEN LOGISTIQUE DES MATÉRIELS ROULANTS FERROVIAIRES
- LES ECE / ECM
- LA MAINTENANCE PRÉDICTIVE
- LES BANCS DE MAINTENANCE
- LES INNOVATIONS POUR DEMAIN

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Ingénierie du Matériel | SNCF VOYAGEURS

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PREDICTIVE MAINTENANCE

The future is now!

Ingénierie du Matériel

SNCF VOYAGEURS

Cyril VERDUN

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INGÉNIERIE DU MATÉRIEL

Ingénierie du Matériel | SNCF VOYAGEURS

ENJEUX

PERFORMANCE :

Pour rester **compétitif**, SNCF Voyageurs et notamment Matériel doivent créer des ruptures pour booster la performance : Régularité / Fiabilité, Coûts de maintenance, Disponibilité des rames et des installations.

- Une **rupture technologique** est déjà visible sur les matériels roulants : Franciliens, REGIOLIS et REGIO2N ; puis du RERNG, TGV^{M} : confort, performances techniques, informatique et électronique embarquées, complexité…

- Ces trains connectés, grâce à leur réseau et leurs données, offrent aussi de **nouveaux leviers** pour optimiser la maintenance, mais aussi pour améliorer les performances de leur maintien en conditions opérationnelles.

- Pour les trains plus anciens (RER Z2N, locomotives, Tram-train, Wagons, Voitures et TGV), le domaine Matériel les équipe en **IoT** pour améliorer leur connectivité.

TÉLÉDIAGNOSTIC-CBM

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INGÉNIERIE DU MATÉRIEL

Ingénierie du Matériel | SNCF VOYAGEURS

LE TÉLÉDIAGNOSTIC & LA MAINTENANCE PREDICTIVE

UNE CHAÎNE COMPLÈTE POUR UNE MAINTENANCE OPTIMISÉE

CONSOLIDER NOS FONDATIONS

+ Connaître l'état du train en temps réel
+ Anticiper une panne
+ Supprimer (automatiser) de la maintenance préventive systématique

La data au cœur du pilotage et de la réalisation de la maintenance

- Accompagnement du changement des opérateurs (dépanneurs et préventif) jusqu'au directeur en passant par la STF, la programmation, les DPX, les DUO
- Systématiser le reflex d'aller chercher dans les données train avant d'intervenir sur rame
- Système d'information robuste et disponible

TÉLÉDIAGNOSTIC-CBM

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INGÉNIERIE DU MATÉRIEL

Ingénierie du Matériel | SNCF VOYAGEURS

LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE

DÉFINITIONS :

TÉLÉDIAGNOSTIC

Le télédiagnostic permet d'optimiser les activités de maintenance grâce à l'exploitation (en temps réel) des données disponibles pour :
Optimiser la fiabilité de mission et la maintenance corrective, avec une veille des redondances, une anticipation des défaillances à partir des précurseurs de pannes, et une anticipation des besoins d'approvisionnements et d'installations pour la maintenance ;

CBM / maintenance prédictive

Le Condition-Based Maintenance (CBM) est une forme de maintenance préventive conditionnelle ou prévisionnelle dite « maintenance prédictive ». Le CBM est lié à la connaissance en continu des données d'une fonction, avec l'établissement de modèles ou de signatures de référence qui décrivent le comportement du système.
Cela permet d'optimiser (supprimer la maintenance préventive systématique) avec des tests, des vérifications, des mesures réalisées automatiquement en continu (via le CBM) et donc sans opérateur de maintenance ni entrée de la rame en atelier.
Cette maintenance prédictive consiste donc à ne plus intervenir en préventif pour vérifier. Mais à intervenir juste au bon moment (la notion de préventif et de correctif se mélangent) : c'est-à-dire juste avant la panne. En analysant en les données et le comportement des équipements du matériel en continu (notamment les portes, les climatisations, les freins, les batteries, les compresseurs, les panto, les équipements de sécurité, etc.) complétées d'autres informations d'exploitation (position, nombre de passager, présence de givre, etc.)

TÉLÉDIAGNOSTIC-CBM

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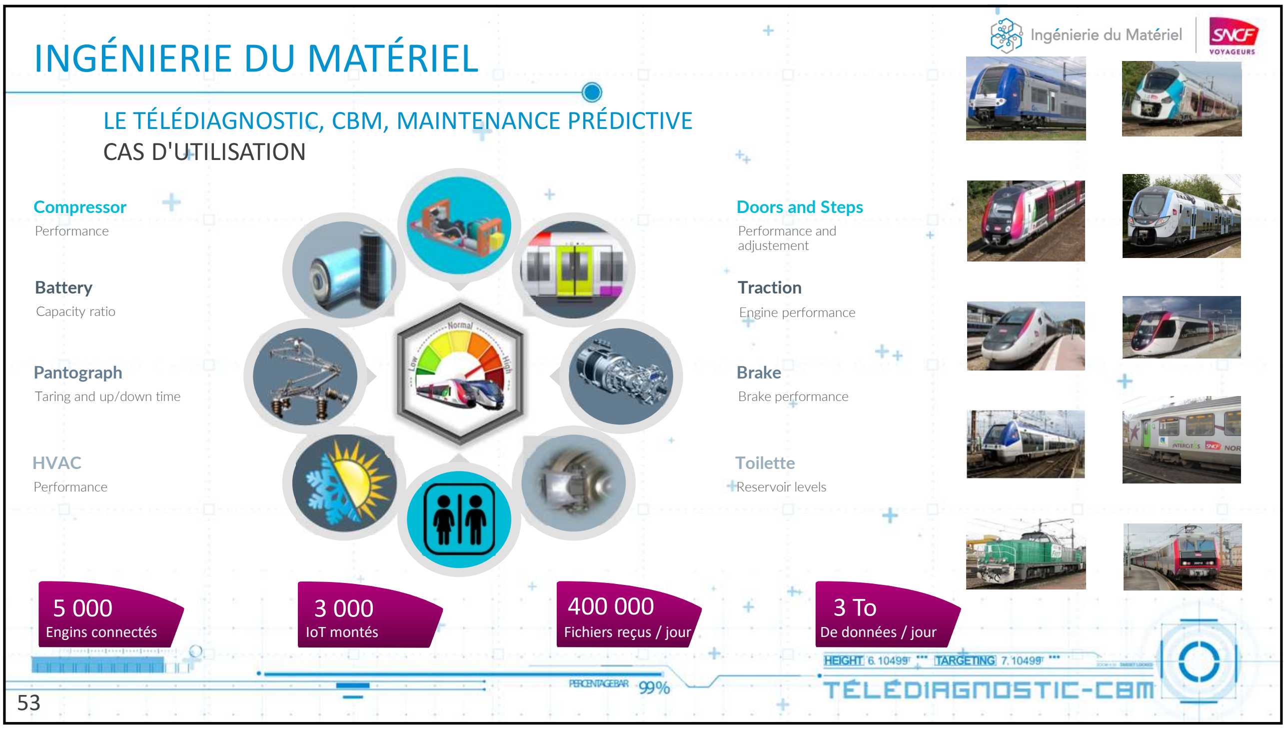
INGÉNIERIE DU MATÉRIEL
Ingénierie du Matériel
SNCF VOYAGEURS
LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE
CAS D'UTILISATION
Compressor
Performance
Battery
Capacity ratio
Pantograph
Taring and up/down time
HVAC
Performance
Doors and Steps
Performance and adjustement
Traction
Engine performance
Brake
Brake performance
Toilette
Reservoir levels
Low
Normal
High
5 000
Engins connectés
3 000
IoT montés
400 000
Fichiers reçus / jour
3 To
De données / jour
TÉLÉDIAGNOSTIC-CBM
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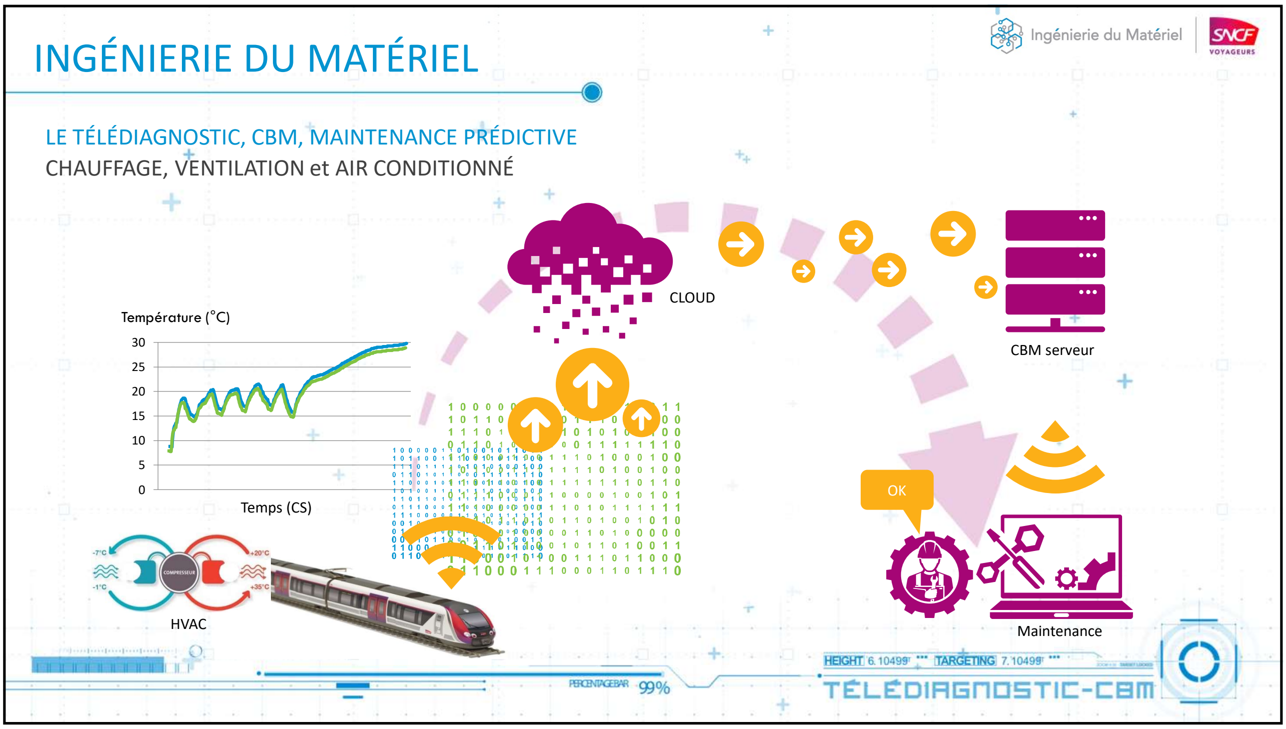
INGÉNIERIE DU MATÉRIEL
Ingénierie du Matériel
SNCF VOYAGEURS
LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE
CHAUFFAGE, VENTILATION et AIR CONDITIONNÉ
CLOUD
CBM serveur
Température (°C)
30
25
20
15
10
5
0
Temps (CS)
HVAC
OK
Maintenance
TÉLÉDIAGNOSTIC-CBM

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INGÉNIERIE DU MATÉRIEL
Ingénierie du Matériel
SNCF VOYAGEURS
LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE
PORTES & ACCES VOYAGEURS
Intensité (A)
Déviation
Temps (CS)
Portes
CLOUD
CBM serveur
Problème avec le joint de la porte
Maintenance
TÉLÉDIAGNOSTIC-CBM

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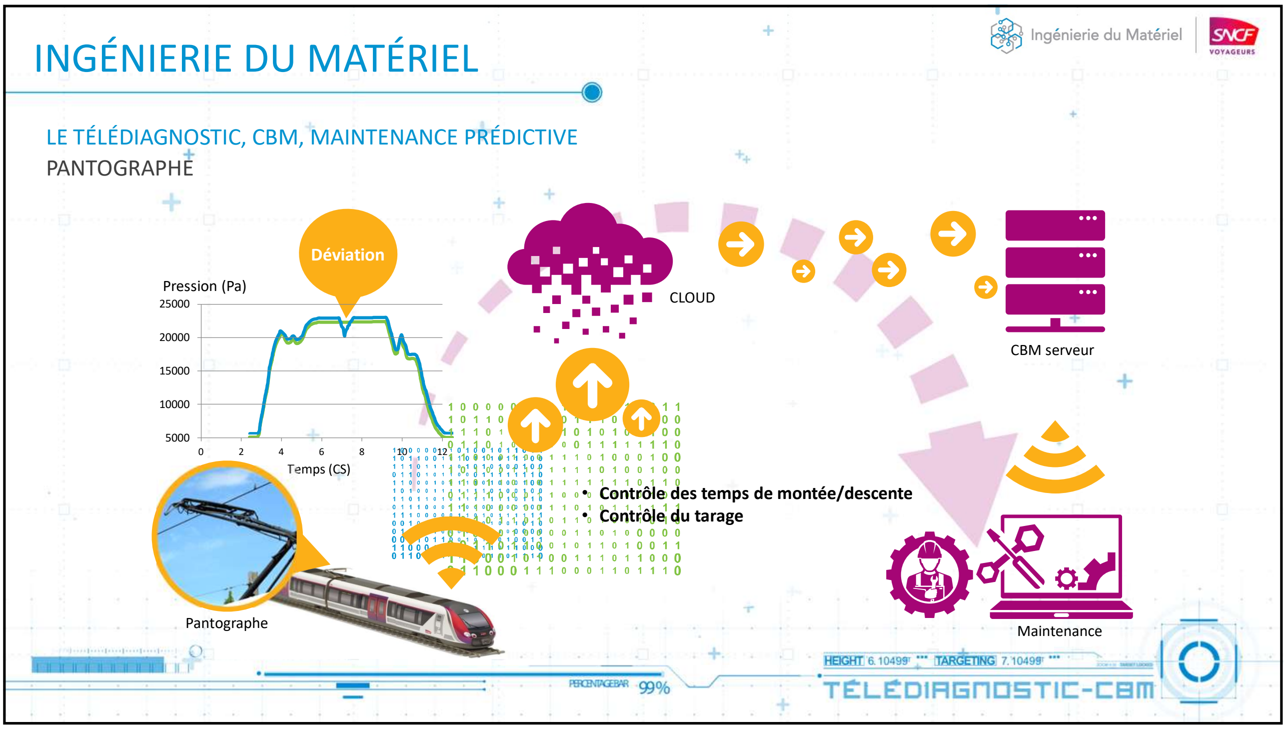

INGÉNIERIE DU MATÉRIEL
Ingénierie du Matériel
SNCF VOYAGEURS
LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE
PANTOGRAPHE
Déviation
Pression (Pa)
Temps (CS)
Pantographe
CLOUD
CBM serveur
Contrôle des temps de montée/descente
Contrôle du tarage
Maintenance
TÉLÉDIAGNOSTIC-CBM

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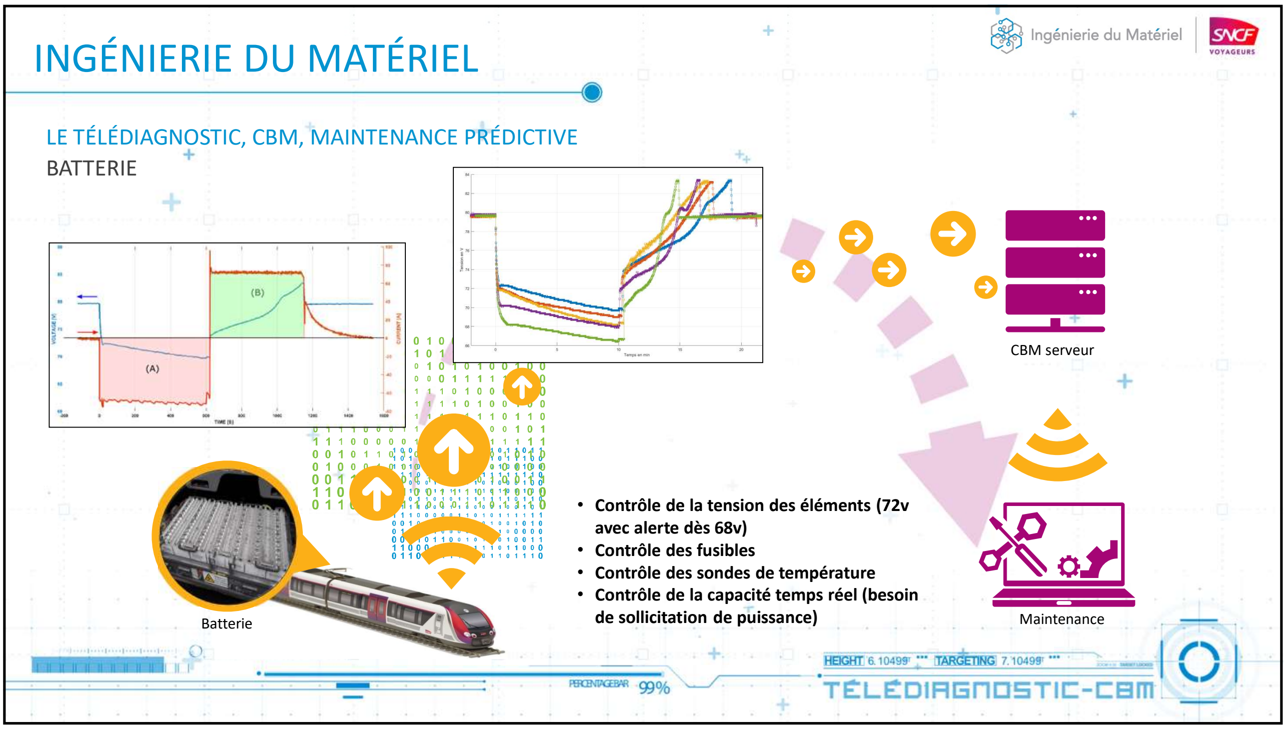
INGÉNIERIE DU MATÉRIEL
Ingénierie du Matériel
SNCF VOYAGEURS
LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE
BATTERIE
CBM serveur
Batterie
Maintenance
• Contrôle de la tension des éléments (72v avec alerte dès 68v)
• Contrôle des fusibles
• Contrôle des sondes de température
• Contrôle de la capacité temps réel (besoin de sollicitation de puissance)
TÉLÉDIAGNOSTIC-CBM

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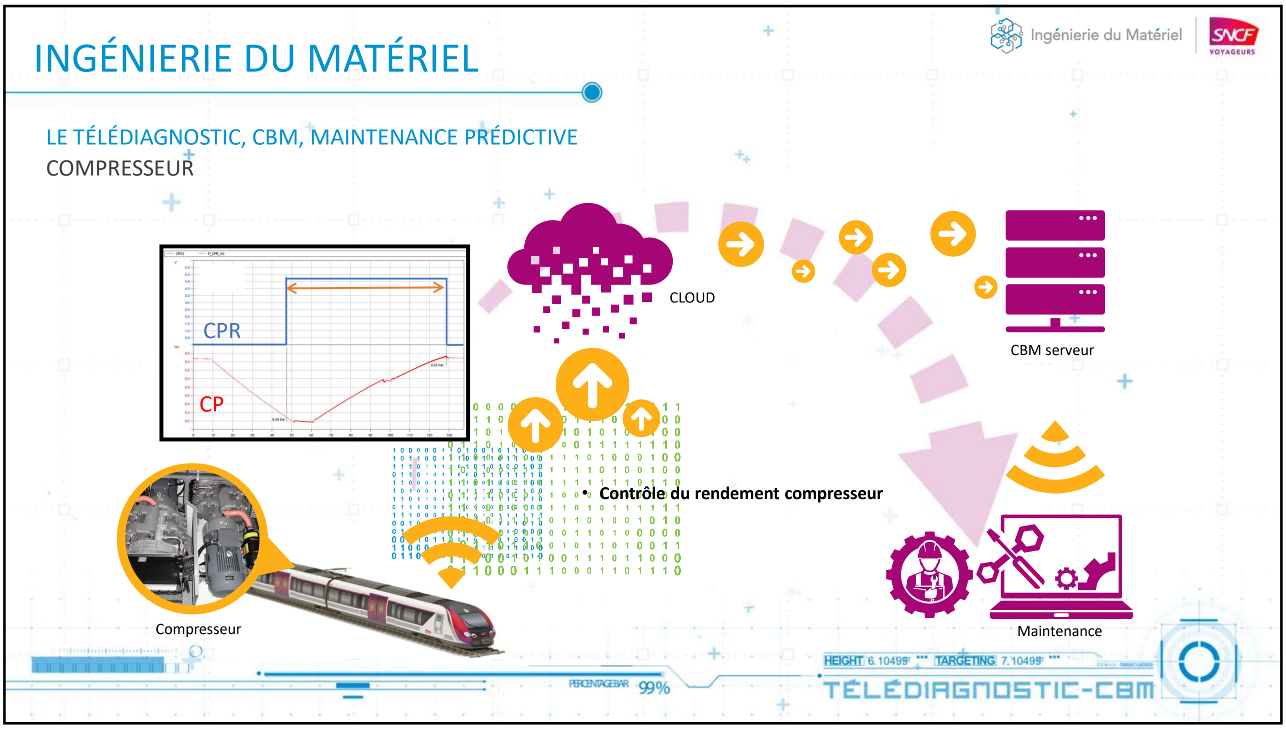
INGÉNIERIE DU MATÉRIEL
Ingénierie du Matériel
SNCF VOYAGEURS
LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE
COMPRESSEUR
CPR
CP
CLOUD
CBM serveur
Compresseur
• Contrôle du rendement compresseur
Maintenance
TÉLÉDIAGNOSTIC-CBM

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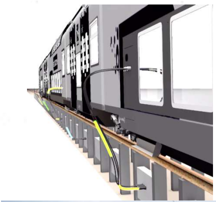
INGÉNIERIE DU MATÉRIEL

Ingénierie du Matériel SNCF VOYAGEURS

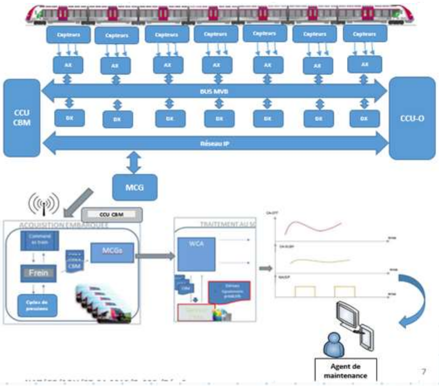
LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE

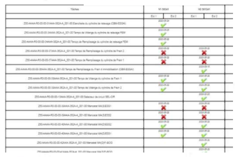
FREIN

1 seule mesure de surveillance tous les 28 mois



1 surveillance régulière et continue




Unité de contrôle CCU-CBM

Module d'acquisition AX Alimentation et mesure de pression des capteurs

TÉLÉDIAGNOSTIC-CBM

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INGÉNIERIE DU MATÉRIEL

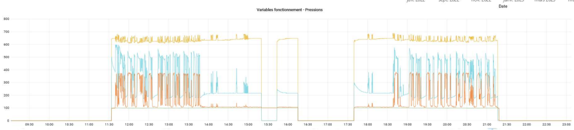
Ingénierie du Matériel SNCF VOYAGEURS

LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE

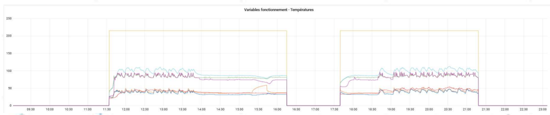
POWER PACK MAN AGC et REGIOLIS

PWP D2876 RÉGIOLIS


- **Données en temps réel, codes défauts avec FMI (Failure Mode Identifier) et criticité**
- **Données de fonctionnement stockées et possibilité de récupérer l'historique**
- **Indicateurs sur des valeurs de fonctionnement sur les précédents cycles**



Visualisation de l'ensemble des données brutes PWP disponibles sur le réseau CAN



Visualisation des défauts internes du moteur

TÉLÉDIAGNOSTIC-CBM

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INGÉNIERIE DU MATÉRIEL

Ingénierie du Matériel — SNCF VOYAGEURS

TÉLÉSURVEILLANCE D'UNE FONCTION « CRITIQUE » PORTES

Quand Exploitant Ferroviaire et/ou ECE ont besoin de surveiller une fonction à fort impact sans donnée facilement accessible, nos solutions objet connecté ont fait leurs preuves !

OBJET CONNECTÉ PLUG & PLAY

MARTI est le premier objet connecté certifié embarqué ferroviaire, il fonctionne sur réseau opérateur, ou avec MELI.
MELI est une passerelle LORA / 4G ferroviaire, qui étend la connectivité de MARTI (notamment en roulant).

Avantage / à d'autres solutions

- Autonomie +5 ans, non-intrusivité
- Accéléromètre, GPS, Bluetooth / LoRa intégrés
- 2 connecteurs acceptant tous types de capteurs standard
- Prix très compétitif
- Écosystème ouvert

Cas d'usage typiques

Récupérer des informations d'état à haute valeur:

- « réveil » du matériel roulant
- Sécurisation des portes d'accès (voir ci-contre)
- Disponibilité des services (eau, sable, WC…)

Sécurisation des portes sur un matériel ancien

- Avec MARTI / MELI, Intercités a mis en place une solution de surveillance des portes des voitures Corail (1975), sans évolution du câblage.
- TER ayant rejoint le projet, cette solution est déployée sur plus de 1300 voitures, et a permis d'améliorer le temps de réaction sur incident et la qualité du dépannage.

TÉLÉDIAGNOSTIC-CBM

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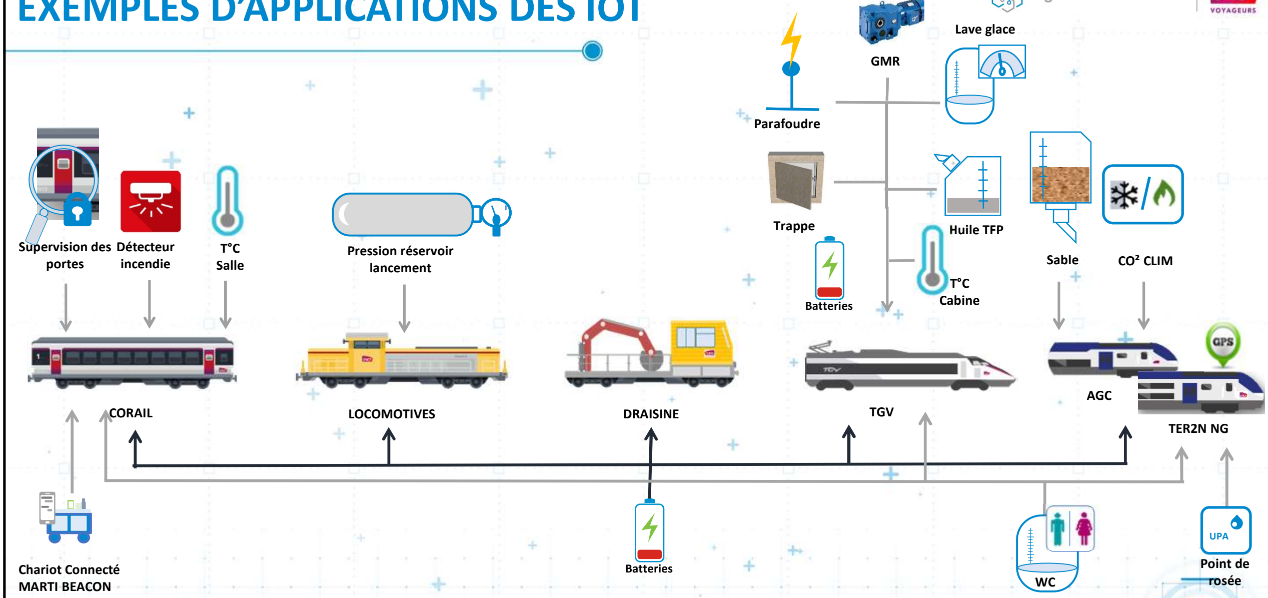
EXEMPLES D'APPLICATIONS DES IOT

Ingénierie du Matériel — SNCF VOYAGEURS



TÉLÉDIAGNOSTIC-CBM

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Ingénierie du Matériel | SNCF VOYAGEURS

INGÉNIERIE DU MATÉRIEL

ENJEUX et GAINS

- **La performance en maintenance/exploitation passe par la connaissance en temps réel de l'état du train. C'est un enjeu compétitif majeur.**
- L'Ingénierie du Matériel SNCF utilise ses connaissances des matériels et le levier de la connectivité pour proposer des offres de maintenance Full Services basées sur l'exploitation des données télétransmises.
- L'Ingénierie du Matériel SNCF, a développé sur fonds propres les pratiques et savoir une **réelle avance** sur ces pratiques et les filiales SNCF et d'autres Entreprises Ferroviaires (hors de France) nous sollicitent de plus en plus pour les aider dans ce domaine.
- Nous sommes **les seuls** à faire de la maintenance prédictive à une telle échelle, **en opérationnel** sur plus de 1 100 rames en Ile de France et TER (et depuis 10 ans).

Les **gains mesurés** sur les séries où la démarche a été mise en place :

- Moins 40 à 50% de pannes visibles de l'exploitation (Fiabilité multipliée par 2)
- Moins 20% sur les coûts de maintenance en main d'œuvre directe
- Moins 20 à 30 % du nombre d'engins arrêtés pour maintenance
- Moins 30% des entrées sur site de maintenance

TÉLÉDIAGNOSTIC-CBM

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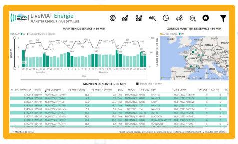
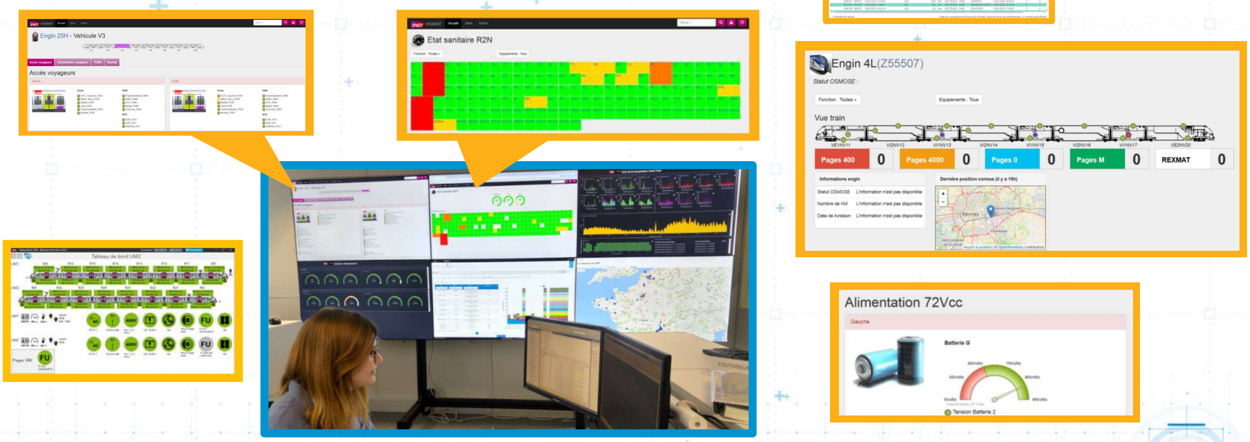
OUTILS & SYSTÈMES INFORMATIQUES SOL

LE TÉLÉDIAGNOSTIC, CBM, MAINTENANCE PRÉDICTIVE
DES OUTILS ET DES POSSIBILITÉS TOUJOURS EN MOUVEMENT





TÉLÉDIAGNOSTIC-CBM

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- LES ECE / ECM
- LA MAINTENANCE PRÉDICTIVE
- LES BANCS DE MAINTENANCE
- LES INNOVATIONS POUR DEMAIN

Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

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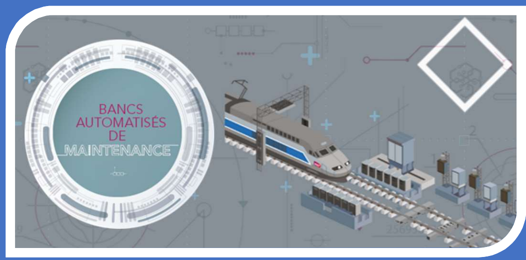
Banc automatique de maintenance



Diffusable

Ingénierie du Matériel SNCF VOYAGEURS

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Déploiement des bancs géométriques dans les Technicentres Transilien

NOISY, installé en juillet 2021

MONTROUGE, installé en octobre 2021

VILLENEUVE, installé en février 2022

LEVALLOIS, installé en avril 2022

JONCHEROLLES, installé en septembre 2022

VAL NOTRE DAME, installé en octobre 2022

Diffusable

Ingénierie du Matériel SNCF VOYAGEURS

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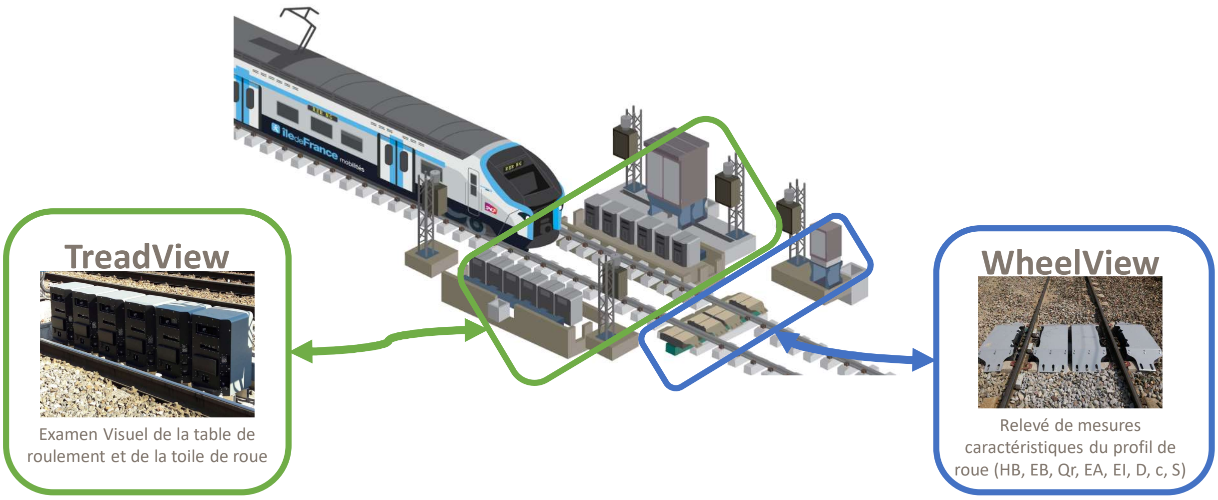
Présentation des modules du Banc géométrique de mesure de Transilien



Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

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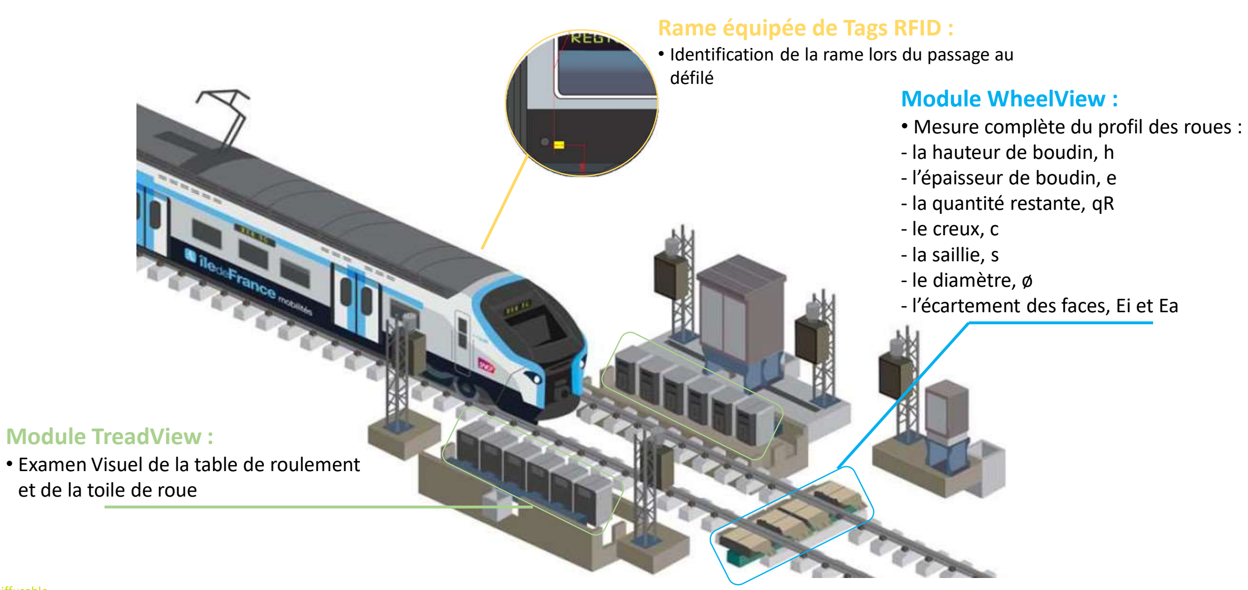
Présentation des modules du Banc géométrique



Diffusable

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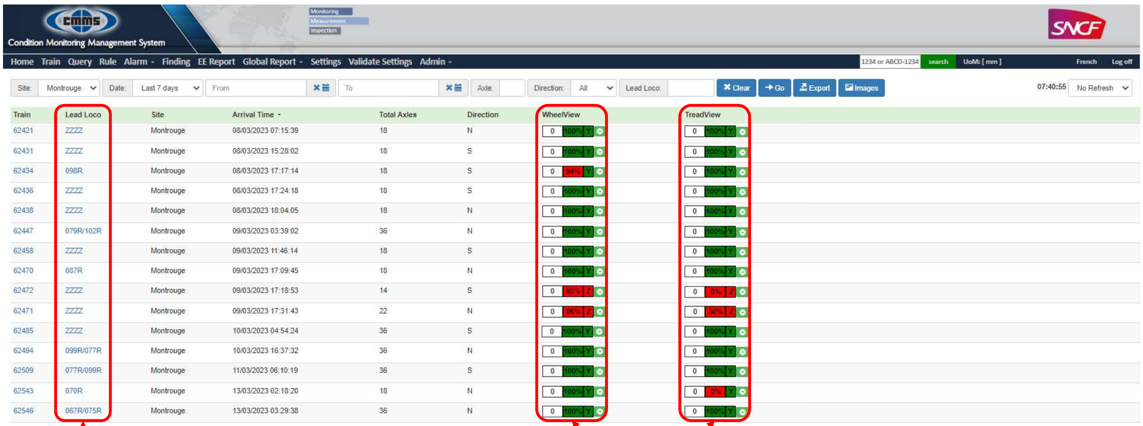
Présentation de l'interface utilisateur

- Suivi des passages au banc



Train	Lead Loco	Site	Arrival Time	Total Axles	Direction	WheelView	TreadView
62421	ZZZZ	Montrouge	08/03/2023 07:15:39	18	N	0 100% Y	0 100% Y
62431	ZZZZ	Montrouge	08/03/2023 15:28:02	18	S	0 100% Y	0 100% Y
62434	098R	Montrouge	08/03/2023 17:17:14	18	S	0 94% Y	0 100% Y
62436	ZZZZ	Montrouge	08/03/2023 17:24:18	18	S	0 100% Y	0 100% Y
62438	ZZZZ	Montrouge	08/03/2023 18:04:05	18	N	0 100% Y	0 100% Y
62447	079R/102R	Montrouge	09/03/2023 03:39:02	36	N	0 100% Y	0 100% Y
62458	ZZZZ	Montrouge	09/03/2023 11:46:14	18	S	0 100% Y	0 100% Y
62470	087R	Montrouge	09/03/2023 17:09:45	18	N	0 100% Y	0 100% Y
62472	ZZZZ	Montrouge	09/03/2023 17:18:53	14	S	0 85% Z	0 0% Z
62471	ZZZZ	Montrouge	09/03/2023 17:31:43	22	N	0 86% Z	0 60% Z
62485	ZZZZ	Montrouge	10/03/2023 04:54:24	36	S	0 100% Y	0 100% Y
62494	099R/077R	Montrouge	10/03/2023 16:37:32	36	N	0 100% Y	0 100% Y
62509	077R/099R	Montrouge	11/03/2023 06:10:19	36	S	0 100% Y	0 100% Y
62543	070R	Montrouge	13/03/2023 02:18:20	18	N	0 100% Y	0 0% Y
62546	067R/075R	Montrouge	13/03/2023 03:29:38	36	N	0 100% Y	0 100% Y

Identification des rames, si ZZZZ rame(s) non identifiée(s)

Taux de contrôle des roues, si ≠100% alors toutes les roues n'ont pas été contrôlées

Diffusable

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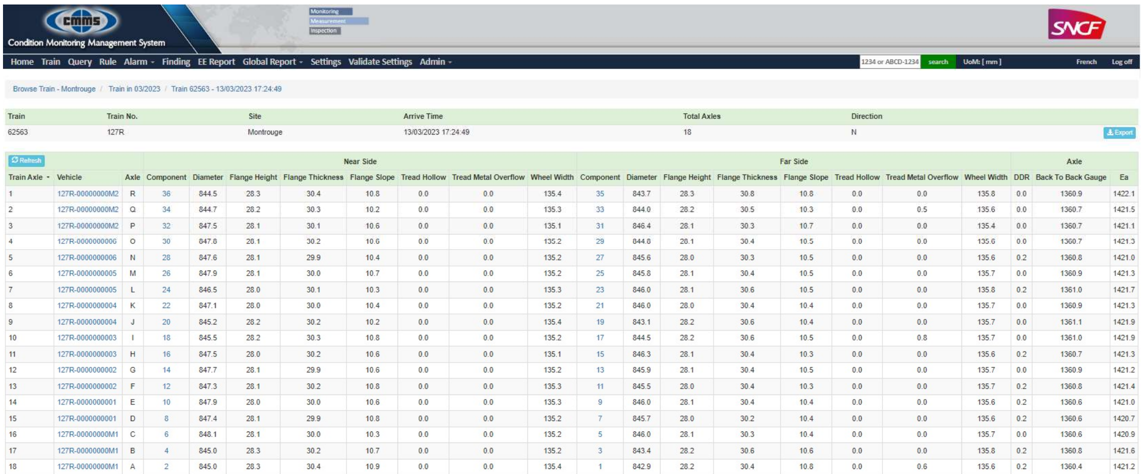
Présentation de l'interface utilisateur

- Relevé des mesures caractéristiques du profil de roue (vue d'ensemble de la rame)



Train	Train No.	Site	Arrive Time	Total Axles	Direction
62563	127R	Montrouge	13/03/2023 17:24:49	18	N

			Near Side								Far Side								Axle		
Train Axle	Vehicle	Axle	Component	Diameter	Flange Height	Flange Thickness	Flange Slope	Tread Hollow	Tread Metal Overflow	Wheel Width	Component	Diameter	Flange Height	Flange Thickness	Flange Slope	Tread Hollow	Tread Metal Overflow	Wheel Width	DDR	Back To Back Gauge	Ea
1	127R-00000000M2	R	36	844.5	28.3	30.4	10.8	0.0	0.0	135.4	35	843.7	28.3	30.8	10.8	0.0	0.0	135.8	0.0	1360.9	1422.1
2	127R-00000000M2	Q	34	844.7	28.2	30.3	10.2	0.0	0.0	135.3	33	844.0	28.2	30.5	10.3	0.0	0.5	135.6	0.0	1360.7	1421.5
3	127R-00000000M2	P	32	847.5	28.1	30.1	10.6	0.0	0.0	135.1	31	846.4	28.1	30.3	10.7	0.0	0.0	135.4	0.0	1360.7	1421.1
4	127R-0000000006	O	30	847.8	28.1	30.2	10.6	0.0	0.0	135.2	29	844.8	28.1	30.4	10.5	0.0	0.0	135.6	0.0	1360.7	1421.3
5	127R-0000000006	N	28	847.6	28.1	29.9	10.4	0.0	0.0	135.2	27	845.6	28.0	30.3	10.5	0.0	0.0	135.6	0.2	1360.8	1421.0
6	127R-0000000005	M	26	847.9	28.1	30.0	10.7	0.0	0.0	135.2	25	845.8	28.1	30.4	10.5	0.0	0.0	135.7	0.0	1360.9	1421.3
7	127R-0000000005	L	24	846.5	28.0	30.1	10.3	0.0	0.0	135.3	23	846.0	28.1	30.6	10.5	0.0	0.0	135.8	0.2	1361.0	1421.7
8	127R-0000000004	K	22	847.1	28.0	30.0	10.4	0.0	0.0	135.2	21	846.0	28.0	30.4	10.4	0.0	0.0	135.7	0.0	1360.9	1421.3
9	127R-0000000004	J	20	845.2	28.2	30.2	10.2	0.0	0.0	135.4	19	843.1	28.2	30.6	10.4	0.0	0.0	135.7	0.0	1361.1	1421.9
10	127R-0000000003	I	18	845.5	28.2	30.3	10.8	0.0	0.0	135.2	17	844.5	28.2	30.6	10.5	0.0	0.8	135.7	0.0	1361.0	1421.9
11	127R-0000000003	H	16	847.5	28.0	30.2	10.6	0.0	0.0	135.1	15	846.3	28.1	30.4	10.3	0.0	0.0	135.6	0.2	1360.7	1421.3
12	127R-0000000002	G	14	847.7	28.1	29.9	10.6	0.0	0.0	135.2	13	845.9	28.1	30.4	10.5	0.0	0.0	135.7	0.0	1360.9	1421.2
13	127R-0000000002	F	12	847.3	28.1	30.2	10.8	0.0	0.0	135.3	11	845.5	28.0	30.4	10.3	0.0	0.0	135.7	0.2	1360.8	1421.4
14	127R-0000000001	E	10	847.9	28.0	30.0	10.6	0.0	0.0	135.3	9	846.0	28.1	30.4	10.4	0.0	0.0	135.6	0.2	1360.6	1421.0
15	127R-0000000001	D	8	847.4	28.1	29.9	10.8	0.0	0.0	135.2	7	845.7	28.0	30.2	10.4	0.0	0.0	135.6	0.2	1360.6	1420.7
16	127R-00000000M1	C	6	848.1	28.1	30.0	10.3	0.0	0.0	135.2	5	846.0	28.1	30.3	10.4	0.0	0.0	135.7	0.0	1360.6	1420.9
17	127R-00000000M1	B	4	845.0	28.3	30.2	10.7	0.0	0.0	135.2	3	843.4	28.2	30.6	10.6	0.0	0.0	135.8	0.2	1360.8	1421.6
18	127R-00000000M1	A	2	845.0	28.3	30.4	10.9	0.0	0.0	135.4	1	842.9	28.2	30.4	10.8	0.0	0.6	135.6	0.2	1360.4	1421.2

Cette fenêtre synthétise toutes les mesures caractéristiques des roues de la rame

Diffusable

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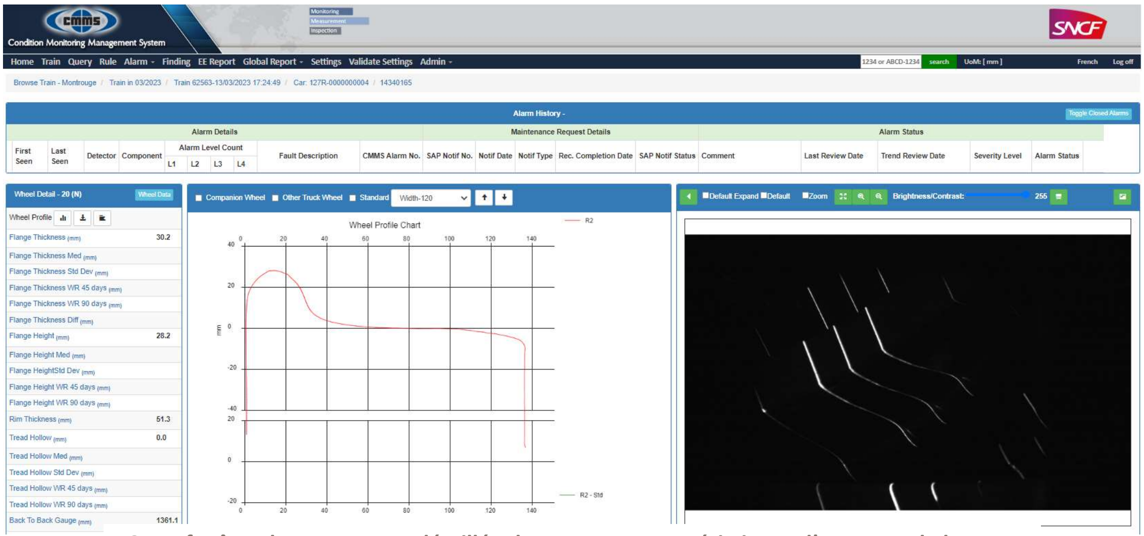
Présentation de l’interface utilisateur

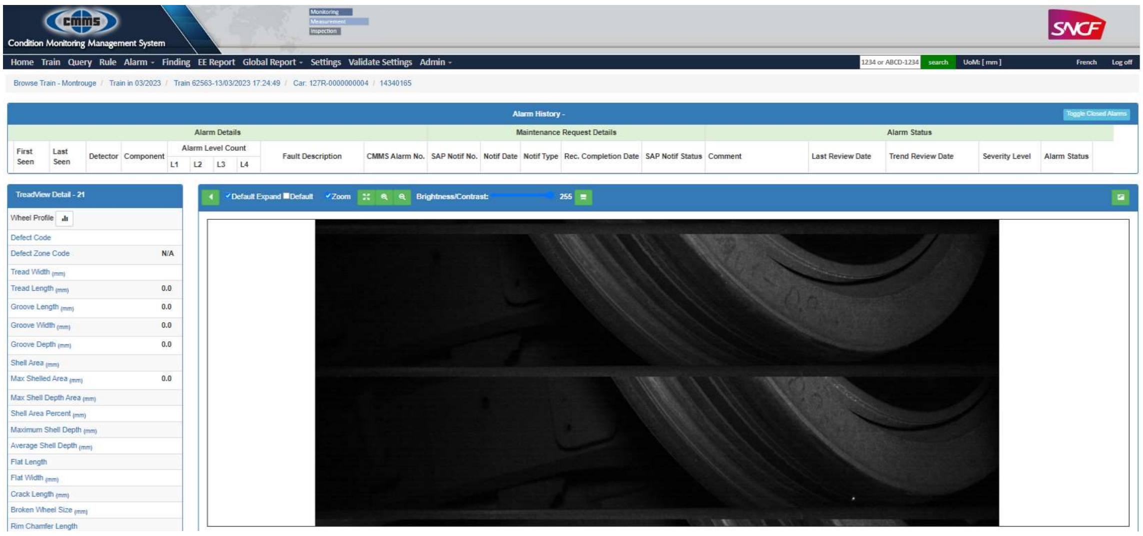
- Relevé des mesures caractéristiques du profil de roue (vue détaillée d’une roue)



Cette fenêtre donne une vue détaillée des mesures caractéristiques d’une roue de la rame

Présentation de l’interface utilisateur

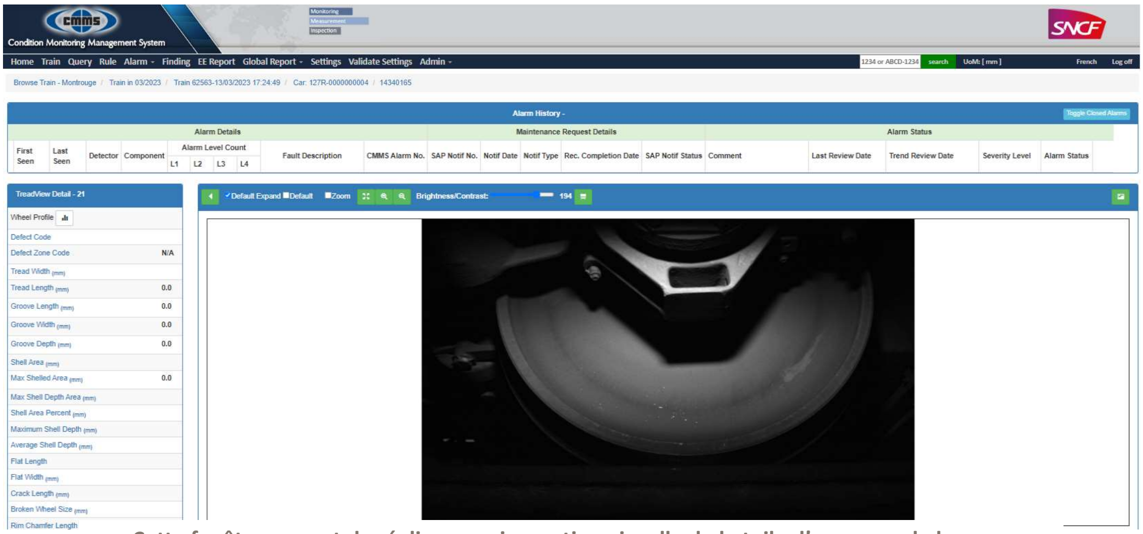
- Inspection visuelle de la table de roulement



Cette fenêtre permet de réaliser une inspection visuelle de la table de roulement d’une roue de la rame

Présentation de l'interface utilisateur

- Inspection visuelle de la table de la toile de roue



Cette fenêtre permet de réaliser une inspection visuelle de la toile d'une roue de la rame

Diffusable

Ingénierie du Matériel

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Déploiement des bancs géométriques dans les Technicentres TGV

Technicentre Atlantique

Technicentre Le Landy

Technicentre Sud Est Européen

Technicentre Est Européen

Technicentre Lyon Gerland

Diffusable

Ingénierie du Matériel

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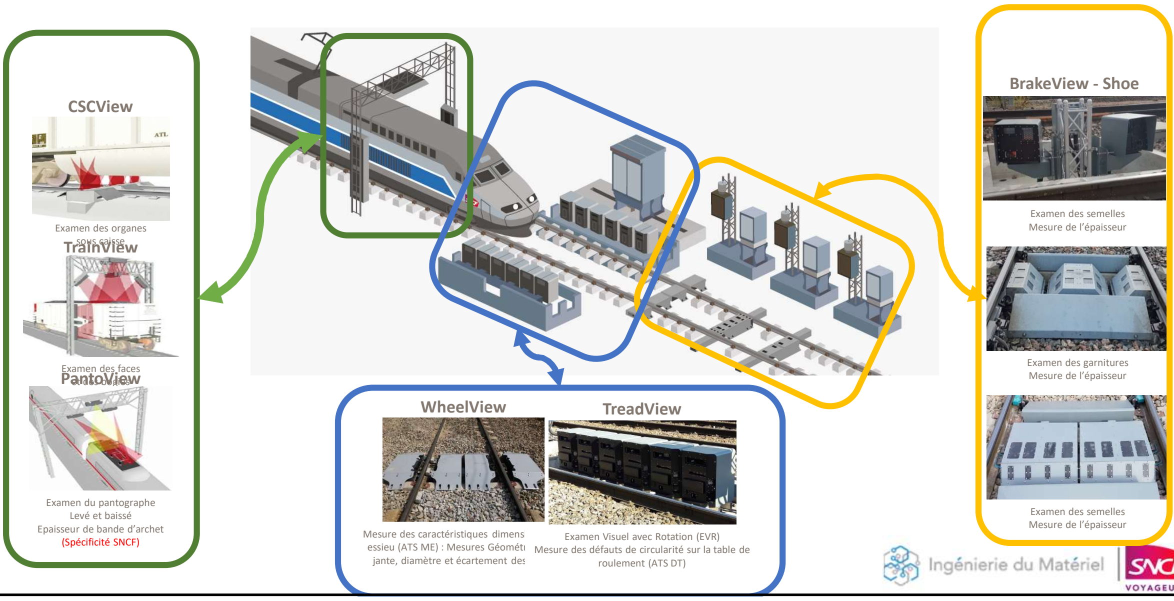
Présentation des modules du Banc géométrique de mesure des TGV



Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

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- LA MAINTENANCE PRÉDICTIVE
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- **LES INNOVATIONS POUR DEMAIN**

Diffusable

Ingénierie du Matériel | SNCF VOYAGEURS

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SURVEILLER L'INTERFACE PANTO-CATÉNAIRE

Ingénierie du Matériel | SNCF VOYAGEURS

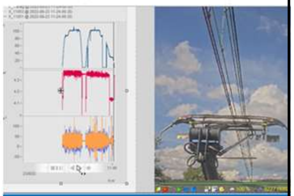
- Parce que l'on ne peut pas toujours passer en atelier pour vérifier l'état des dispositifs de captage et réagir à une crise, l'Ingénierie propose plusieurs solutions

Dispositif d'inspection agile
- Une caméra sur perche isolante permet d'inspecter la toiture sans installation fixe spécifique
- Option caméra thermique, utilisée par exemple sur Régio2N pour le contrôle des points chaud sur les coupleurs de la ligne train.

Surveillance en continu
- Dispositifs embarqués sur des trains commerciaux


Perche KITCAM – réponse aux crises
- Légèreté, maniabilité, opérée avec un seul agent, réactivité, coût
- Levée de doute rapide sur des engins lors de signalements

CAPTRACKER: capacité de surveillance dans la durée et à l'échelle
- Détection d'une grande variété de défauts caténaire, prouvée par les essais
- Surveillance au long cours pour détecter des précurseurs.



- **Surveillance de la caténaire par train commercial**
  - Un essai en ligne sur 12 mois a permis de valider le concept de capteurs pour la détection des anomalies caténaire, en croisant avec les constatations de la maintenance caténaire.
  - Avec la seule rame d'essai, il a été possible de réagir très rapidement à 2 crises sur Auvergne-Rhône Alpes.
  - Préparation d'un appel d'offres de déploiement

HEIGHT 6.10499 TARGETING 7.10499 PERCENTAGEBAR 99%
TÉLÉDIAGNOSTIC-CBM

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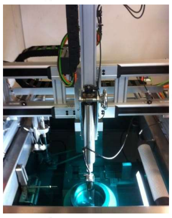
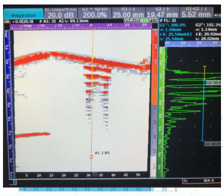
CONTRÔLE PAR ULTRASONS DES ORGANES DE ROULEMENT

Ingénierie du Matériel | SNCF VOYAGEURS

- Analogues aux échographies du domaine médical, les contrôles par ultrasons sont obligatoires pour les organes de roulement. Les multiéléments permettent des gains significatifs en production

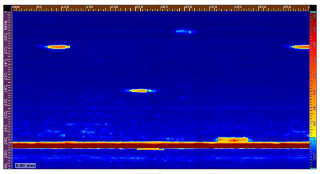
Description de l'innovation
- Les dispositifs ultrasons multiéléments génèrent une image de la zone contrôlée






Avantages par rapport aux contrôles conventionnels
- Gain financier : Réduction des temps de production, de 50% à 80% selon les organes!
- Gain SEF : Augmentation de la probabilité de détection, grande fiabilité du procédé
- Gain qualité : Traçabilité car enregistrement de la cartographie de contrôle
- Gain environnement : Couplage à l'eau ou lieu de la graisse ou du gel
- Qualité de vie au travail : Ergonomie, visuel opérateur avec l'emploi d'équipements modernes

Applications en maintenance ferroviaire
1. Contrôle de santé interne des bandages roues TGV avec AQUASCAN (en production depuis 2018)
2. Contrôle des roulements cartouche TGV (en production depuis 2019)
3. Contrôle de santé des axes toutes séries avec SUMAX (mise en production à l'étude en 2023)



- **Les ultrasons multiéléments :**
  - Un exemple avec le contrôle des 52 roues d'un TGV : UT conventionnels 6h vs UT multiéléments 2h!
  - Satisfaction en production (opérateurs, DPX, Méthodes, DUO), les opérateurs ne veulent plus revenir à l'ancienne méthode.
  - +10 ans en labo AEF, +5 ans en établissements SNCF

HEIGHT 6.10499 TARGETING 7.10499 PERCENTAGEBAR 99%
TÉLÉDIAGNOSTIC-CBM

80

80

CONTRÔLES PAR COURANTS DE FOUCAULT

Ingénierie du Matériel | SNCF VOYAGEURS

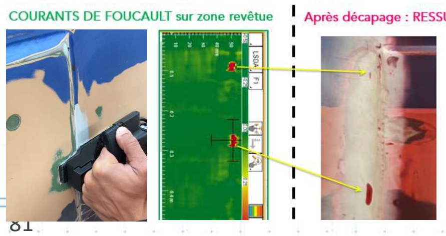
- Longues, fastidieuses, onéreuses, inconfortables… ce sont les recherches de fissure par ressuage effectués sur les caisses des rames TGV 2N lors de leur OP mi-vie ! Avec les courants de Foucault, finis le décapage, les produit chimiques et les EPI, le contrôle devient digital, plus performant techniquement et plus rapide.

AVANTAGES SQCDH COURANTS DE FOUCAULT

Description de l'innovation

- ➢ Les éventuelles inhomogénéité du matériau métallique perturbent les courants induits par la sonde, dont les variations sont analysées automatiquement.
- ➢ L'opérateur dispose d'un appareil tactile compact, d'une sonde et d'un étalon.
- ➢ Après lancement de l'acquisition, la sonde parcourt la soudure « peinte » à examiner (70 mm/s); le résultat est donné en direct et enregistré : ➔ tache rouge = fissure

COURANTS DE FOUCAULT sur zone revêtue | Après décapage : RESSUAGE



← Comparaison avec le ressuage

Avantage / à d'autres solutions

- ➢ Suppression du décapage de la peinture avant contrôle
- ➢ Suppression de l'utilisation des produits chimiques et des EPI spécifiques
- ➢ Garantir la détection de fissure
- ➢ Détection de défauts sous-jacents
- ➢ Digitalisation du contrôle
- ➢ Amélioration du confort opérateur

Multiples cas d'usage potentiels

- ➢ **Contrôles des structures aluminium**
- ➢ Contrôle de pièces acier mécano-soudée (bogies…)
- ➢ Contrôle des transformateurs motrice TGV
- ➢ Contrôle d'essieux

- Mise en œuvre fin 2023 des contrôles par courants de Foucault en production au TI de Bischheim et Hellemmes pour le contrôle des structures aluminium des TGV 2N (toutes séries) en OP mi-vie.
- Gain de **40 k€ /rame**, soit une réduction des coûts de maintenance de 60% et **un amortissement en moins d'un an**

TÉLÉDIAGNOSTIC-CBM

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CONTRÔLE NON DESTRUCTIF PAR FIBRE OPTIQUE

Ingénierie du Matériel | SNCF VOYAGEURS

Détection de fissure par fibre optique

S'assurer de l'état de santé de la structure de nos trains, sans démontage, dans des zones stratégiques difficiles d'accès.

Zones sensibles sous haute surveillance …

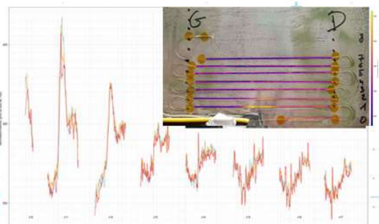
- La fibre optique collée sur une surface permet d'avoir une multitude points de contrôle de la déformation.
- Après l'enregistrement d'un signal de référence, il suffit de connecter la fibre optique au matériel d'acquisition pour réaliser une mesure sans aucun démontage, lors d'un passage en Technicentre.
- La comparaison avec le signal d'origine permet alors de constater d'éventuelles dérives pouvant impacter la circulation du matériel roulant.

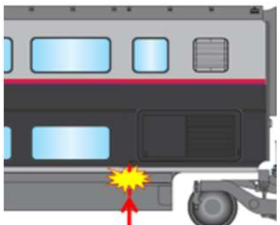
Les objectifs du projet :

- Détecter et suivre l'évolution d'une fissure : essai sur maquette en partenariat avec GEOMAS / INSA Lyon
- Industrialiser la pose de la fibre optique : mesure en service commercial (Rame 208)
- S'assurer de la tenue du collage dans le temps : essai en partenariat avec l'AEF

Applications visées & avantages

- ➢ L'équipement peut se faire sur matériel neuf, lors opération de maintenance lourde ou en réparation
- ➢ Une fois en place, la fibre ne demande ni alimentation ni entretien.





Surveillance du potentiel des structures mécaniques

- ➢ Optimiser l'exploitation du matériel roulant en ciblant les rames prioritaires pour la maintenance lourde
- ➢ Se prononcer sur l'aptitude à prolonger la durée de vie de nos trains *sans démontage*

TÉLÉDIAGNOSTIC-CBM

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CONTRÔLE PAR VISION ASSISTÉE POUR LA MAINTENANCE

Ingénierie du Matériel | SNCF VOYAGEURS

CAIMAN – IA appliquée à la magnétoscopie des essieux

Quand la maintenance peut révolutionner les conditions de travail et la qualité des contrôles avec une solution ultra-moderne !

CAIMAN : INTELLIGENCE ARTIFICIELLE

Déterminations des caractéristiques de l'appareillage nécessaire (caméra, filtre, éclairage UV et paramètres)

Obtention des zones contrôlées en images

Application d'un algorithme de détection des indications pour assister l'opérateur

Traçabilité, conditions de travail, efficacité

- Traçabilité complète des contrôles
- Analyse a posteriori
- Diminution de l'exposition aux champs magnétiques, aux UV et aux produits chimiques
- Augmentation de la probabilité de détection grâce à l'aide à l'opérateur par IA
- Gain de temps de 25% en moyenne sur le passage en cabine d'un essieu dans un contexte d'automatisation complète

Application industrielle

Les cabines de magnétoscopie existantes peuvent faire l'objet de rétrofit avec automatisation, prise de vues et poste d'analyse

Les traçabilités obtenues en laboratoire avec un système prototype ont permis de :

- Vérifier la fidélité des images obtenues avec la réalité
- Vérifier la possibilité de les analyser en concluant identiquement à l'analyse classique.
- Initier une banque d'images pour le développement de l'algorithme futur.

HEIGHT 6.10499 TARGETING 7.10499 PERCENTAGEBAR 99%

TÉLÉDIAGNOSTIC-CBM

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FINE PITCH – CONTRÔLE PAR VISION ARTIFICIELLE

Ingénierie du Matériel | SNCF VOYAGEURS

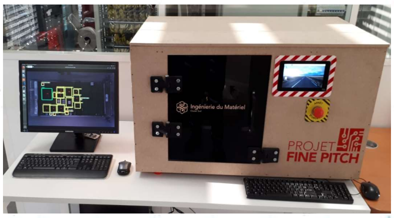
Inspection automatique des cartes électroniques par IA

Réduction de 70% du temps d'inspection

Moins de pénibilité pour les opérateurs

Description de l'innovation

Une intelligence artificielle analyse des images prises d'une carte électronique pour détecter les défauts de brasure et d'assemblage.

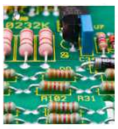


Avantage / à d'autres solutions

- Ne nécessite pas le dossier CAO des cartes pour paramétrer l'inspection
- Adapté au type de défauts vus en « maintenance » (brasures sèches, pollution)
- Capacité à inspecter toutes les cartes électroniques malgré leur nombre, en début et fin de chaîne.

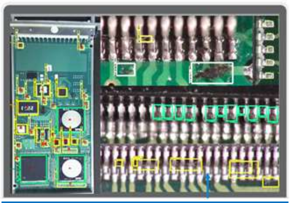
Cas d'usage

Conçu à la fois pour les vieilles et les nouvelles technos de cartes



TRAVERSANT

CMS



Au Technicentre Industriel de Vénissieux, les gains visés sont :

- Temps d'inspection unitaire réduit de 25 min à 7 min en moyenne
- Gain estimé de plus de 1 ETP par an
- … et la réduction d'un travail répétitif épuisant!

HEIGHT 6.10499 TARGETING 7.10499 PERCENTAGEBAR 99%

TÉLÉDIAGNOSTIC-CBM

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FABRICATION ADDITIVE ET GESTION D'OBSOLESCENCE
Ingénierie du Matériel
SNCF VOYAGEURS
Disposer de pièces pour maintenir le matériel roulant
Réduire les délais d'approvisionnement & les immobilisations
• Diminuer les stocks physiques au profit d'un « stock numérique »
• Réparer, adapter, modifier.
PBF-LB - Métal
FDM - Polymère
Fonderie rapide
L'innovation à échelle industrielle
• Fabrication à la demande selon 3 technologies en place au Matériel (PBF-LB; FDM; Fonderie rapide)
• Organisation en réseau au niveau National, autour de l'ingénierie du Matériel: Achats, Supply Chain, Établissements
• Processus d'analyse et d'achat industriel avec la documentation associée (ST-M)
Gérer l'obsolescence et les manquants
Délai
Stock
Qualité (réparation- modification)
Le plus court chemin du design à la pièce
Technologie de fabrication Métal, polymère, élastomère à la juste quantité, juste matière, rapide, sans outillage, à partir d'un objet numérique.
Quelques cas d'usage en circulation
Palier de store alliage d'Al
Equerre de renvoi sur FRET PBF-LB 316L
Sabot de porte 3D + fabrication + livraison = 5 j
Protection prise
Bouchon de réservoir lave glace
Support d'amortisseur anti-gîte (TGV) Sans et avec redesign PBF-LB Inconel 718
WAAM
Vers la grande dimension et la réparation
-> AMI CORIFER ADDITIVE4RAIL
Immobilisation évitée !
La rupture d'approvisionnement d'étriers indispensables à la fixation des antennes sous-châssis des rames Régiolis risquait d'immobiliser deux rames Régiolis.
Après le design 3D, la fabrication additive de l'ensemble du lot a permis d'éviter les immobilisations.
Ces 2 tâches ont été réalisées en trois jours par l'atelier de confection du TICP-Saintes.
ÉDIAGNOSTIC-CBM
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En vrai, avec l'IA on en est où ?
~~Transforming the Rail Industry with AI~~
virtual vehicle

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À retenir : utilisons les outils d’IA pour nous aider

L’ « intelligence » de l’IA est assez complémentaire de la nôtre !

La forces des IA:
ce sont des machines

- ❑ Idéales pour les grands ensembles de données bien organisées
- ❑ Gèrent le volume: « il suffit d’ajouter du processeur et de la mémoire »
- ❑ Travaillent sans s’arrêter
- ❑ Parfaites pour les tâches répétitives

La forces des humains:
ce sont des vrais gens

- ❑ Gérer l’ambiguïté et les zones grises
- ❑ Comprendre le contexte et les nuances
- ❑ Avoir le « sens commun »
- ❑ Gérer la nouveauté et l’inattendu

Et pour le management:

- ➢ *Pousser nos équipes à s’approprier les outils qui existent*
- ➢ *Identifier le potentiel des cas d’usage*
- ➢ *Capitaliser et protéger nos données de tous types*
- ➢ *Utiliser les expertises internes pour évaluer les promesses fournisseurs*

Diffusable

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QUESTIONS ?

Ingénierie du Matériel | SNCF VOYAGEURS

Diffusable

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IV.2 CTU - Transportation Systems and Technology

<u>Reccommended study literature for the module 3711R004 – “ITS - Intelligent transport systems”:</u>

1) Intelligent Transport Systems: Technologies and Applications (A. Perallos, U. Hernandez-Jayo, E. Onieva, I. J. García Zuazola)
2) Information Technology and Intelligent Transportation Systems (Volume 1, Proceedings of the 2015 International Conference on Information Technology and Intelligent Transportation Systems ITITS 2015, held December 12-13, 2015, Xi’an China)
3) Recent Developments and Challenges in Intelligent Transportation Systems (ITS)—A Survey, First Online: 22 June 2021, pp. 37–44, Vishal Sharma, Love Kumar & S. Sergeyev)
4) Framework of Intelligent Transportation System: A Survey Conference paper (Online: 28 June 2022, pp. 93–108, R. Mandal, A. Mandal, S. Dutta, M. Y. Alam, Sujoy S.& S. Nandi)
5) Lecture Notes in Networks and Systems (Springer, ISBN 2367-3389, J. Kacprzyk)
6) Intelligent Transportation Systems in Future Smart Cities (Online: 12 December 2018, pp, 109–120, S. Khazraeian, M. Hadi)

IV.3 ESTACA - Transport engineering / System design

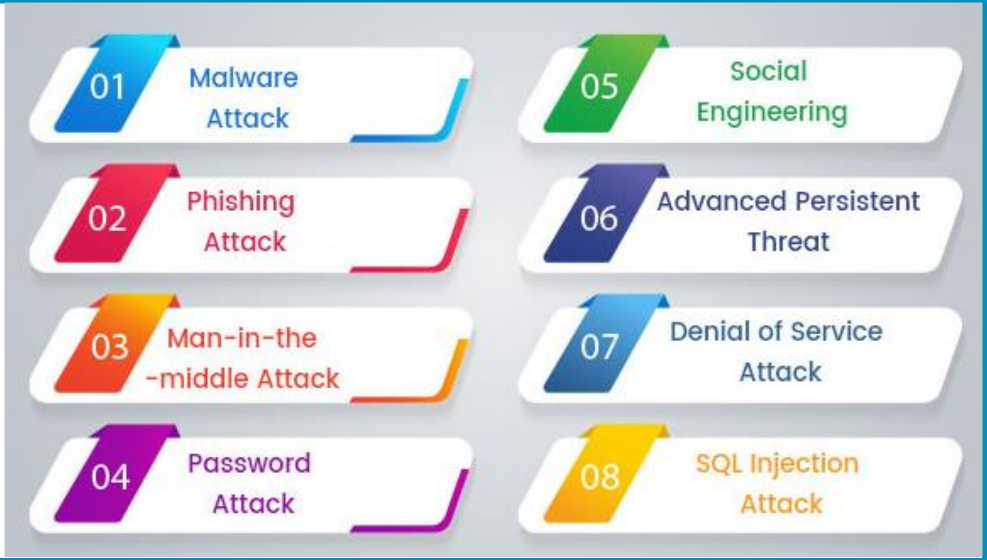
STAFFER Deliverable 6.6

Cybersecurity and the Internet of Things (IoT) module

1- Cybersecurity

By the end of this part of course, students will have acquired the skills that can lead them to a successful career in cybersecurity, enabling them to protect critical infrastructure, sensitive data, and digital assets from the growing landscape of cyber threats

This part of the cybersecurity course is conducted through lectures and application examples. Several practical exercises are provided to students to help them understand the challenges of cybersecurity,
A computer lab is made available to students to allow them to simulate examples of cyber attacks.



Co-funded by the Erasmus+ Programme of the European Union

STAFFER Deliverable 6.6

STAFFER
EUROPEAN RAIL SKILLS ALLIANCE

ESTACA
ECOLE D'INGENIEURS

CREATEUR DE NOUVELLES MOBILITES

Cybersecurity and the Internet of Things (IoT) module

2- Internet of Things (IoT) :

This part of course help students acquire the skills necessary to develop IoT solutions and understand how to manage IoT systems. Several practical examples in the railway field are covered to provide engineers with in-depth skills.

In this second part of the course, students develop skills in the Internet of Things (IoT), which requires a combination of knowledge in several areas, including electronics, software development, data analysis, and network management

- 01 Intrduction
- 02 Wireless sensor networs
- 03 IPv6 - 6LoWPAN
- 04 CoAP - MQTT
- 05 Vehicle-to-vehicle network
- 06 Contiki - NG
- 07 Smart Cities
- 08 Smart Transport

Co-funded by the Erasmus+ Programme of the European Union

IV.4 SGH - Postgraduate course in "Ogranistation of extra-urban public transport"

The inaugural lecture by Polish book writer and sociologist Olga Gitkiewicz discusses the social aspects of the lack of transportation options in non-urban areas in Poland, particularly focusing on the challenges faced by those without access to public transport. It highlights the long-term struggle with limited transportation options, citing personal experiences and statistics, such as kilometers traveled by different modes of transportation, to illustrate the significant daily impact on individuals. The document emphasizes the concept of transport exclusion, where nearly 14 million Poles experience difficulties in accessing basic services and opportunities due to insufficient transportation.

The consequences of this transport deficit include social isolation, limited access to essential services such as healthcare and education, and challenges in the job market. People are often forced to use private cars, leading to traffic congestion, environmental pollution, and financial strain, especially for low-income individuals. The document argues that public transportation is crucial for meeting basic social needs, improving quality of life, and reducing inequalities, particularly for marginalized communities in rural areas. It also underscores the social and emotional importance of mobility, quoting studies and personal stories to drive home the issue's relevance.

The second warm-up workshop by Krzysztof Zienkiewicz focuses on the planning and organization of public transport networks, emphasizing the importance of convincing stakeholders to assume the role of transport organizers. It begins by defining public transport according to Polish legal frameworks, such as local, inter-municipal, and international transport. Various entities, including local governments and transport operators, play critical roles in managing these services. The presentation addresses how different officials—like mayors, county governors, and rural leaders—perceive public transport, often viewing it as either a necessity or a financial burden, depending on the context.

The document also discusses strategies for promoting public transport investment, with examples of specific municipalities such as Gmina Dywity, Stawiguda, and Gietrzwałd. It highlights the benefits of a well-organized public transport system, such as providing residents with greater mobility, freedom of choice, and financial savings. Additionally, public transport reduces reliance on personal vehicles, thus contributing to environmental sustainability and improving the overall quality of life.

The workshop on the legal conditions of public transport in Poland by Grzegorz Kubalski outlines key aspects of organizing and managing public transportation systems. The first part provides an overview of the legal framework surrounding public transport, emphasizing various laws such as the Public Transport Act of 2010, the Road Transport Act, and others. It explores core concepts such as communication lines, municipal transport, and the role of different administrative entities (gminas, counties, etc.) in organizing transportation. It also discusses the challenges and paradoxes in current legislation, such as inconsistencies in the responsibilities of cities, counties, and inter-municipal unions, and addresses the basic legal obligations of organizing public transportation, including for elections and school transport.

The second part focuses on the establishment and functioning of county-municipal unions, which are collaborations between counties and municipalities to organize and manage public transport. It covers the legal foundation for forming these unions, the process for drafting statutes, and the responsibilities they assume. The lecture also highlights the financial and operational aspects of public transport management, including the importance of developing a sustainable transport plan, controlling service delivery, and setting up systems like integrated ticketing. Throughout, the lecture stresses the need for cooperation among local governments to ensure accessible, efficient public transport that meets citizens' mobility needs.

The workshop on public procurement by Dr. Anna Szymańska covers the legal framework and principles governing public procurement, particularly in the context of public transportation in the European Union and Poland. It outlines the key regulations, including EU Regulation 1370/2007, which governs public service obligations in passenger transport, and the Public Procurement Law (Prawo Zamówień Publicznych, Pzp) of 2019. The presentation discusses various types of public procurement, including classic, sectoral, and defense/security-related tenders, emphasizing the need for transparency, equal treatment, and competition in procurement processes.

Additionally, the presentation details the stages of the public procurement process, from announcing a tender to awarding contracts, and highlights the importance of effective competition and fair negotiation procedures. It also explains the role of legal frameworks in ensuring that public contracts for transport services, such as rail and bus networks, meet the needs of public service providers while complying with EU laws.

The lecture on contracting public transport services (PTZ) in Poland, presented by Mariola Oleszyńska, covers the legal framework and procedures for awarding public transport service contracts. It primarily focuses on the application of Regulation 1370/2007 of the European Union, which governs public transport services, and the Polish Public Transport Act of December 16, 2010. The lecture highlights different types of contracts, including direct awards, small-scale contracts, and in-house service arrangements, and explains the criteria under which these contracts can be awarded.

Key components of the lecture include the definitions of public transport services, the roles of operators and organizers, and the legal provisions governing the contracting process. It discusses the preliminary steps required before a transport contract is awarded, such as transport planning and issuing prior information notices. The presentation also covers specific conditions under which contracts can be directly awarded, particularly in emergency or small-scale transport scenarios.

The workshop by Piotr Gołębiowski titled "Technology and Market of Railway Transport" explores key aspects of the railway sector, particularly in the context of the European Union and Poland. It covers the creation of a unified European railway area, which promotes sustainable mobility and enhanced railway infrastructure across EU countries. The presentation outlines the core elements of the railway system, including infrastructure such as tracks, stations, and control systems, as well as the types of trains (passenger, freight, and high-speed) operating on these networks. Special attention is given to interoperability, which ensures that trains can operate seamlessly across different national railway systems.

The workshop also discusses the technical aspects of train operations, including signaling systems, train schedules, and the management of railway traffic. Gołębiowski emphasizes the importance of modernizing railway infrastructure to support high-speed trains and improve the overall efficiency of rail transport. Additionally, the presentation covers the maintenance and operation of railway vehicles, outlining the various types of traction systems (electric, diesel, and hybrid) and the importance of adhering to safety standards to ensure reliable railway services.

The workshop on railway transport regulation by Jakub Majewski transport provides a comprehensive exploration of the legal, operational, and strategic aspects of organizing and managing public transport systems, especially in the context of Poland. The first part introduces the structure and legal framework governing public transport, highlighting key regulatory institutions and the responsibilities of various stakeholders. The workshop delves into the role of public transport in sustainable mobility, focusing on the balance between public service obligations (PSO) and commercial transportation.

Subsequent sections cover the planning and development of transport services, the design and scheduling of timetables, and the practical considerations for route management. These include the types of train schedules (annual, temporary, and individual), the role of infrastructure managers, and the complexity of coordinating services across multiple operators. The workshop concludes by discussing the evolution of Poland's passenger transport market, the impact of regulatory reforms, and the challenges of balancing state-owned and regional services.

The lecture „Technika i rynek transportu autobusowego” („Technology and market of bus transport”) discusses the technical and market aspects of bus transport in Poland. It begins by outlining the objectives of the session, including providing knowledge about the road transport market, understanding the limitations that affect bus transport planning, and serving as a knowledge base for graduates. It refers to various literature sources, focusing on public transport organization, with a key emphasis on both urban and non-urban areas.

The presenter, Jakub Burdziński, also shares his professional background and current role managing a large bus transport operation in Poland. He oversees a fleet of Solaris Urbino buses, handling over 4 million commercial kilometers annually. The presentation touches on the challenges in bus transport, highlighting issues such as financial constraints, lack of scientific research, and insufficient management in the industry. Furthermore, it addresses the market division of bus services, licensing requirements, and the legal framework that governs road transport in Poland. The presentation also discusses the technical aspects of buses, including the types of buses used in Poland, and the challenges faced in maintaining a modern and efficient fleet.

The workshop "Planowanie sieci i organizacja przewozów" by Marcin Gromadzki discusses the processes involved in planning and organizing public transport services, particularly focusing on non-urban transport. The presentation covers key aspects such as collecting empirical data, designing bus routes and fare structures, and the collaboration between transport organizers and operators. It also highlights the critical role of the timetable as the most essential component of public transport, influencing service quality, passenger satisfaction, and operational efficiency.

A major part of the discussion is dedicated to the challenges of integrating various levels of public transport in Poland, where multiple organizers at the city, county, and regional levels often operate independently, causing fragmentation. The presentation emphasizes the need for a coordinated approach to route planning, financial management, and service provision, particularly in the context of rural areas and inter-municipal transport. It also touches on marketing research methods to assess passenger demand and optimize transport offerings, alongside the complexities of securing funding through programs like the FRPA FRPA (Fundusz Rozwoju Przewozów Autobusowych – Bus Transport Development Fund).

The workshop "Finansowanie przewozów i rozliczanie FRPA" ("Financing of transport operation and FRPA settlement") by Marcin Gromadzki provides a comprehensive overview of financing public transport services in Poland, particularly focusing on the mechanisms for funding and settling services through the. The presentation outlines two primary models of contracting public transport operators: the "net" and "gross" models. In the net model, the operator bears the risk associated with revenue from ticket sales, while in the gross model, the organizer (often a local government) takes on that risk, allowing for better transport integration.

It also discusses the complexities of financing public transport, including the legal framework surrounding subsidies and compensation under the FRPA. It explains that the compensation system ensures that operators are not at a financial loss for providing essential public transport services, especially in less profitable routes. Key concepts like "reasonable profit" and "deficit calculation" are explored, with practical examples illustrating how local governments can manage and document transport services in compliance with Polish regulations. The presentation emphasizes the need for proper financial planning and contractual clarity to ensure that public transport remains sustainable and adequately funded.

IV.5 UNIGE - Master of Science in "Safety engineering for transport, logistics and production" - "Rail Transport" module – course on "Sustainable Powertrains and Green Mobility in Rail Transport"

le cnam

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EUROPEAN RAIL SKILLS ALLIANCE

Sustainable Powertrains and Green Mobility in Rail Transport

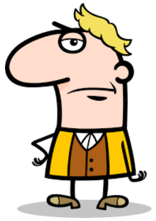
Sustainable rail energy management

Università Di Genova

06 – 10 November, 2023

Khaled ITANI

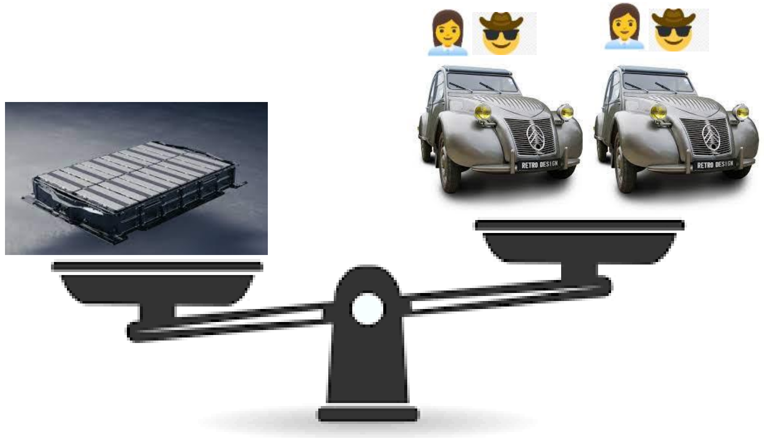
Contents

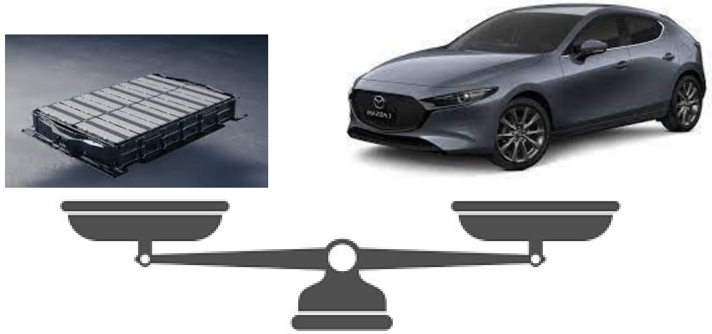


- Raise fundamental questions.
- Skeptical view
- Propose optimal solutions for a Green mobility.

Is Electromobility Green ?

GMC Hummer EV Edition1
560 km range
205 kWh battery
750 kW Motors power
4000 kg Weight
1325 kg Battery Weight





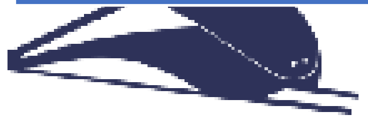
I need to hide my 1.4 MW !

Hey ! I've got a 700 kW motor. And I am cool !

le cnam

Is Electromobility Green ?

	France	Germany
Vehicle fleet	38.2 millions	48.5 millions
Average cost of a liter of fuel	1.91 euros/L	1,81 euros/L
CO2 emission per km	135 g/km (target level in Europe is 95 g CO2/km – 2024)	
Distance travelled annually	13 000 km	
ICE Vehicle consumption L/100 km	6 L/100 km	
EV consumption kWh/100 km	17 kWh/100 km	
Average energy mix (in 2022)	75% Nuclear /25% of RE	52% Coal/48% RE
Average CO2 emission per kWh (Electricity generation emission in 2022)	73g CO2/kWh	380g CO2/kWh
Electricity Cost	0.2062 euro/kWh	0.35 euro/kWh
CO2 emitted annually	73.6 10^6 Tonnes CO2/an	85.11 106 Tonnes CO2/an
Indirectly emitted CO2 by EV for 1 km	12.4 g/km	64.6 g/km (if only coal 950 g/kWh, we will have 161.5 g/km !!)
Energy cost to travel 100 km (ICE)	11.46 euro/100 km	10.86 euro/100 km
Energy cost to travel 100 km (EV)	3.5 euro/100 km	5.95 euro/100 km



6,68 gCO2/pass.km for Thalys, 6,64 gCO2/pass.km for Eurostar

Rail Transport Emission in France

	Emissions (gCO_2/pass.km)
TGV	2,36
Long Distance Train	5,92
Regional Express Train (TER) – majority are diesel loco	29,6
Paris metro	2,74
Regional Express Network (RER) and transilien	7,28
Paris Tramway	2,68
Metro, tramway, trolleybus - 2018 – Urban area > to 250 000 residents	3,29
Métro, tramway, trolleybus - 2018 - Urban area between 100 000 and 250 000 habitants	5,03

In case of freight rail transport: 1.99 g of CO2 per tonne-km in France (17.4 g of CO2 / tonne-km in Europe !!!)

Let us investigate the Battery.

An NMC Li-Ion battery contains

Lithium

Cobalt

Nickel

Manganese

Natural Graphite

Silicon

Let us investigate the Cathode Materials

Raw Material (*critical)	Use in LiB	Main EU Supply	EU import	EU deposits	Recycling	Note
Lithium* (Li)	Lithium oxide is the active cathode material. Li ions passes from cathode through elec-trolyte to the anode and back.	Chile, Bolivia and Argentina (from brine). Canada, Australia, China and USA (from hard rock mining).	100%	Portugal, Spain, Czechia, Finland.	Possible, but presently not so economically viable	Li is abundant, but production capacity and supply is limited
Cobalt* (Co)	Provides thermal and chemical stability to the cathode	DRC, Australia and as byproduct to copper and nickel mining globally.	86%	Co is byproduct of Cu- and Ni- mining and available as recycled metal.	Recycling is common (pyrometallurgy and biohydro-metallurgy)	Price and mining conditions in the DRC are drivers for Co-free batteries
Nickel (Ni)	Improves energy density and replaces Co.	Australia, New Caledonia, Canada, Russia.	59%	Fin Explor Greec Sw		Ni is abundant, but supply is limited.
Manganese (Mn)	Improve the cathode and is a cheap alt. to Co and Ni.	South Africa, Ukraine, Brazil, Australia, India	89%	In Czec tailings. low con in soils globally		Mn is abundant, but supply is limited

Let us investigate the Anode Materials

Raw Material (*critical)	Use in LiB	Main EU Supply	EU import	EU deposits	Recycling	Note
Natural Graphite* (C)	Active anode material	China, India, Brazil, Turkey.	98%	Norway, Czechia and Austria have reserves.	Not often recycled, but methods are underway.	Synthetic graphite is an option.
Silicon* (Si)	[illegible]	[illegible]	[illegible]	[illegible]	in ot	Abundant, but supply is limited.

Mendeleyev Table

Pipes coming from a rare-earth smelting plant spew into a tailings dam on the outskirts of Baotou in China's Inner Mongolia autonomous region.

The mining of critical raw materials leaves rubble dumps in its wake

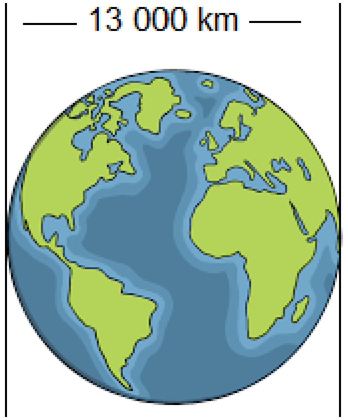
Periodic table of the elements

- Alkali metals
- Alkaline-earth metals
- Transition metals
- Other metals
- Other nonmetals
- Halogens
- Noble gases
- Rare-earth elements (21, 39, 57–71) and lanthanoid elements (57–71 only)
- Actinoid elements

period \ group	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

lanthanoid series 6	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
actinoid series 7	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

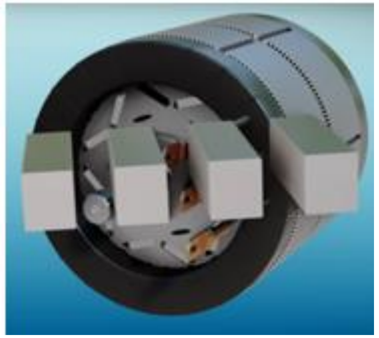
*Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC).



Yellow-brown acid mine drainage flows into a wastewater pond in efforts to reduce heavy metal and chemical contaminants

Rare earth discharge gushes into a black lake that has accumulated from wastewater near Baotou in northern China

Back to Railway Electrotechnical Systems

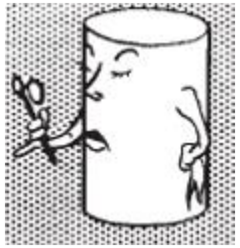


A permanent magnet for the rotor is an alloy such as:
Samarium cobalt (SmCo)
Neodymium-iron-boron
To allow an increase in power:
Part of the neodymium is replaced with dysprosium and terbium which are also heavy rare earths elements, very expensive, and extracted almost exclusively from China.

In electromobility, the cooling of electrotechnical systems (such as traction motors, batteries,…) is crucial to maintain their efficiency and prevent overheating. There are several types of coolants that can be used for this purpose, including:
Air cooling
Water cooling
Water-Glycol Mixtures : Ethynol glycol is toxic and could have aquatic impact and ground water contamination if disposed improperly.
Dielectric Coolants : Could lead to environmental contamination if there is a leak or improper disposal.
Refrigerant-based Systems : Refrigerants, like R-134a and R-410a, have high global warming potentials.
Oil-based Coolants : Contain substances that are considered greenhouse gases.

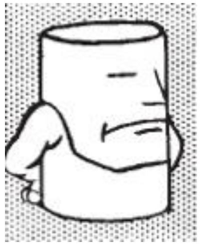
Innovation in Traction System

PMSM based on **ferromagnetic ferrites rare earth free** (SrFe12O19 – strontium ferrite) are iron oxide ceramics.

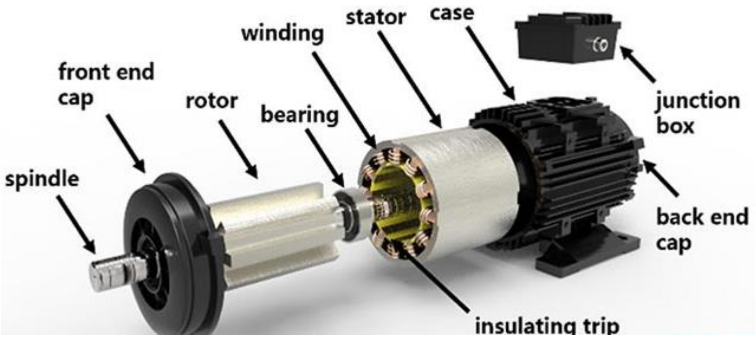


Disadv : They are weak**.**

Reluctance Motor

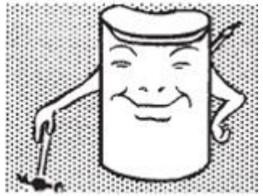


Robust construction, tolerance for degraded operation, high power density, easy control, interesting torque-speed characteristics
Disadv: Generation of acoustic noise, High current and torque ripples, Complex topology of the converter.



Reluctance Motor

Innovation in Traction System



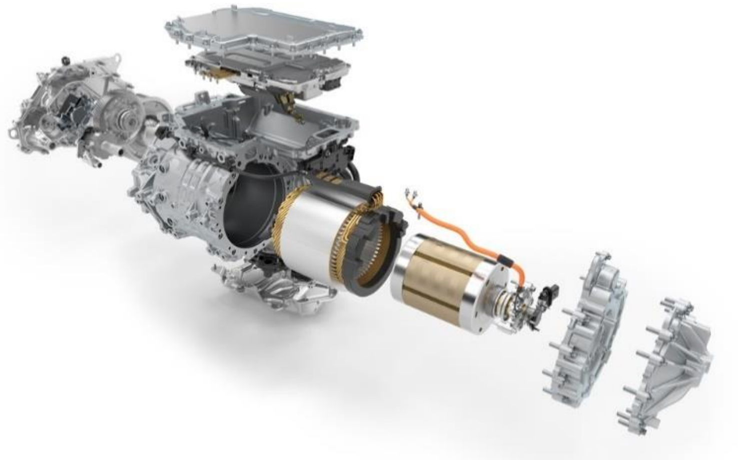
Back to traditional synchronous motor with wound rotor

Easily controllable motor flux

Significant range of constant maximum power at various speeds.

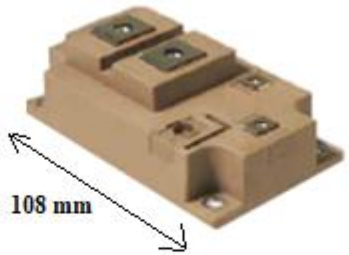
Operation at unity power factor

Acceptable efficiency (>95%)



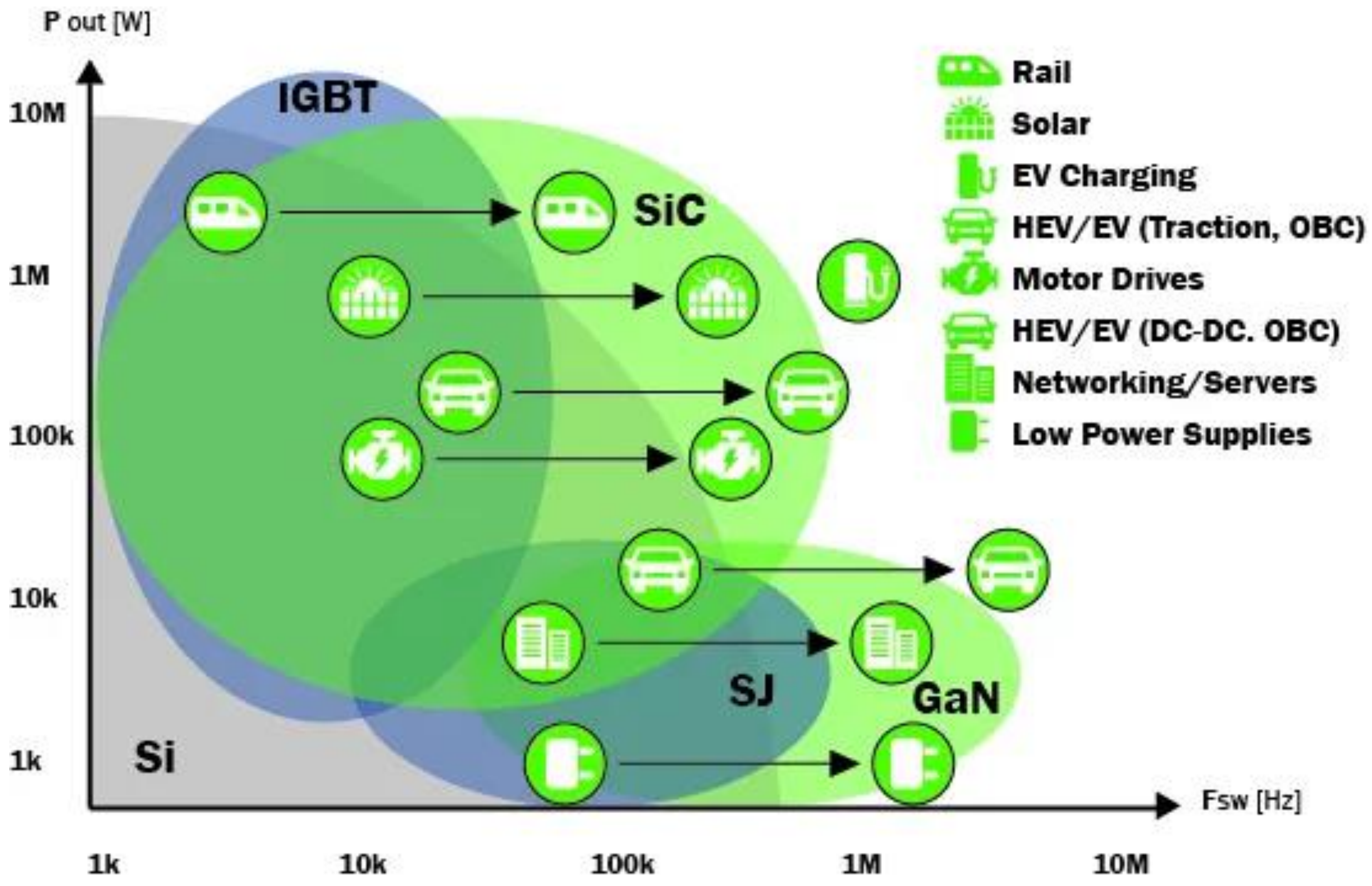
- Disadv: lower mass and volume power density, need to cool the rotor, lower maximum speed compared to IM, more challenging manufacturing

Innovation in Power Conversion



Fuji Electric / IGBT Module
1200 V / 900 A

1.2 kV SiC modules for a half-bridge 120 A



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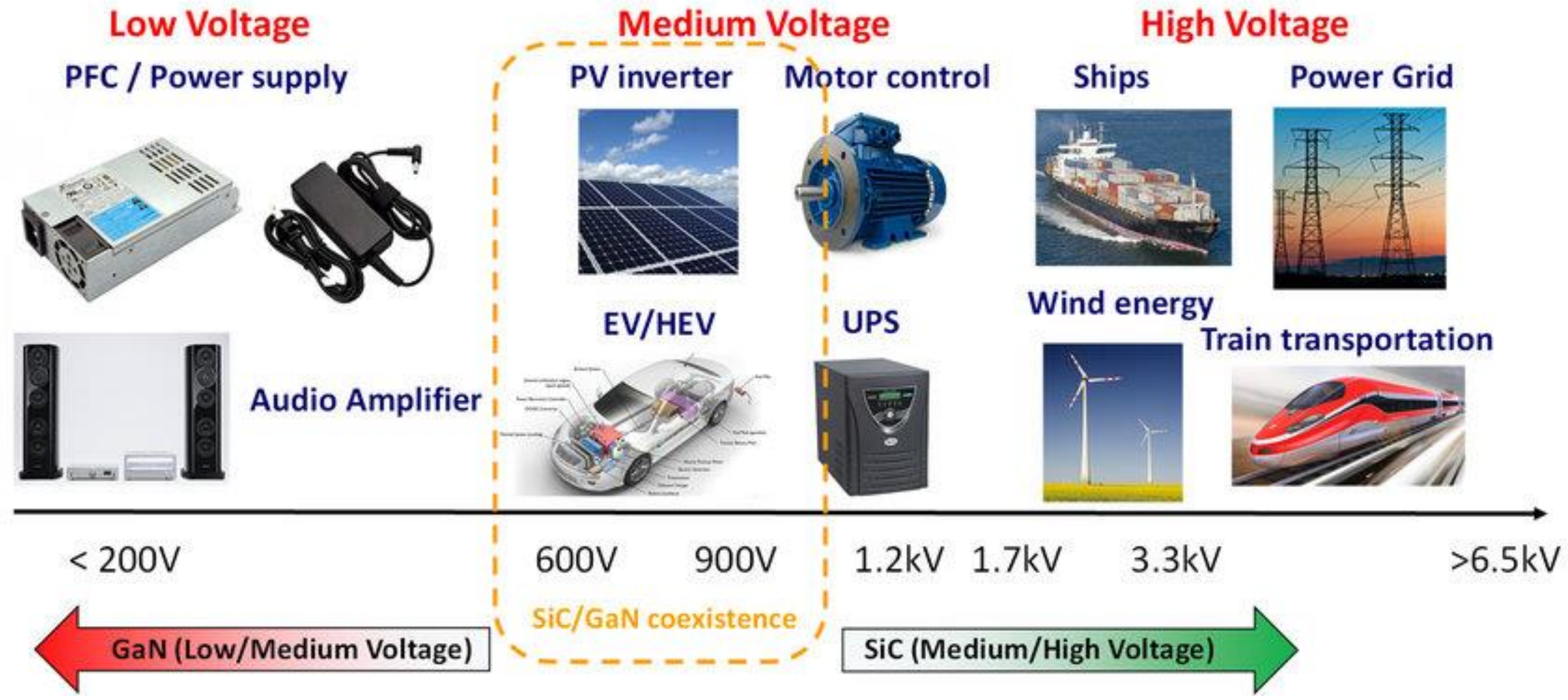
Innovation in Power Conversion



Innovation in Power Conversion

- The mutation of SiC high power and high frequency power switch technology could :
  - Increase power converters efficiency by minimizing losses and consuming less power.
  - Reducing size and weight
  - Lower cooling requirements
  - Improve the voltage and current signal waveforms by working on high frequency thus :
    - Reducing harmonics (and filters).
    - Improve the output torque of the traction motor.
    - Improve the recharging of the battery pack
    - Use of more advanced control requiring higher switching frequencies.

Hydrogen : Vector of Energy

- Hydrogen can be obtained by separating it either from methane molecules through steam methane reforming (SMR), gasification, methane pyrolysis, or using water molecules by electrolysis.
- The colors of hydrogen can be summarized as follows:

Gray or black: Steam Methane Reforming (SMR) / Gasification - Source: Methane / Coal - Without carbon capture and storage - $CH_4 + H_2O$ (+ heat) → $CO + 3H_2$ / $C + H_2O$ (+ heat) → $CO + H_2$;

Blue: Steam Methane Reforming or Gasification - Source: Methane or Coal - With captured and stored carbon monoxide (85-95%);

Turquoise: Pyrolysis - Source: Methane derived from natural gas. The process is driven by heat produced with electricity rather than the combustion of fossil fuels. CH_4 (+heat) → $C + 2\ H_2$, and

Green Hydrogen: Electrolysis - Source: Electricity generated from renewable energy - $2H_2O$ → $2\ H_2 + O_2$.

There is also **pink**, yellow and **brown** hydrogen.

Cost comparison

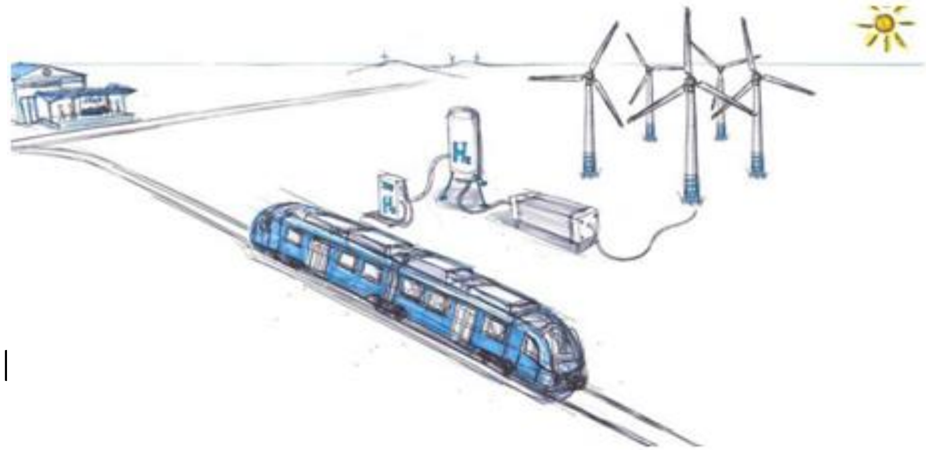
TRAIN	Diesel	Electric	Battery	Hydrogen
Weight	95 tons	102 tons	108.12 tons	107.1 tons
Passengers	150 176 (new)	176	176	176
Energy Source Prices	0.5 €/l	0.089 €/kWh	0.089 €/kWh	2 – 5 € /kg
Consumption per km	1.62 l/km 1.2 l/km (new)	4.08 kWh/km	4.76 kWh/km	0.25 kg H2/km
Energy cost per km	0.81 €/km 0.6 €/km (new)	0.36 €/km	0.42 €/km	0.5 – 1.25 €/km
Unit Price of Equipment	3.5 M€ 6.325 M€ (new)	4.6 M€ 5.5 M€ (new)	6 M €	6.6 M€
Maintenance Cost (per km)	3.6 €/km 2.4 €/km	0.97 €/km	1.8 €/km	2.4 €/km

Efficiencies comparison

Diesel	(Renewable) Energy 100 kWh		
Internal Combustion Engine 20-35 %	**Hydrogen Efficiency H2 (23%)**	**Electric Battery Efficiency (69%)**	**Electrical Train Efficiency (77%)**
	AC Power (95%) 95 kWh	AC Transmission (90%) 90 kWh	AC Transmission (90%) 90 kWh
	Electrolysis (75%) 71 kWh	DC + Battery Charging (85%) 77 kWh	DC Conversion (95%) 86 kWh
	Hydrogen Compression (90%) 64 kWh	Traction (90%) - 69 kWh	Traction (90%) 77 kWh
	Hydrogen Transport (80%) 51 kWh		
	Fuel Cell Conversion (50%) 26 kWh		
	Traction (90%) 23 kWh		

Overall energy efficiency of hydrogen not much better than diesel
Environmental benefits hydrogen comparable for non-CO2 emissions
+ Low efficiency & vulnerability fuel cells (replace every 2-3 years)

Efficiency of a Hydrogen Train

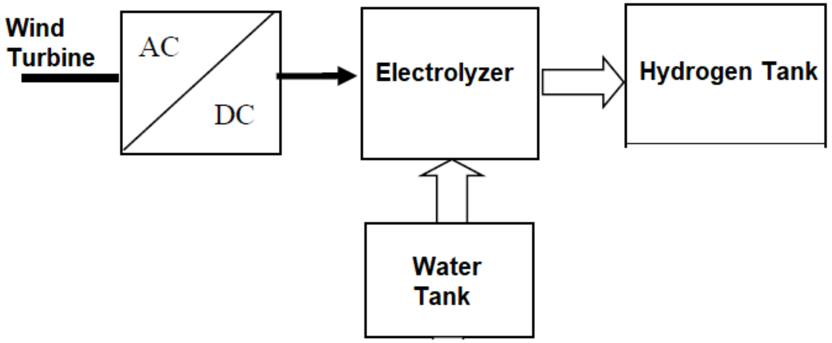


Electrolyzer efficiency η1 : 70 %

Fuel Cell efficiency η2 : 50 %

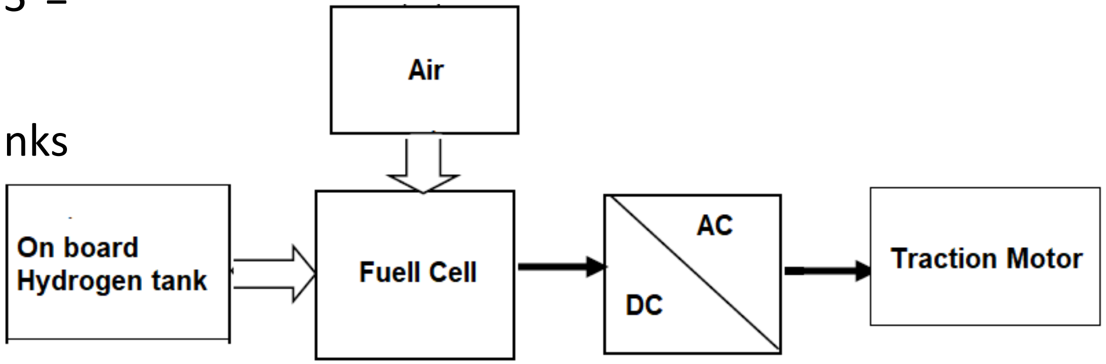
Electronic power conversions losses, auxiliary systems (pum compressors, etc.) losses are negligible.

Overall efficiency over a complete charging and discharging cycle: 0.7*0.5 = 0.35.



Mass of hydrogen to store in order to release 100 kWhe , with a specific energy of hydrogen of 34 kWh/kg is: 200 kWh / (34 kWh/kg) = 5.88 kg.

The volume needed of hydrogen to provide 100 kWhe (Hydrogen density : 0.09 kg/m³ at atmospheric pressure : 5.88 kg/0.09 kg/m3 = 65.3 m3.



Volume of H2 required to provide these 100 kWhe in a 350 bars tanks (PV = constante assuming a constante temperature) :

V2=(P1xV1/P2)=1 bar x 65.3 m3 /350 bars = 0.186 m3

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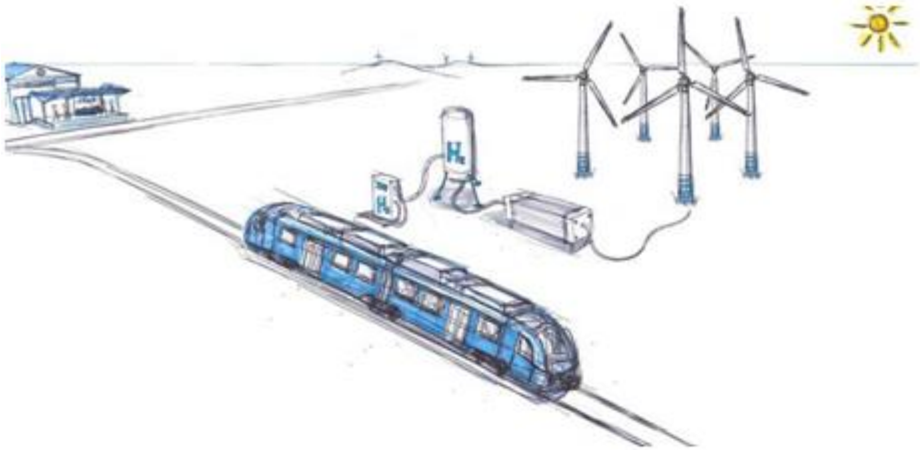
Efficiency of a Hydrogen Train

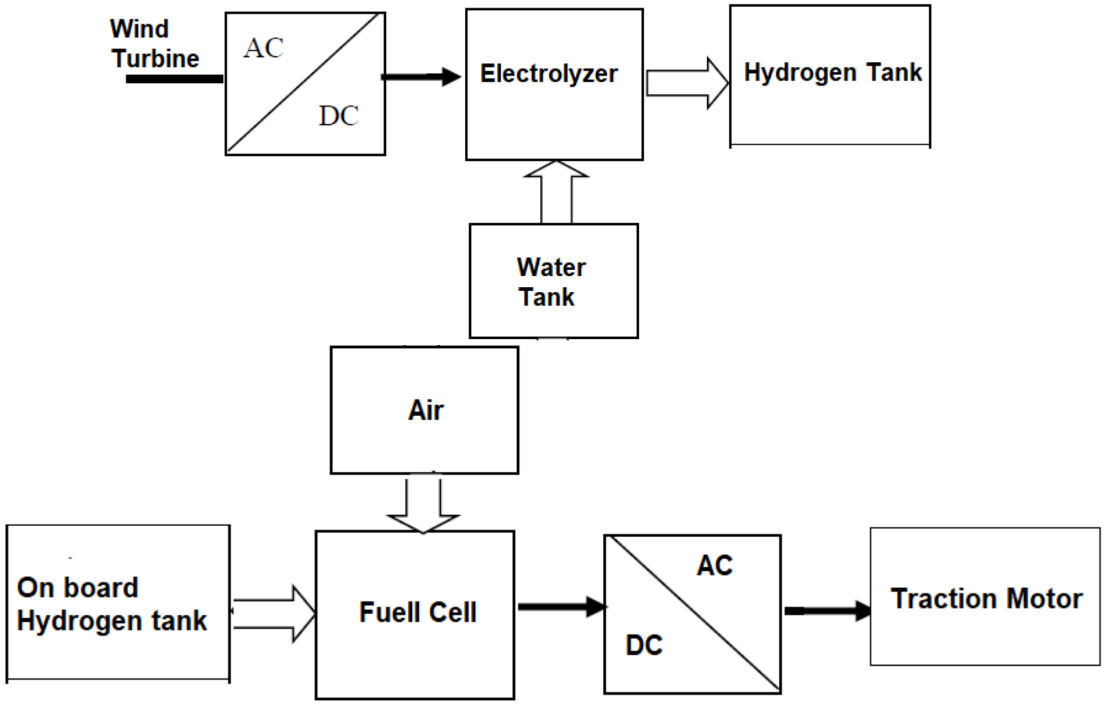
The H2 mass consumed to travel 1 km is 0.21 kg/km. In terms of electrical energy :
0.21 kg/km x 34 kWh/kg x 0.5 = 3.57 kWhe/km

The mass of H2 required for traveling 900 km:
0.21 kg/km x 900 km = 189 kg.

The tank reservoir volume of hydrogen at 350 bars required is:
V = 0.186 m3 x 189 kg / 5.88 kg = 6 m3.

The Coradia iLint is fitted with two roof-mounted hydrogen tanks, one on each car, each with *a maximum capacity of 94 kg*.

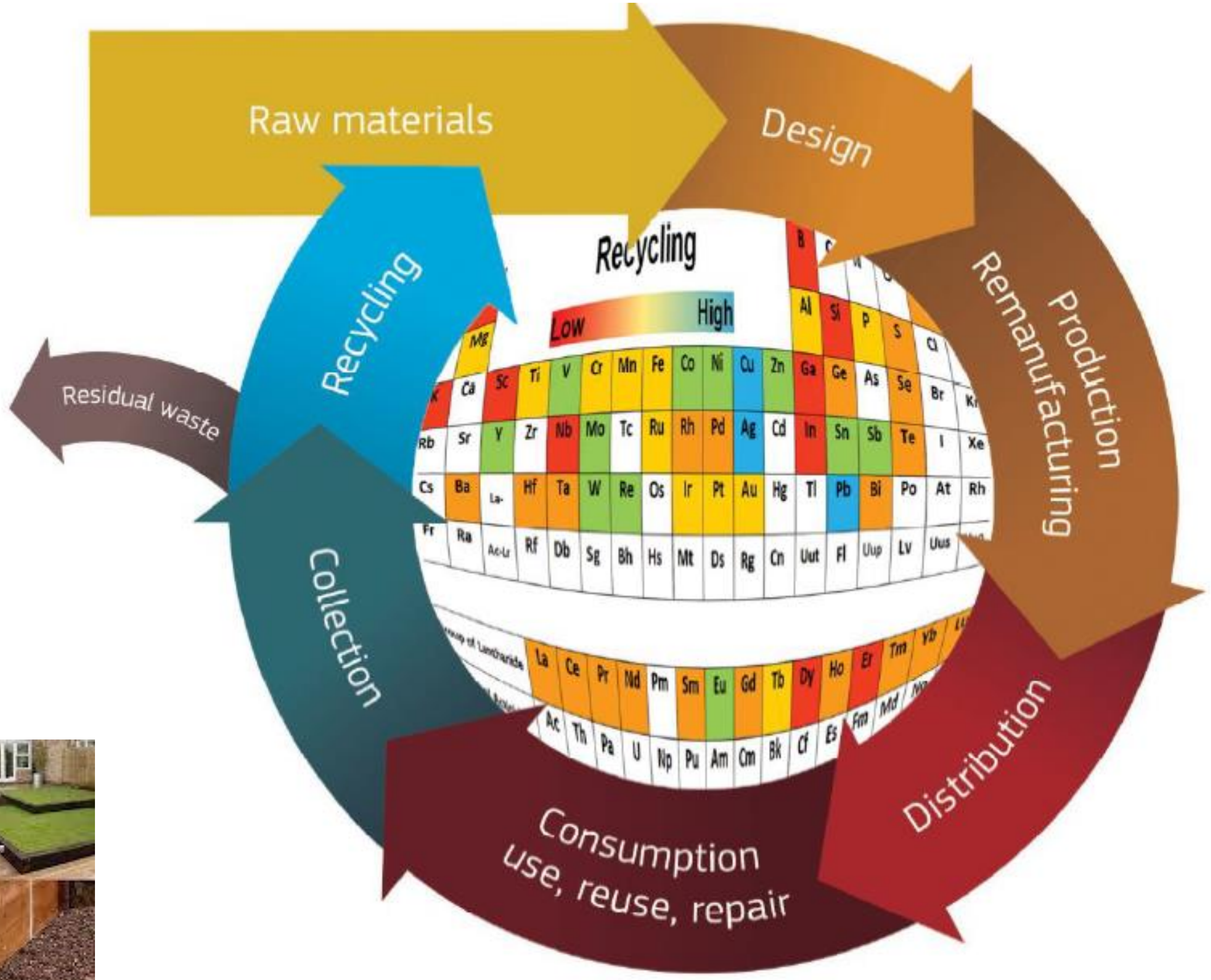




Again, is Electromobility Green ?

Electromobility can be "green" if we embrace the principles of circular economy, eco-design, mindful usage, renewable/decarbonated energy and innovation.

By adopting these approaches, we can significantly reduce the environmental impact of transportation and make a positive contribution towards a more sustainable future.



Railroad ties for gardens!

Rail Transportation

- In the upcoming years, the train stands out as the sole environmentally conscious, high-capacity transportation mode capable of enabling a significant change in transportation preferences.

→ Airplanes will need more time

Quick approximate calculation

- Hydrogen vs Kerosen in airplane mode.
- Hydrogen may provide more energy by mass than kerosene fuel, but it delivers less energy by volume.
- At normal atmospheric pressure and ambient temperature, you would need approximately 3,000 liters of gaseous hydrogen to achieve the same amount of energy as one liter of kerosene fuel.
- The hydrogen is pressurized at 700 bars – an approach used in the automotive sector. In our example, this would slash the 3,000 liters to just six.
- To go further still, we can dial down the temperature to -253°C. That's when hydrogen transforms itself from a gas to a liquid, increasing its energy density even more.
- Four liters of liquid hydrogen would be the equivalent of one liter of standard jet fuel.
- Maintaining such a low temperature requires very specific storage tanks (Cryogenic liquid hydrogen storage tanks).
- Don't forget about the efficiency of the conversion processes!

Rail Transport : Solutions to get Greener

Increasing the share of green energy in its mix

Enhancing energy efficiency of the rail system

Managing energy consumption

Material recyclability

Use of recycled material

Energy regeneration to the overhead wires during braking

A more aerodynamic nose shape

Thermal insulation of carriages

Optimizing air conditioning based on passenger count

Eco-driving system.

Eco-parking of trains

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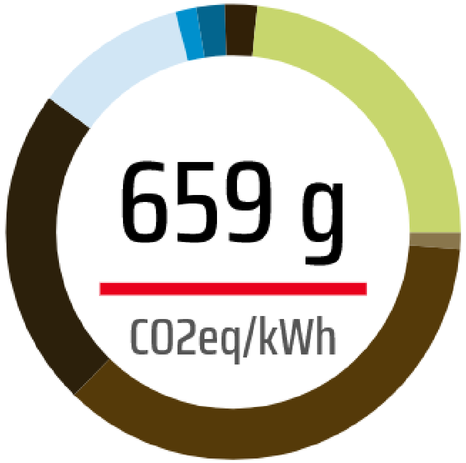
Energy Mix

CURRENT EMISSIONS IN POLAND



- Biomass (1.2%)
- Coal (36.1%)
- Coal (Lignite) (22.7%)
- Gas (10.9%)
- Hydro (1.5%)
- Hydro Storage (2.0%)
- Oil (2.3%)
- Wind (23.3%)

28% renewable

15.4 GWh total

Last updated at 2023-11-05 21:00 (Local time)

Last updated at 2023-11-03 14:00 (Local time)

WIND AND SOLAR FORECAST

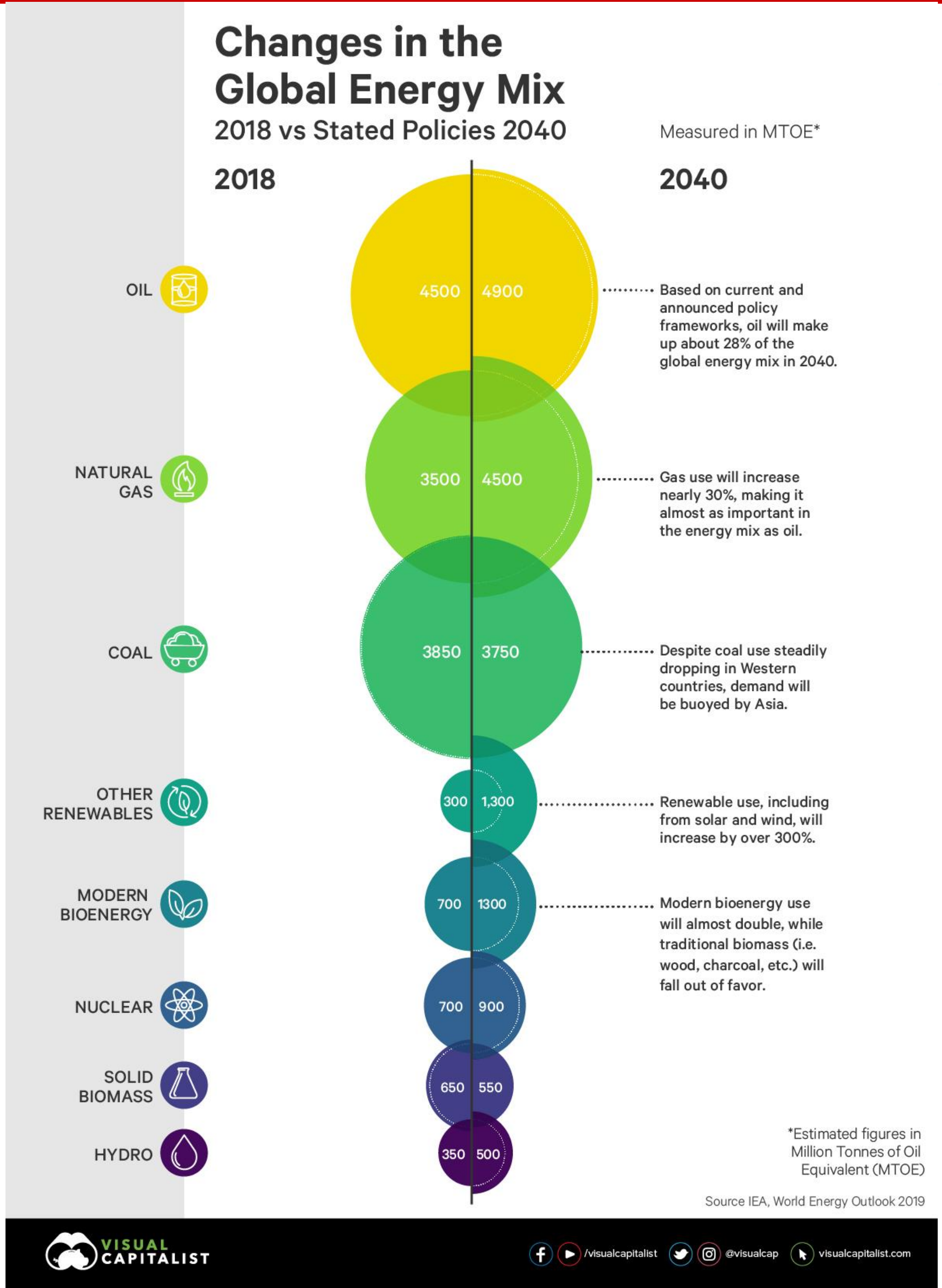
	Wind	Solar
CURRENT	3596 MW	--- MW
IN 1 HOUR	4882 MW	--- MW
IN 3 HOURS	5299 MW	--- MW
IN 6 HOURS	6028 MW	--- MW
IN 9 HOURS	6844 MW	7 MW

Higher energy production than current, lower emissions

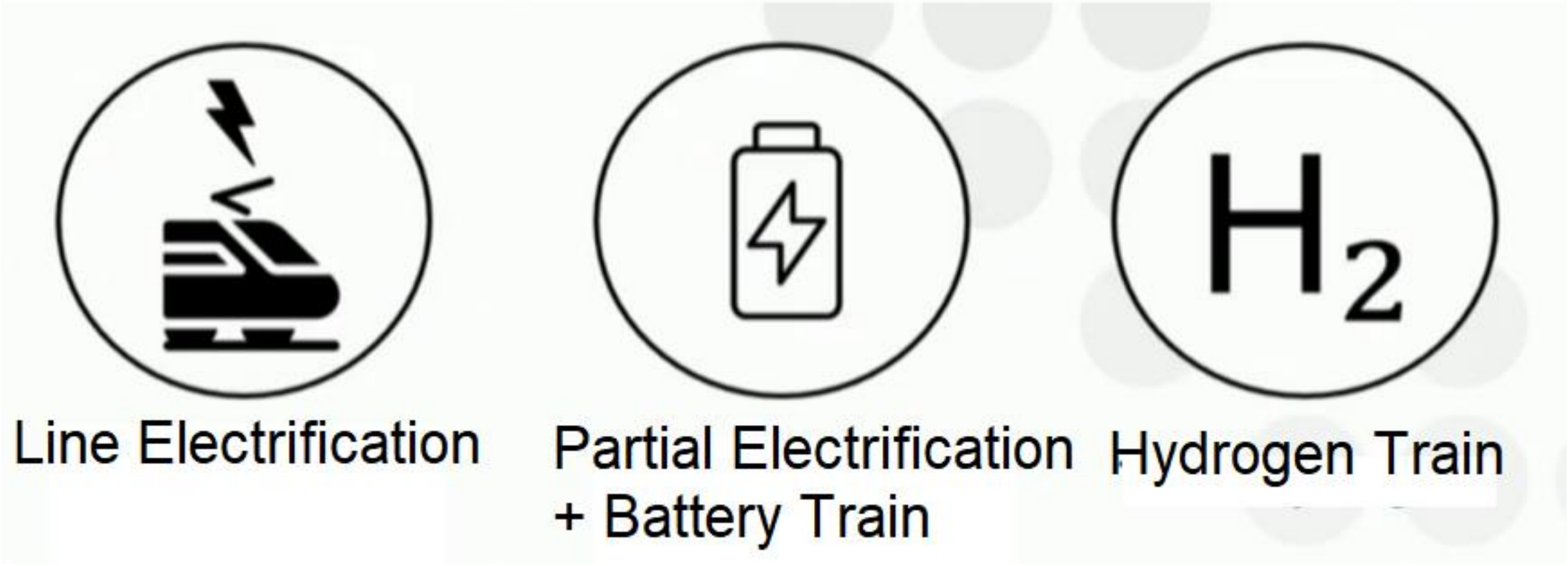
Lower energy production than current, higher emissions

https://www.nowtricity.com/

Energy Mix


Changes in the Global Energy Mix
2018 vs Stated Policies 2040
Measured in MTOE*
2018
2040
OIL
4500
4900
Based on current and announced policy frameworks, oil will make up about 28% of the global energy mix in 2040.
NATURAL GAS
3500
4500
Gas use will increase nearly 30%, making it almost as important in the energy mix as oil.
COAL
3850
3750
Despite coal use steadily dropping in Western countries, demand will be buoyed by Asia.
OTHER RENEWABLES
300
1,300
Renewable use, including from solar and wind, will increase by over 300%.
MODERN BIOENERGY
700
1300
Modern bioenergy use will almost double, while traditional biomass (i.e. wood, charcoal, etc.) will fall out of favor.
NUCLEAR
700
900
SOLID BIOMASS
650
550
HYDRO
350
500
*Estimated figures in Million Tonnes of Oil Equivalent (MTOE)
Source IEA, World Energy Outlook 2019
VISUAL CAPITALIST
/visualcapitalist
@visualcap
visualcapitalist.com

Rail Transport : Solutions to get Greener



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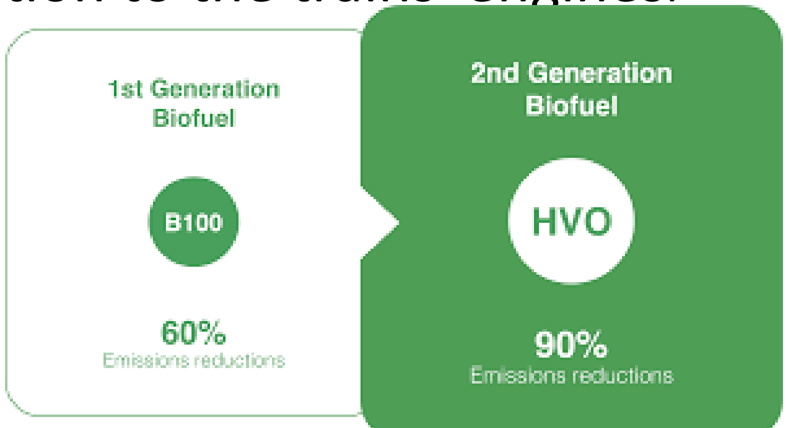
Rail Transport : Solutions to get Greener

- Replace diesel with **biofuels** in thermal trains to reduce greenhouse gas emissions like :

- B100, a 100% pure biofuel that doesn't compete with food needs.

- HVO (Hydrotreated Vegetable Oil), a biofuel made from hydro-treated vegetable oil, or from waste processing (used oils, animal fats).

- This solution brings more than 60% reduction in greenhouse gas emissions and requires no modification to the trains' engines.



Rail Transport : Solutions to get Greener

- For air conditioning in various rolling stock, replacing Hydrofluorocarbon (HFC) refrigerants with a new refrigerant that better withstands high temperatures and contributes less to the greenhouse effect.
- Replacing current refrigerants (R134A and R407C) with **R513A**, which enhances the resistance and reliability of high-temperature air conditioning units and has a significantly lower "Global Warming Potential."

le cnam

THANK YOU !!!

IV.6 UNIGE - Master of Science in "Safety engineering for transport, logistics and production" - "Sustainable Rail and Road Infrastructure" module - course on "Design and modelling of the track access charges system for the use of rail infrastructure"

The introduction of competition on the railway infrastructure required, in addition to the restructuring of the historical railway companies, the introduction of completely new market regulation instruments that did not exist in the monopoly era. One of them is the track access charges for the use the railway infrastructure.

In more detailed, with these restructurinng of railway, the railway infrastructure ceases to be only a technical system and a cost category in the traffic management and operation of rail service. It becomes a special system which should be managed on a commercial basis. Now operators have to pay the access charges for railway infrastructure use to infrastructure managers. At the same time, these charges represent the infrastructure managers' instrument for achieving business operations efficiency.

Knowledge of the concept of track access charges (TAC), the historical development of strategic documents that led to the introduction of TAC, the legal framework that regulates the area of TAC as well as its basic solutions, classification of infrastructure services to be supplied to the train operators, economics principles for determining TAC as well as the structure of TAC will enable students to understand one of the essential instrument for the transport services market regulation on the infrastructure.

To understand how to design TAC first of all students needed to know why TAC for the use of the railway infrastructure appeared, what are the limitations arising from EU legislation and why there is still great freedom in determining the model and level of TAC. Understanding that TAC are charges and not prices, fees, it is necessary to understand the state of the environment (Figure A) in which they are implemented, ie. what is the problem with defining the model and the level of TAC.

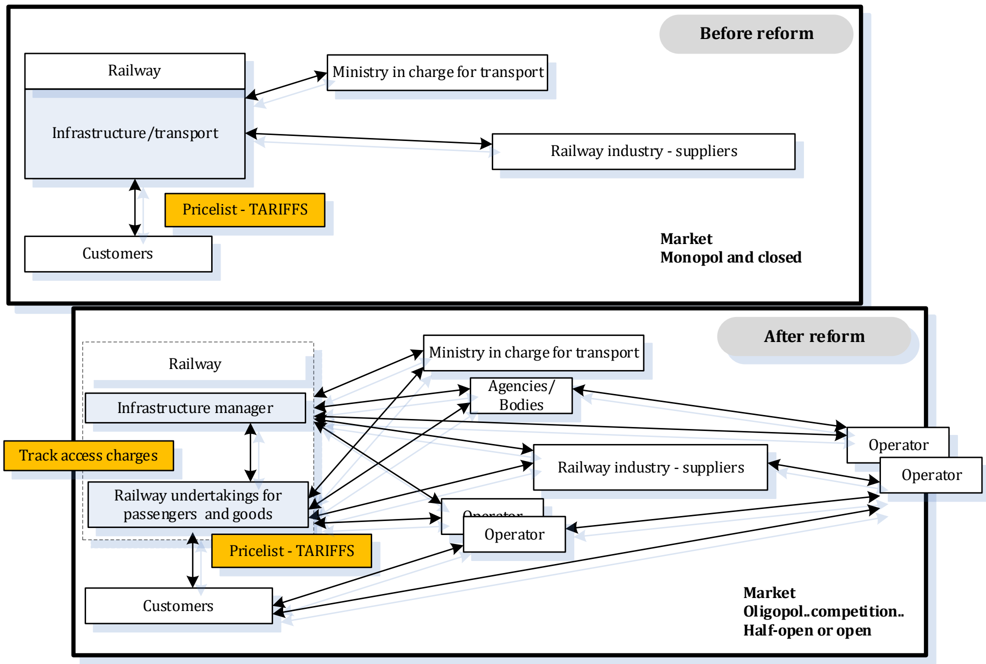
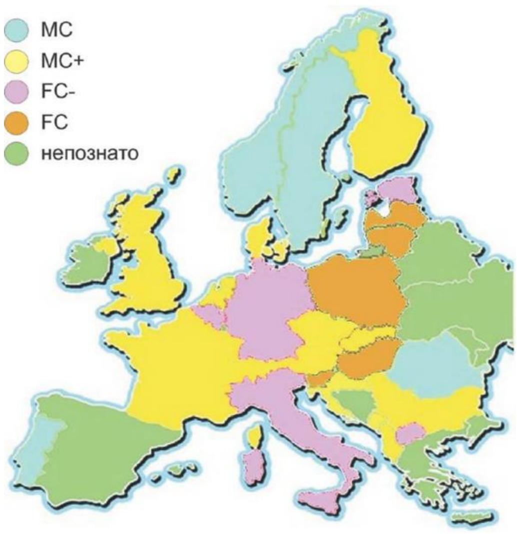


FIGURE A: FRAMEWORK FOR IMPLEMENTING TAC (SOURCE: AUTHOR)

In order for train operators to understand the services they pay for, in other word what the infrastructure manager charges, the system of TAC is defined in Directive 2012/34/EU. Understanding the structure and elements of TAC theoretically is the goal of the second topic. This is supported by examples of TAC systems (Italy, Montenegro as a country with small railway network, one country with medium-sized railway network) and how to “read” them.



A group of high-level experts in EU proposed that the charges be based on cost principles, which was adopted by EC, so the next topic is to make understanding economic principles for setting track access charges for the minimum access package by comprehension general approaches and principles for TAC definition and introduction each of the economic principles and selection of TAC principles; At the end is given an overview of TAC principle choices in Europe (figure B).

FIGURE B: OVERVIEW OF TAC PRINCIPLE IN EUROPE (SOURCE: AUTHOR)

The difference in TAC levels in the EU, as well as other differences that have been pointed out in previous topics required the new approach to define TAC. The new approach is based on the idea that the TAC structure should be based on objective findings stakeholders about the market and the possibilities of adaptation of market actors to both changes in the market and innovations in technology and organization. The need and development of a different approach to designing TAC are the topic of interest and discussion in international papers even today (shown in some published papers) and in this topic of lecture were went a step further, how to include experience and evaluate the operator's opinion is supported by the CONJOINT method. (Figure C.)

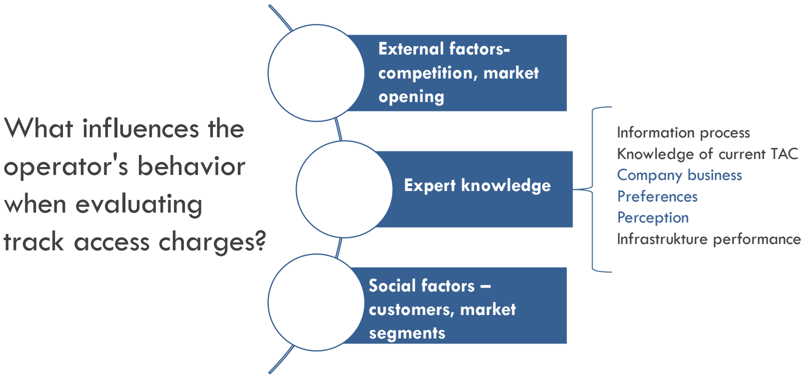


FIGURE C: THE DISCRETE CHOICE EXPERIMENT

What is the importance to understand how to design and modelling the track access charges system for the use of the infrastructure? With the selection of the TAC structure (choice of elements, their evaluation and relations), the infrastructure manager sends signals to the operators in terms of evaluation and incentives for the areas of improvement of work and selection of rolling stock, as well as certain behaviours in traffic. By the end, students recognize and understand does the TAC calculation structure sends a message about whether the infrastructure manager encourages an increase in the mass and length of the trains and how he values it, or whether it is less important in relation to the factor (occupancy) of the infrastructure (track) capacity. Also, the selected TAC may serve to prevent or deter the entry of new operators or, more precisely, serve to protect the dominant position of railway undertaking.

IV.7 UNIROMA1 - Master of Science in “Transport Systems Engineering” - “Railway Engineering” module

RAILWAY ENGINEERING
Lectures on Vehicles
27/09/2023 - 22/12/2023

Riccardo Licciardello

(http://stefanoricci.site.uniroma1.it/)

SAPIENZA
UNIVERSITÀ DI ROMA

Day One (1)

Getting to know each other

- Presentations and sign-up to Google Classroom (access from your uniroma1 account, **eorvuss**)
- **SAPIENZA Railway Group Research,** some projects: **Assets4Rail**, **Capacity4Rail**, **Gearbodies**, **OptiYard**, **Run2Rail**, **MOST**
- **Survey (in Wooclap)**

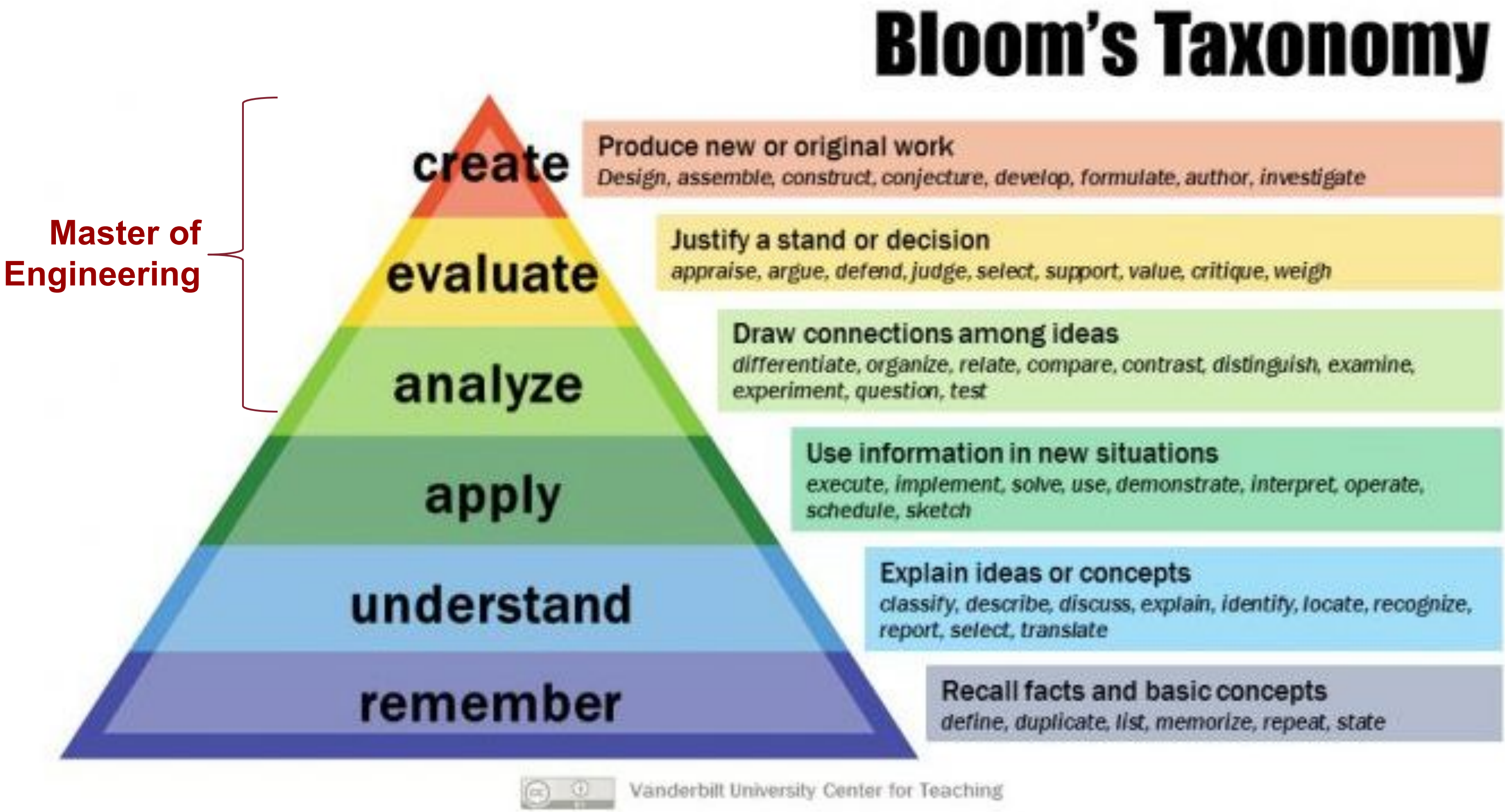
Learning objectives, syllabus, exams

Rail sector companies

Assignments:

1. read slides VE1_VE2, prepare for “flipped classroom”
2. prepare presentation on either a) a specific vehicle type b) a recent or emerging technology (see ERJU catalogue of solutions) using the **template** on the shared Classroom folder

Day One (2)



Bloom's Taxonomy
Master of Engineering
create
evaluate
analyze
apply
understand
remember
Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate
Justify a stand or decision
appraise, argue, defend, judge, select, support, value, critique, weigh
Draw connections among ideas
differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test
Use information in new situations
execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch
Explain ideas or concepts
classify, describe, discuss, explain, identify, locate, recognize, report, select, translate
Recall facts and basic concepts
define, duplicate, list, memorize, repeat, state
Vanderbilt University Center for Teaching

Day One (3)

At the end of the "vehicle part" of the course, the student will

know how

• to **describe the fundamental elements** of rolling stock for different applications (railway, metro, tram, freight/passenger etc.) **and the different vehicle architectures**, including the main **conventional and emerging technologies**

• to **dialog with specialist railway engineers** using adequate terminology with the goal of solving the issues that may arise during transport system planning and operations

• to **list / present** the **basic physical quantities** characterising a railway vehicle from an engineering point of view together with **orders of magnitude** for the main ones

be able

• to **solve simple mechanical, electrical and system related numerical problems**, by applying basic physics principles and the knowledge acquired during the course, assuming the correct orders of magnitude of the influence factors and usefully interpreting the results, regarding essentially:

  - traction/braking needs (given the train to be hauled) and performance (given the tractive rolling stock) in terms of traction/braking force and power, and electric current/voltage;
  - static free-body calculations regarding the forces and moments applied to railway vehicles during traction, braking and standstill conditions, on straight and curved track;
  - suspension frequencies and their relationship with excitation frequencies (e.g. due to hunting and track irregularities)

• to make **elementary engineering sketches** of the fundamental technological elements of railway vehicles

RAILWAY ENGINEERING
Lectures on Vehicles
27/09/2023 - 22/12/2023

Riccardo Licciardello

(http://stefanoricci.site.uniroma1.it/)

SAPIENZA
UNIVERSITÀ DI ROMA

VE1. Vehicle types and architecture

Rolling stock: main categories

- Railway system: traction units, passenger coaches, freight wagons
- Metros, tram, and other light rail vehicles
- Vehicles reserved for a strictly local, touristic use (e.g. historical).
- Special vehicles

EU definitions – TSI Loc&Pas

- A ‘**unit**’ may be composed of several ‘vehicles’
- A ‘**train**’ is an operational formation consisting of one or more units
- A ‘**passenger train**’ is an operational formation accessible to passengers (a train composed of passenger vehicles but not accessible to passengers is not considered as a passenger train).
- A ‘**fixed formation**’ is a train formation that can only be reconfigured within a workshop environment.
- A ‘**predefined formation**(s)’ is a train formation(s) of several units coupled together, which is defined at design stage and can be reconfigured during operation.
- ‘**multiple operation**’: is an operational formation consisting of more than one unit: trainsets designed so that several of them are capable of being coupled together to operate as a single train controlled from 1 driver's cab; locomotives designed so that several of them are capable of being included in a single train controlled from 1 driver's cab.

https://www.era.europa.eu/activities/technical-specifications-interoperability_en

Thermal or electric traction units (TSI)

- A **Locomotive** is a traction vehicle (or combination of several vehicles) that is not intended to carry a payload and has the ability to be uncoupled in normal operation from a train and to operate independently.
- A **Shunter** is a traction unit designed for use only on shunting yards, stations and depots.
- Traction in a train can also be provided by a powered vehicle with or without driving cab, which is not intended to be uncoupled during normal operation. Such a vehicle is called a **Power Unit** (or power car) in general or a **Power Head** when located at one end of the trainset and fitted with a driving cab.

Self-propelling thermal or electric passenger trains (TSI)

- A **Trainset** is a fixed formation that can operate as a train; it is by definition not intended to be reconfigured, except within a workshop environment. It is composed of only motored or of **motored** and **non-motored vehicles**.
- An **Electric** and/or **Diesel Multiple Unit (EMU/DMU)** is a trainset in which all vehicles are capable of carrying a payload (passengers or luggage/mail or freight).
- A **Railcar** is a vehicle that can operate autonomously and is capable of carrying a payload (passengers or luggage/mail or freight).
- A **tram – train** is a vehicle designed for combined use on both a light-rail infrastructure and a heavy-rail infrastructure;

Passenger coaches and other related cars (TSI)

- **A Coach is a vehicle without traction in a fixed or variable formation capable of carrying passengers (by extension…restaurant cars, sleeping cars, couchettes cars, etc.).**
- A **Van** is a vehicle without traction capable of carrying payload other than passengers, e.g. luggage or mail, intended to be integrated into a fixed or variable formation which is intended to transport passengers.
- A **Driving Trailer** is a vehicle without traction equipped with a driving cab.
- A coach may be equipped with a driver's cab; such a coach is then named a **Driving Coach**.
- A van may be fitted with a driver's cab and as such is known as a **Driving Van**.
- A **Car Carrier** is a vehicle without traction capable of carrying passenger motor cars without their passengers and which is intended to be integrated in a passenger train.
- A **Fixed Rake of Coaches** is a formation of several coaches 'semi-permanently' coupled together, or which can be reconfigured only when it is out of service

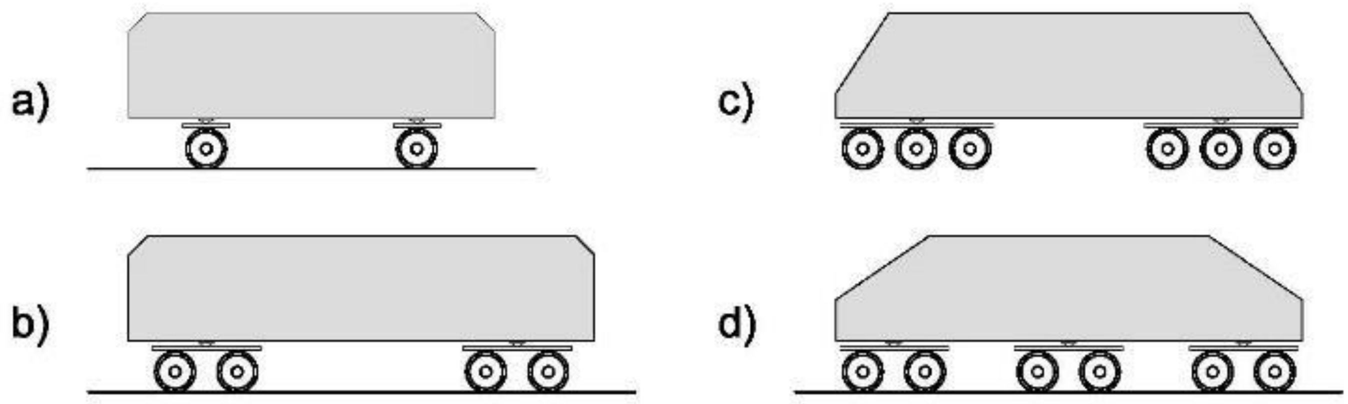
Other categories (TSI)

- **Freight wagons**, including low-deck vehicles designed for the entire network and vehicles designed to carry lorries
- **Special vehicles**, such as on-track machines. **On-Track Machines** (OTMs) are vehicles specially designed for construction and maintenance of the track and infrastructure. OTMs are used in different modes: working mode, transport mode as self-propelling vehicle, transport mode as a hauled vehicle. **Infrastructure inspection vehicles** are utilised to monitor the condition of the infrastructure. They are operated in the same way as freight or passenger trains, with no distinction between transport and working modes.

Conventional vehicle architectures

- **Maximum mass per axle** defines the minimum number of axles per vehicle (e.g. 20 t/axle).
- Two axles limit total weight: for example 2*20=40 t maximum mass; they have single stage suspension connecting carbody and wheelsets (a).
- For heavier vehicles: four or six axles per car (b), (c), (d).
- More wheelsets are connected together to make a bogie: two-stage suspension
  - ❑ Primary suspension: between wheelset and bogie-frame
  - ❑ Secondary suspension: between bogie-frame and body

!



Conventional vehicle architectures

- Solution a): freight wagons, often with only one suspension stage (no secondary)
- Solution b): very common, used for locomotives, passenger coaches, multiple units, freight wagons, metros
- Solutions c) and d): for very high masses (locos, exceptionally heavy freight wagons).

Conventional vehicle architectures

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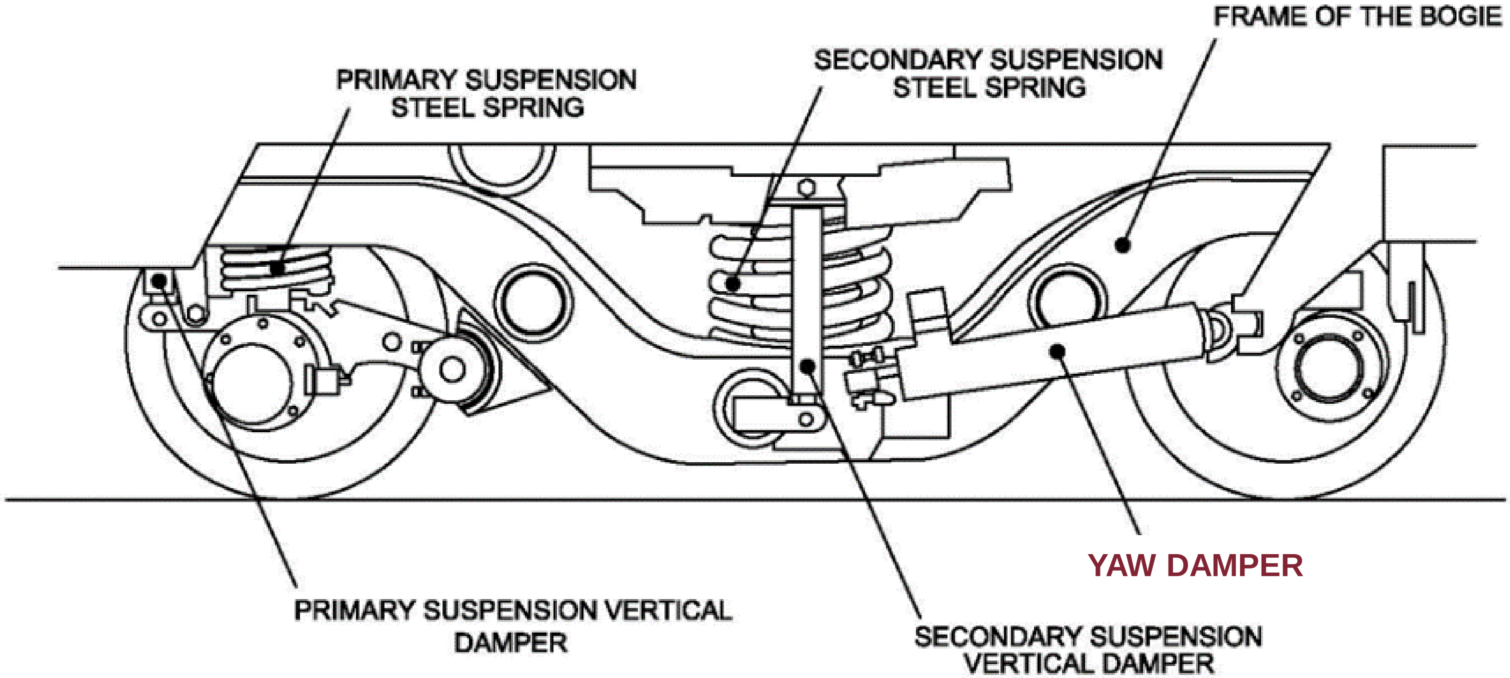


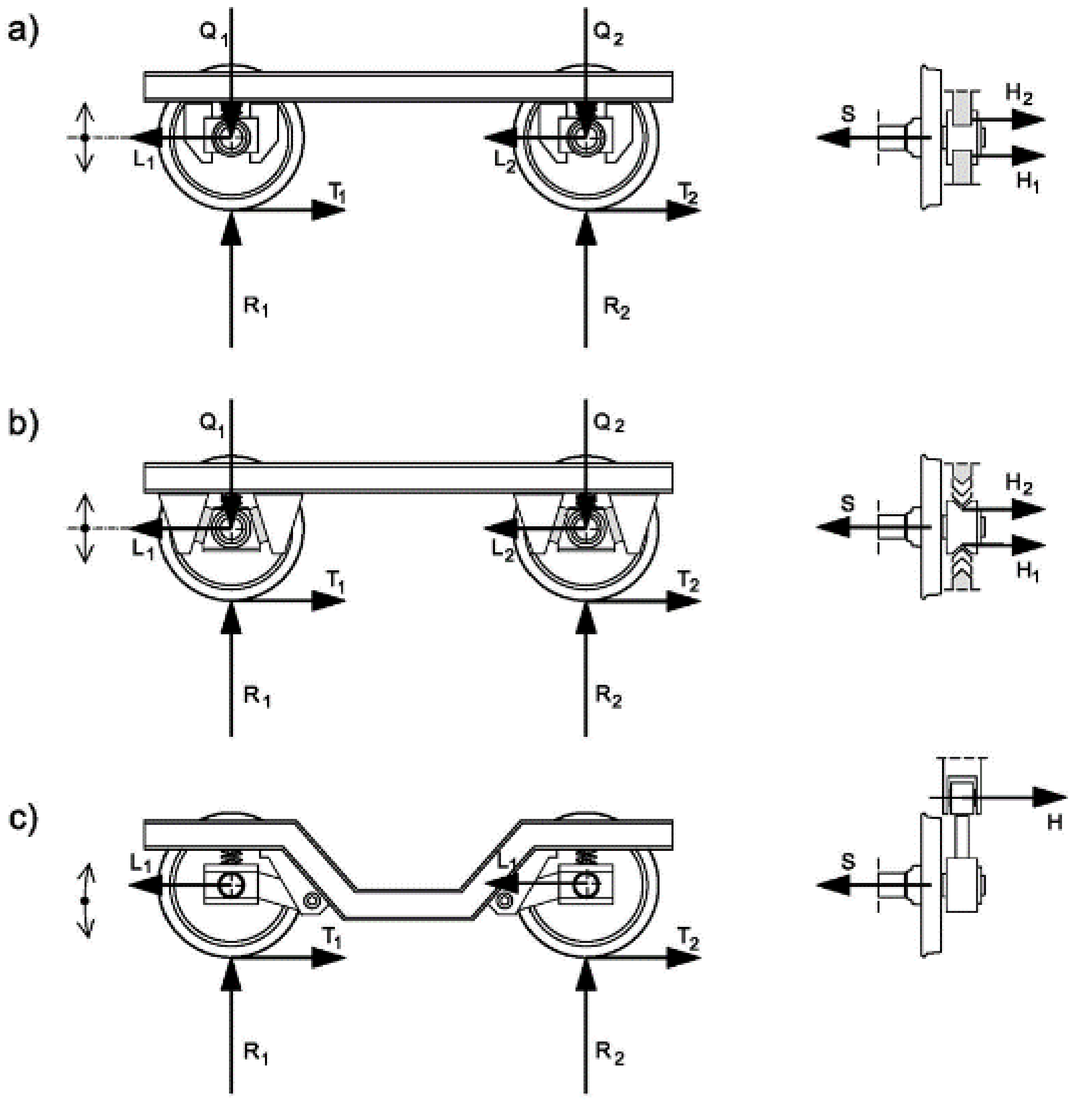
In all the 6 generalised directions:

- Springs (e.g. steel coil springs, air springs, composite rubber/steel springs) provide flexibility
- Dampers suppress persistent oscillations
- “bump-stops” limit the amplitudes of oscillation

Conventional vehicle architectures

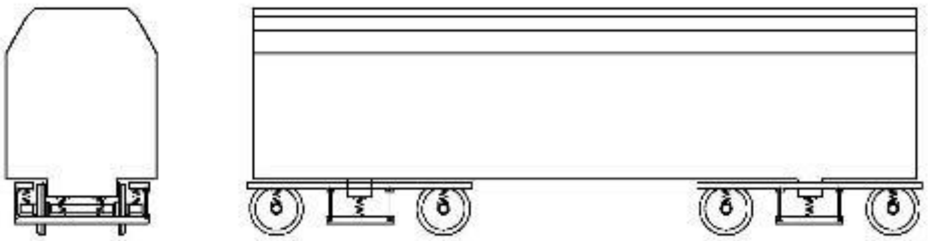
Examples of primary suspension

a) Vertical and transversal guide, steel spring
b) Vertical and transversal guide, rubber and steel composite (spring and damper)
c) Articulated guide, steel beam, steel spring, elastic connection between frame and steel beam (“trailing arm”, “radial arm” configuration).

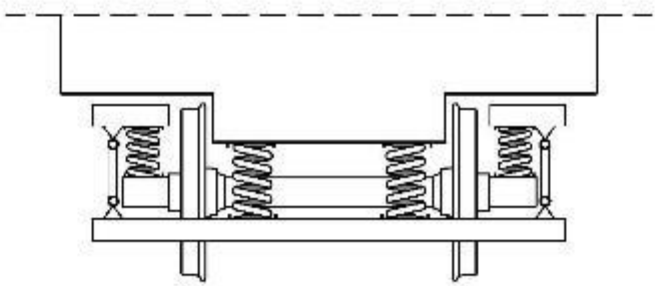


Conventional vehicle architectures

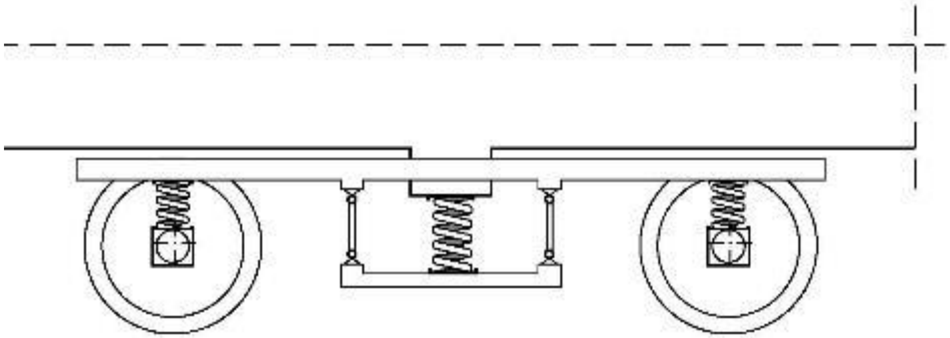
Examples of overall suspension



- Primary suspension group



- Secondary suspension group



- Oscillating beam (bogie bolster)

Conventional running gear (bogies)

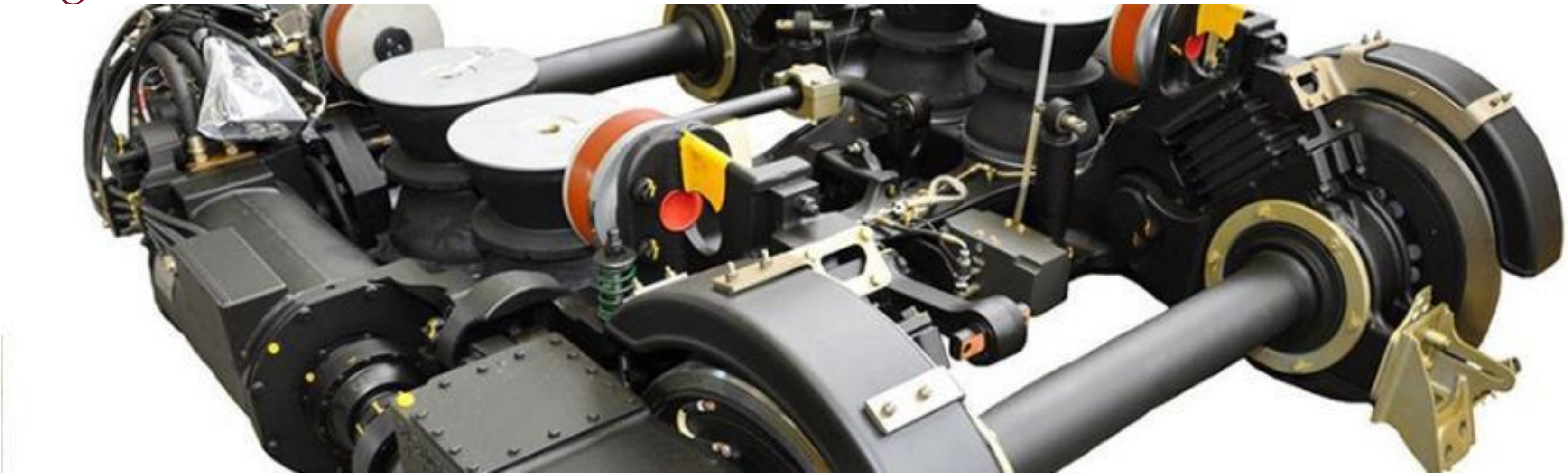
Commuter and
Regional Trains

Intercity and
High-speed Trains

Locomotives

Conventional running gear (bogies)

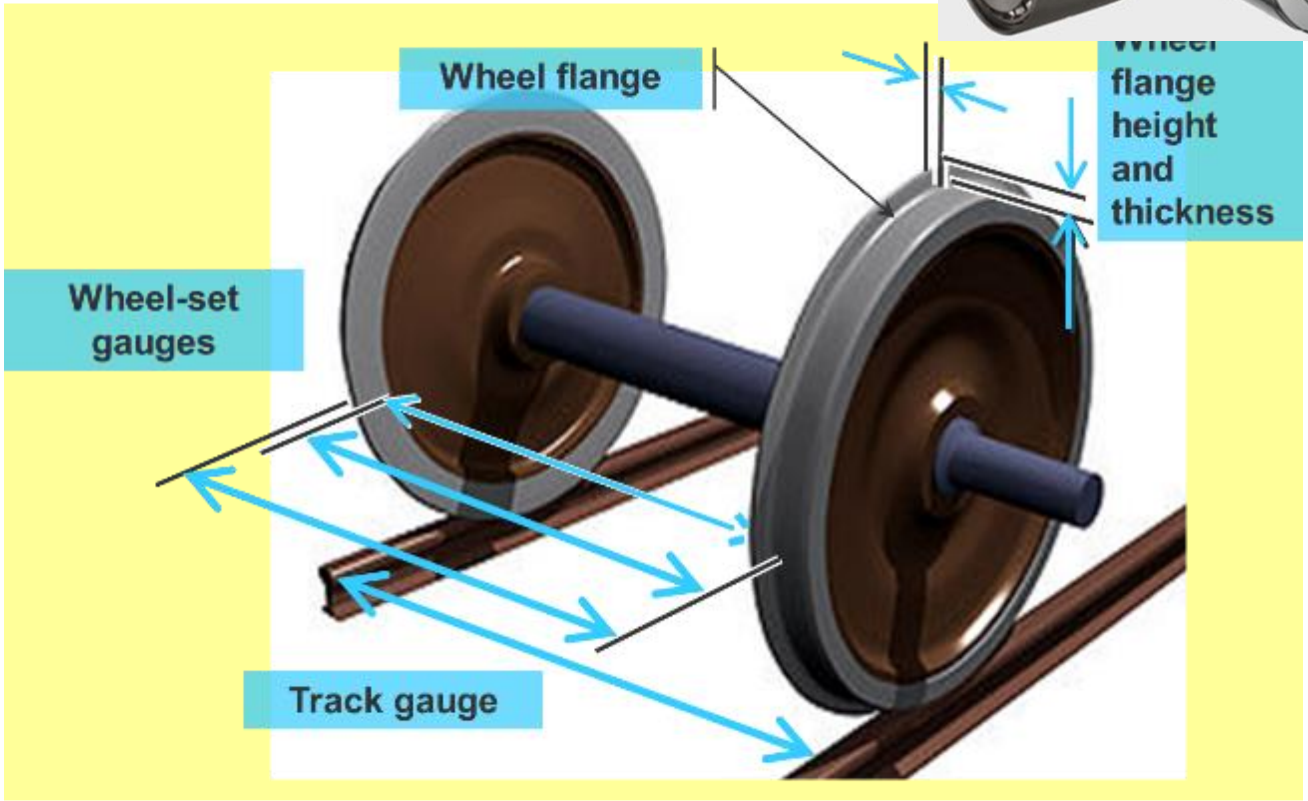
Light Rail Vehicles



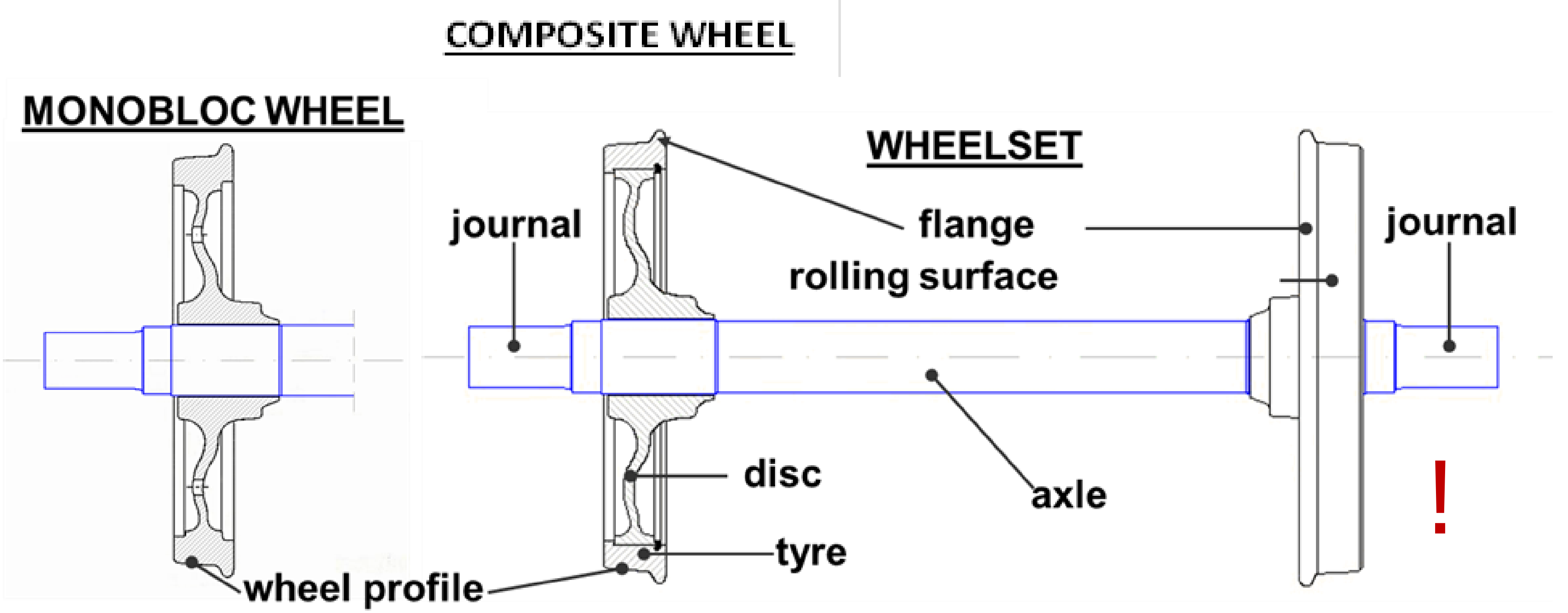
Metros

Conventional running gear: “solid” wheelset

!



Conventional running gear: “solid” wheelset

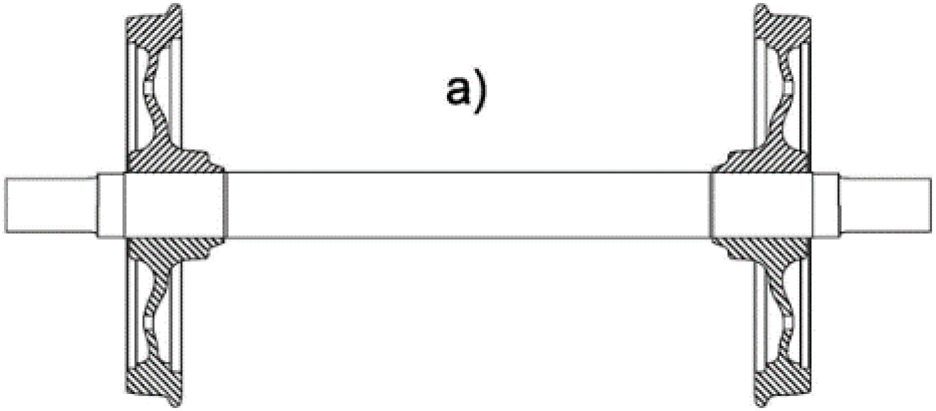


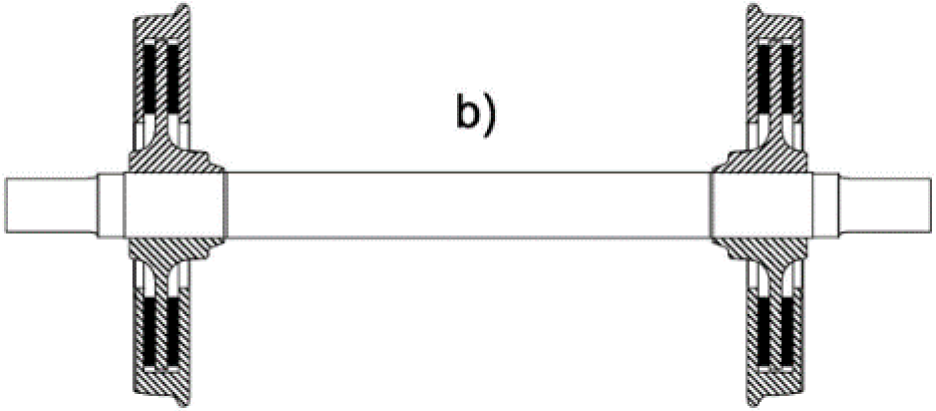
Monobloc wheel: the wheel is made up of a single piece
Composite wheel: the wheel consists of 2 components, disc and tyre (or rim)
Journals: lateral surfaces of the axle where the axleboxes and bearings are mounted, thus connecting the wheelset (in rolling movement) to the frame of the vehicle (in translational movement)

Conventional running gear: “solid” wheelset

a) Monobloc and Composite wheel. The vibrations coming from the contact are transmitted to whole wheelset because of the continuity of the material.

b) Elastic wheels (steel and rubber). The rubber reduces the vibrations coming from the contact. But there are some problems for stability especially at high speed.

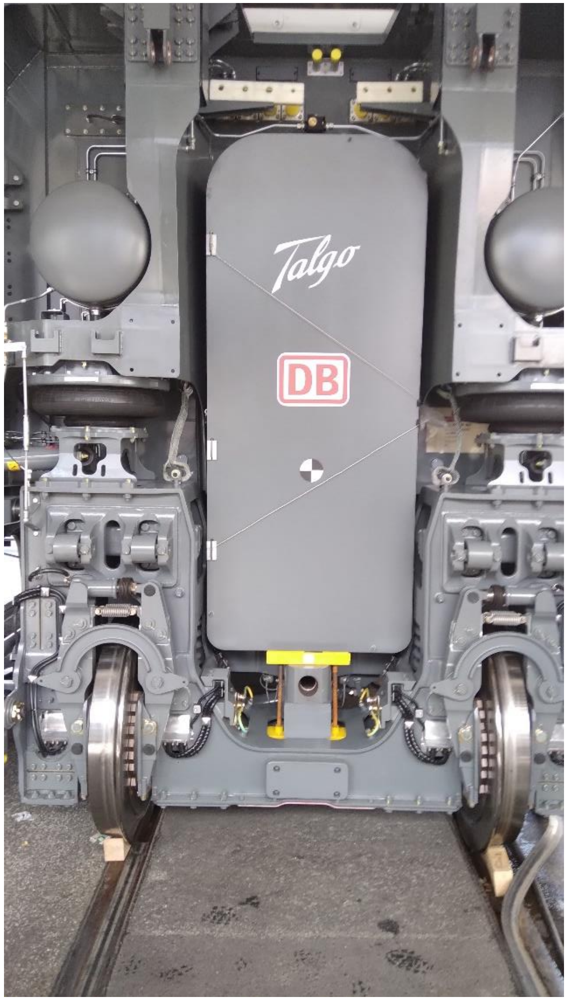




Non-conventional running gear

Example: ICE-L train manufactured by Talgo for DB presented in Innotrans 2022 (v_{max} = 230 km/h) – single-axle running gear between two vehicles with Independently Rotating Wheels (IRW)

Two-axle IRW are widely used in trams but generally do not guarantee stability at high speeds



VE2. Wheel-rail contact

Wheel-rail Adhesion

Adhesion is the fundamental phenomenon for motion to occur.

The tangential force T exchanged between two bodies in contact depends on
- the characteristics of the bodies
- the intensity of the P force, normal to the contact surface

!

$$T \leq \varphi P$$

The maximum tangential force is $T=\varphi P$ where

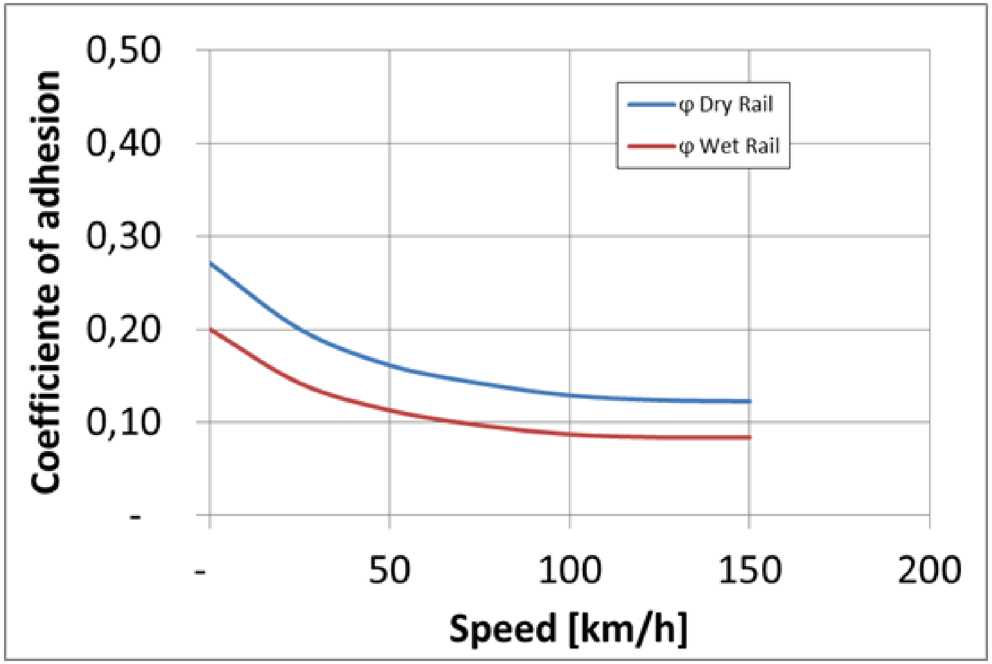
φ is the coefficient of adhesion (limit of adhesion)
φ depends on the materials in contact:
- steel on steel: 0,1÷0,3 (lubricated / contaminated) , up to 0,8 (dry and clean);
- rubber on asphalt: 0,2-1,0 (wet / contaminated – dry)

This applies to all wheels with tractive or braking capability.

Adhesion versus speed

!

- A single "adhesion coefficient" φ_{TU} may be assigned to an entire Traction Unit (TU)
- Coefficient of adhesion φ_{TU} decreases with vehicle speed v
- Adhesion with wet rail is less than adhesion with dry rail. Leaves and lubricants lower adhesion levels further (e.g. 0,05).
- Safe (low) values are assumed in the chart below.



Adhesion in design

- The coefficient of adhesion influences the maximum traction force (and the maximum braking force, with similar values).
- Size and strength of the Traction Unit's key traction drive components depend on the choice of the adhesion coefficient chosen for the design. This in turn depends on the expected wheel-rail contact conditions expected.
- The value used by any TU manufacturer may be obtained by dividing the declared maximum traction effort by the weight of the TU:

$$\varphi_{TU} = T_{max} / P_{TU}$$

- Commonly, this design value is in the range 0.3 to slightly above 0.4.

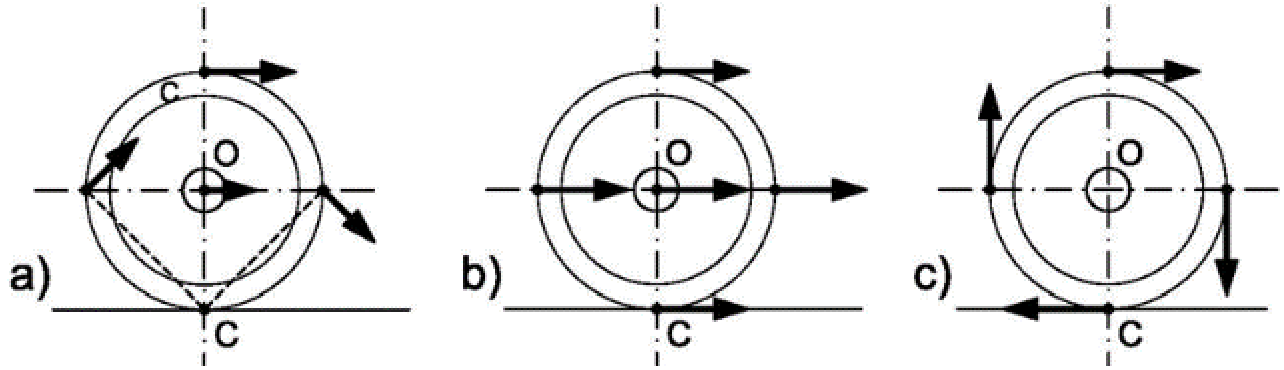
Rolling, rotational and translational motions

- Figures a), b) and c) show the absolute speed of each point of the wheel in different motion conditions.

a) wheel in pure rolling: C contact point v = 0; other points **v= ωr** (r= distance from contact point C; ω=angular velocity)

b) wheel in perfect translational motion (pure sliding): all points have the same velocity v

c) Wheel in perfect rotational motion (pure slip / slippage): the centre of wheel has v = 0; other points have the same v= ωr (r = radius of the wheel; ω=angular velocity)



Adhesion and Friction

!

1. **slip**: vehicle (almost) stopped with wheel in motion, e.g. traction phase
2. **slide**: vehicle in motion with wheel stopped, e.g. braking phase
3. **creep / creepage / micro-slip**: more usual and desirable conditions with invisible effects

$$\gamma = \frac{\omega - {}^{v}/_{r}}{v/r}$$

with pure wheelslip or wheelslide we have: T= fP
f = coefficient of **friction** < φ

!

optimal traction / braking requires the wheel to be kept rolling (**anti-slip / anti-slide devices**), in order to attain the full traction/braking force T= φ P and to avoid “wheel flats”

Creep – creepforce relationship

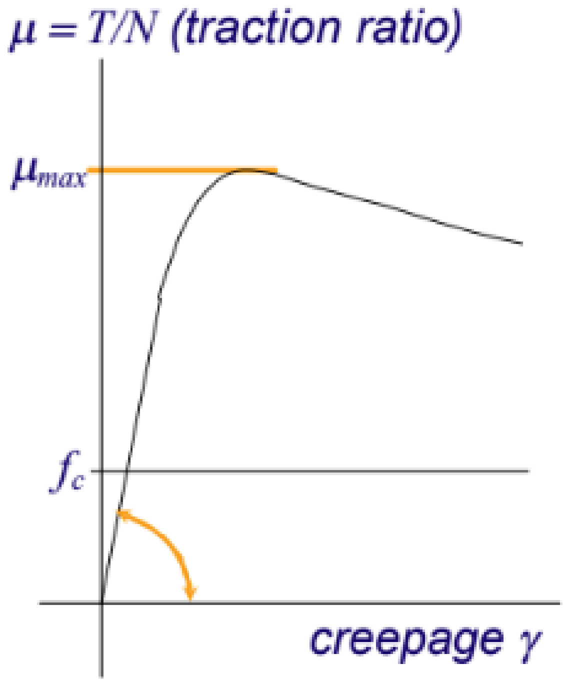
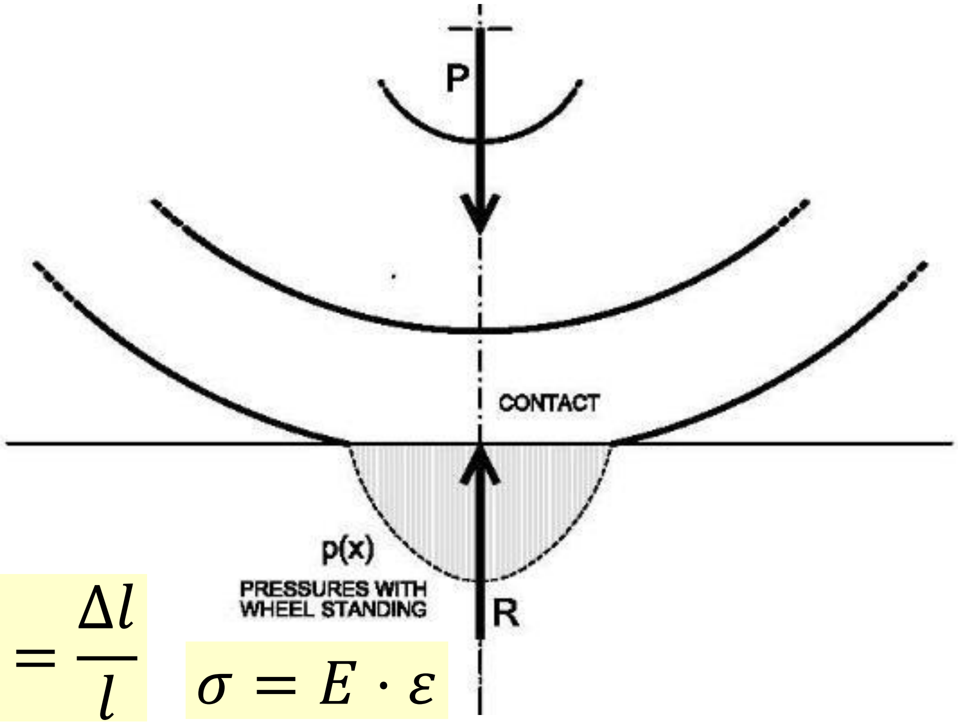


Figure 9 – basic relationship for the calculation of friction force T acting on the wheel on the basis of the kinematical situation of the wheel respect to the rail (summarised by the generalised creepage) – the curve is characterised by its slope at zero creepage and by the maximum traction ratio μ_{max} – f_c is the Coulomb coefficient of friction, valid for complete sliding – current theories used for MBS do not take into account the decay of traction at high creepage values

Contact pressure distribution: wheel at standstill

- **P** = total load on the wheel
- **R** = resultant force of the vertical reaction pressure
- **p(x)** = pressure (**stress**) distribution (symmetric); proportional to the amount of **strain** of the wheel



$$\varepsilon = \frac{\Delta l}{l}$$

$$\sigma = E \cdot \varepsilon$$

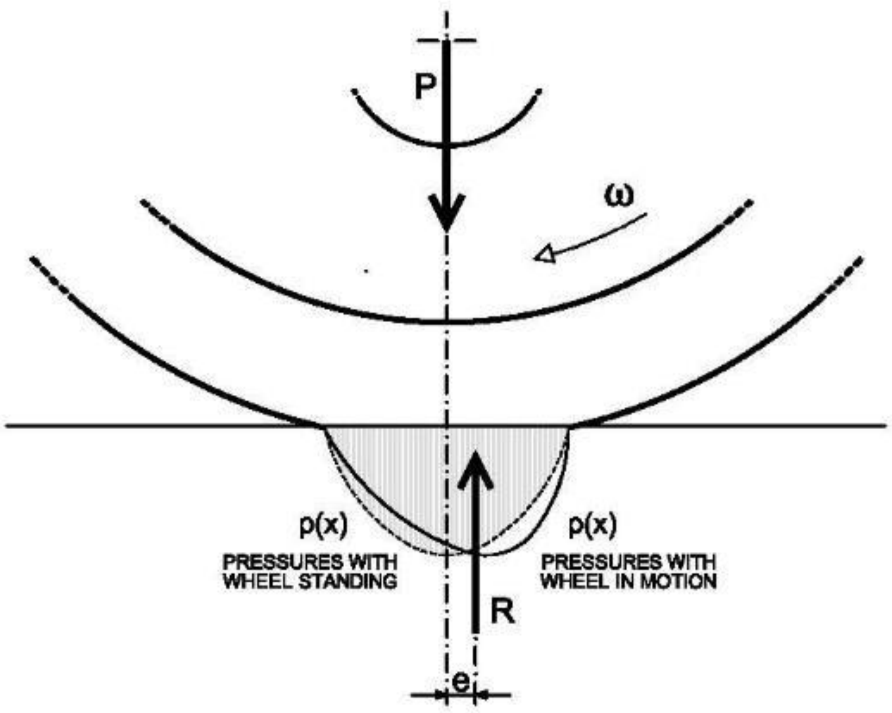
P and **R** have

- same line of application of the force,
- opposite sense,
- same magnitude.

Contact pressure distribution: wheel in motion

- **p(x):** pressure distribution is not symmetric, peak pressure is moved forward
- **P** and **R** have different lines o action, opposite sense, same magnitude
- eR corresponds to the rolling resistance; the greater the "e" value, the greater the rolling resistence
- Note: rolling resistance is different from adhesion, the former is undesirable, the latter necessary for traction

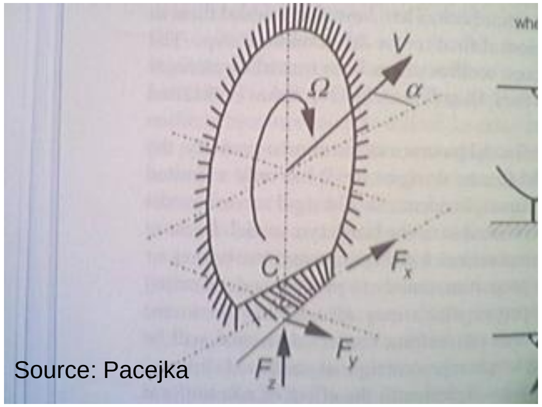
!



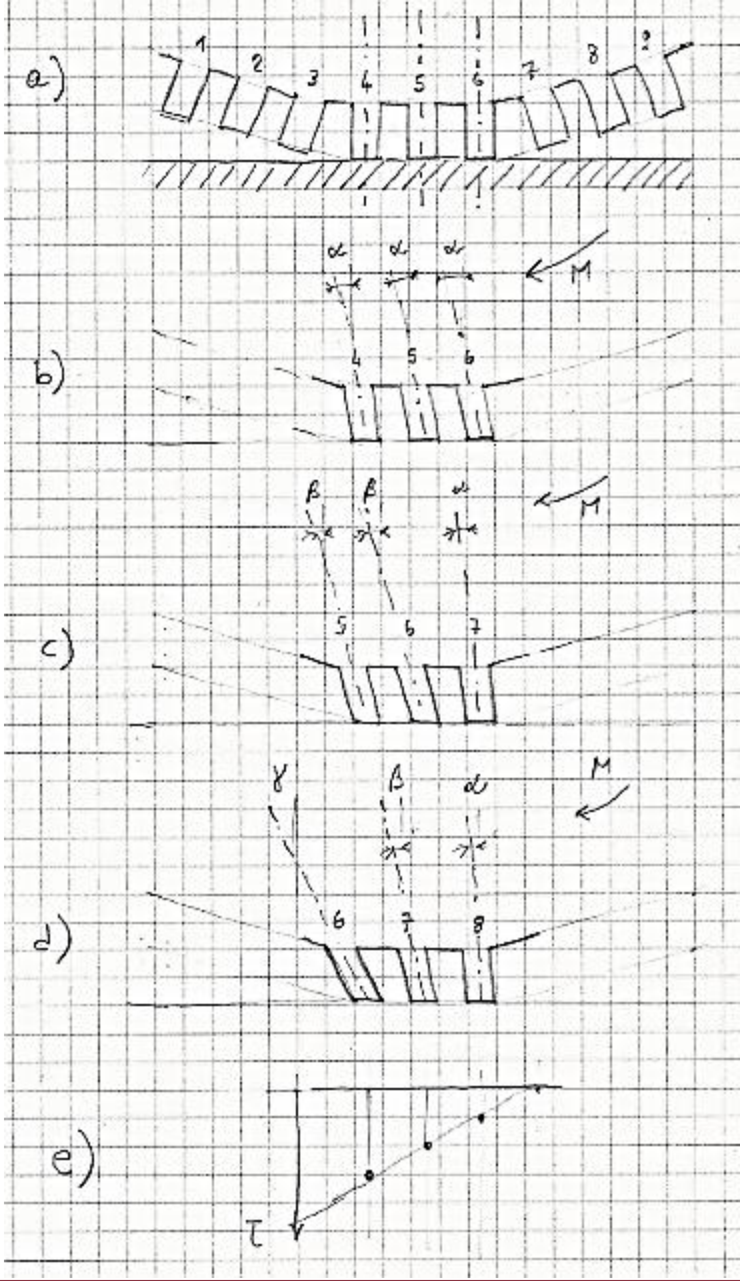
Contact strain and stress

Idealised representation of the rolling surface of the wheel to study the distribution of the tangential strain and stress in contact area.

a) Wheel at standstill with no torque
b) Wheel at standstill with torque M
c) Wheel rolling with torque M – Step 1
d) Wheel rolling with torque M – Step 2
e) Distribution of τ tangential stress; τ stress is proportional to strain

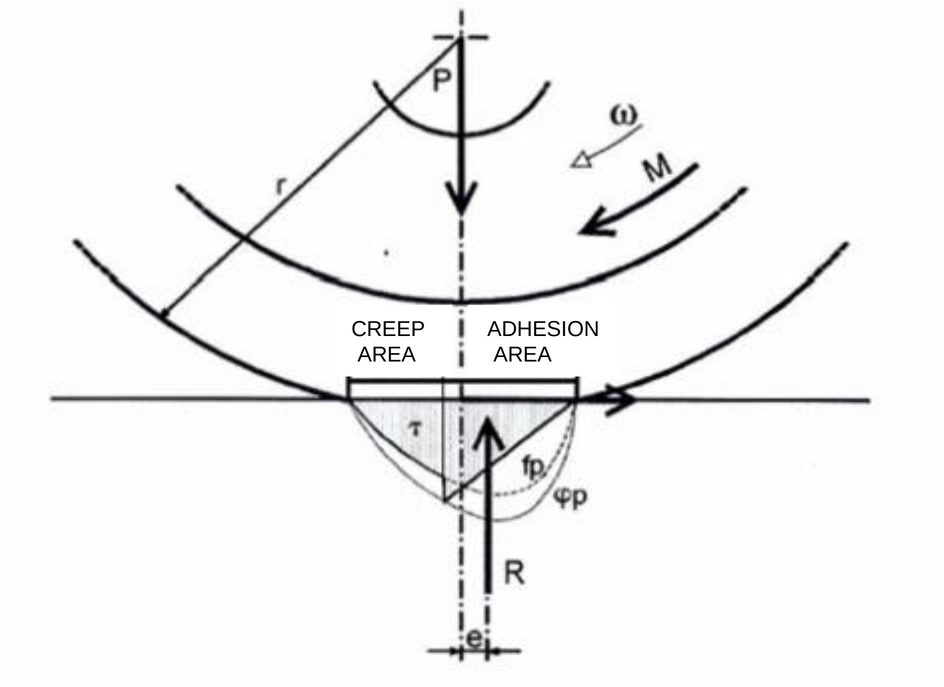


Source: Pacejka



Tangential stress contact distribution: wheel in motion

- **τ** = φp: tangential stress in adhesion condition
- **τ** = fp: tangential stress in slip (friction) condition
- **T**: Traction force T = Στ
- The lower the **T**, the smaller creep area, less wear
- The greater the **T**, the greater the creep area, more wear
- Contact stresses affect key **cost drivers**: **wear** and **Rolling Contact Fatigue (RCF)**



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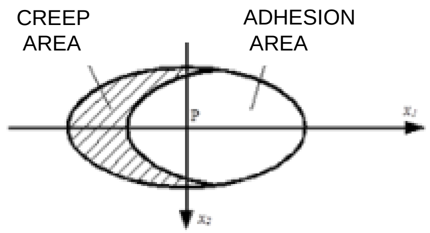
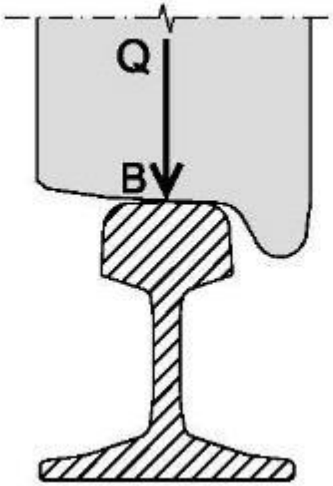
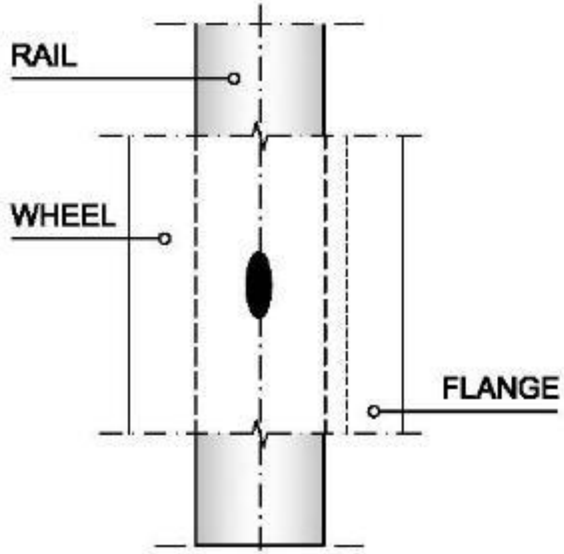
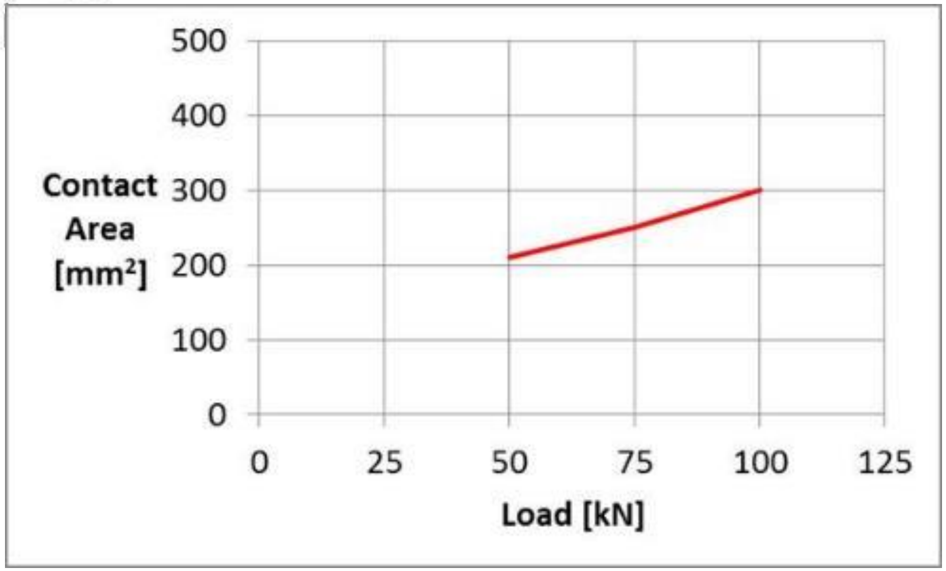


Contact area dimensions





- Contact area and dimensions

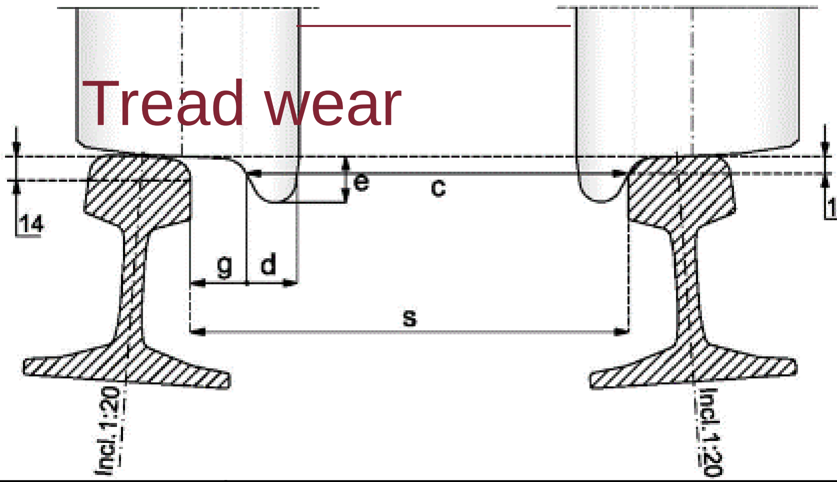


- High pressure
- E.g. $\frac{100kN}{200mm^2}$ =500 MPa

!

Wheelset – track coupling, key geometrical quantities

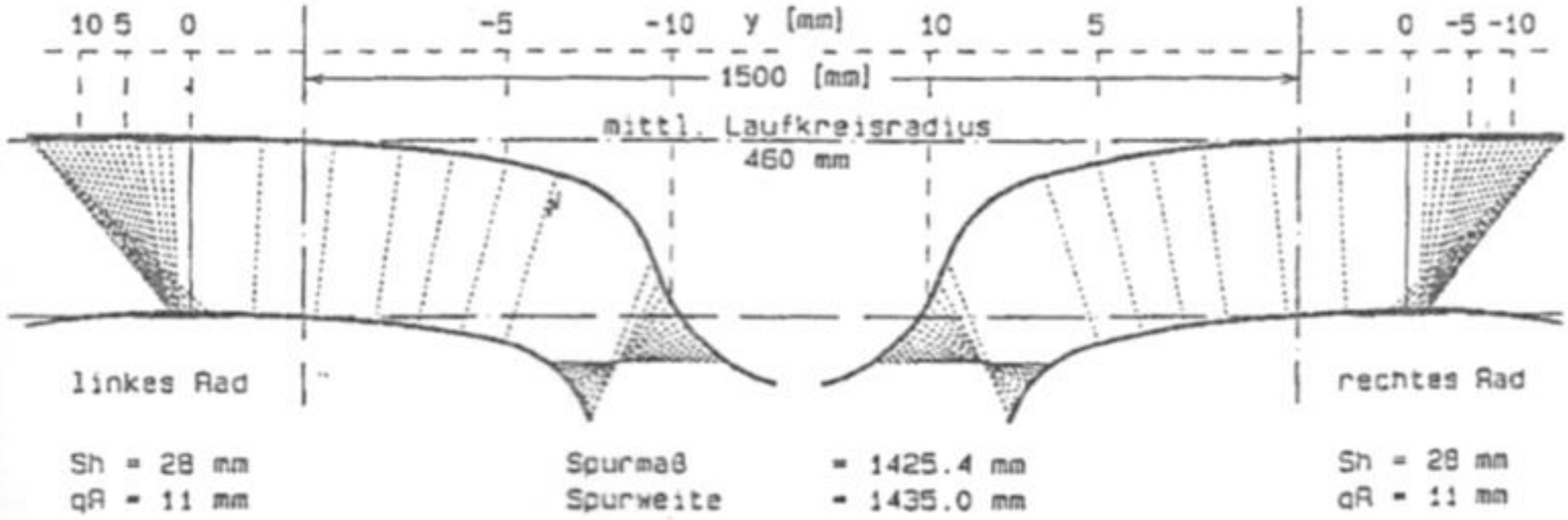
!



Symbol	Description
s	track gauge
c	spacing of active faces
g=s-c	wheelset – track play
e	flange height
d	flange thickness
L	Flangeback spacing

Some quantities do not vary much with service: inclination, flangeback spacing **Flange lubrication** is useful!!!

Wheel-rail contact points



!

The points of mutual contact between wheel and rail move "non-linearly" when the vehicle is running.
The above profiles are "wear profiles": the contact is distributed quite evenly across the profiles with the intention to distribute wear evenly and reduce **reprofiling** costs.

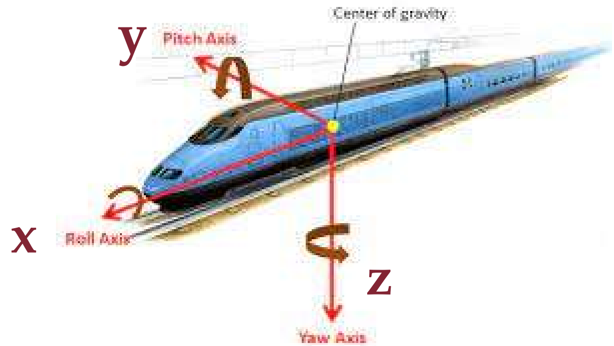
VE3. Vehicle lateral dynamics on straight and curved track

Longitudinal, lateral and vertical dynamics

!

!

- Longitudinal dynamics: traction and braking + longitudinal vibrations (and **pitch**)
- Lateral dynamics: lateral stability on straight track ("hunting" and critical speed), quasi-steady-state curving, lateral vibrations (and **roll**, **yaw**)
- Vertical dynamics: vibration acceleration limits (including passenger/worker comfort, health&safety)
- Vibrations in all directions must be limited in amplitude to avoid interferences
- Running-gear characteristics are key in ensuring adequate vehicle dynamics



Tzanakakis, K. (2013). The Mechanism of Track Faults Creation. In: The Railway Track and Its Long Term Behaviour. Springer Tracts on Transportation and Traffic, vol 2. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-36051-0_18

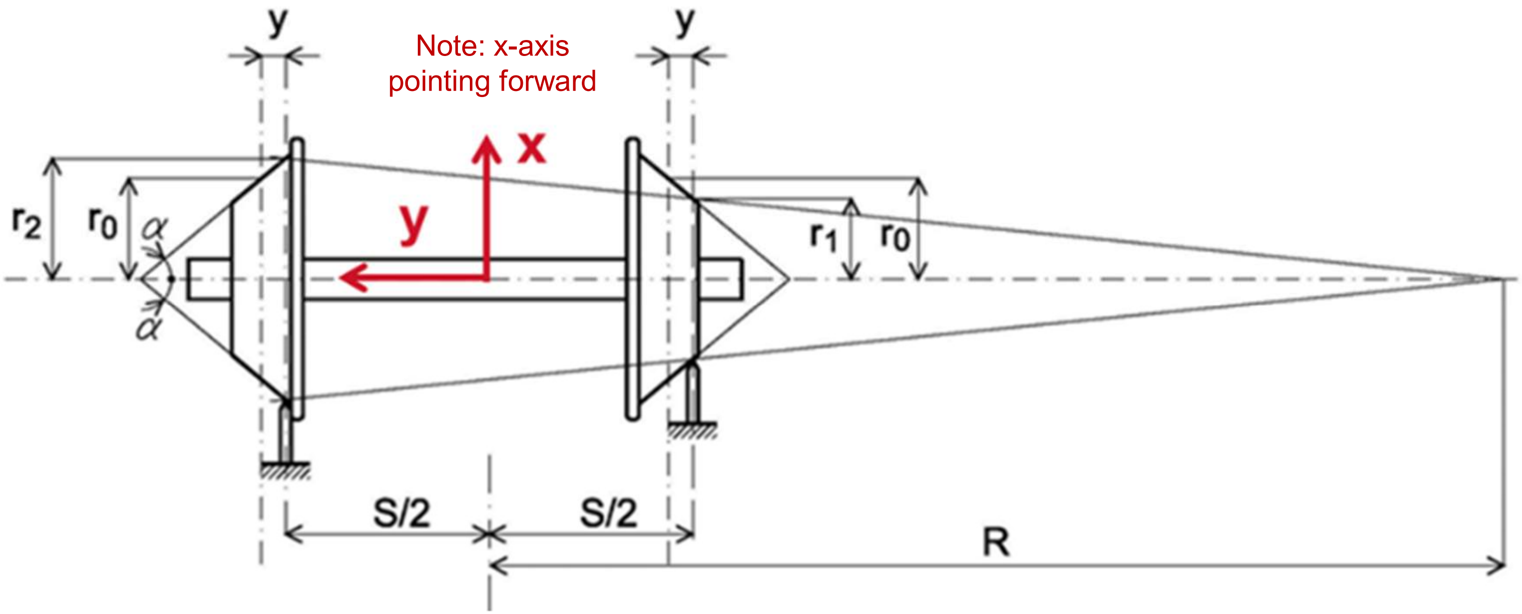
Lateral dynamics: theoretical wheelset motion on straight track

Kinematic theory (Klingel)

In the equilibrium condition on a straight track the two wheels run on the same rolling radius $\mathbf{r_0}$.

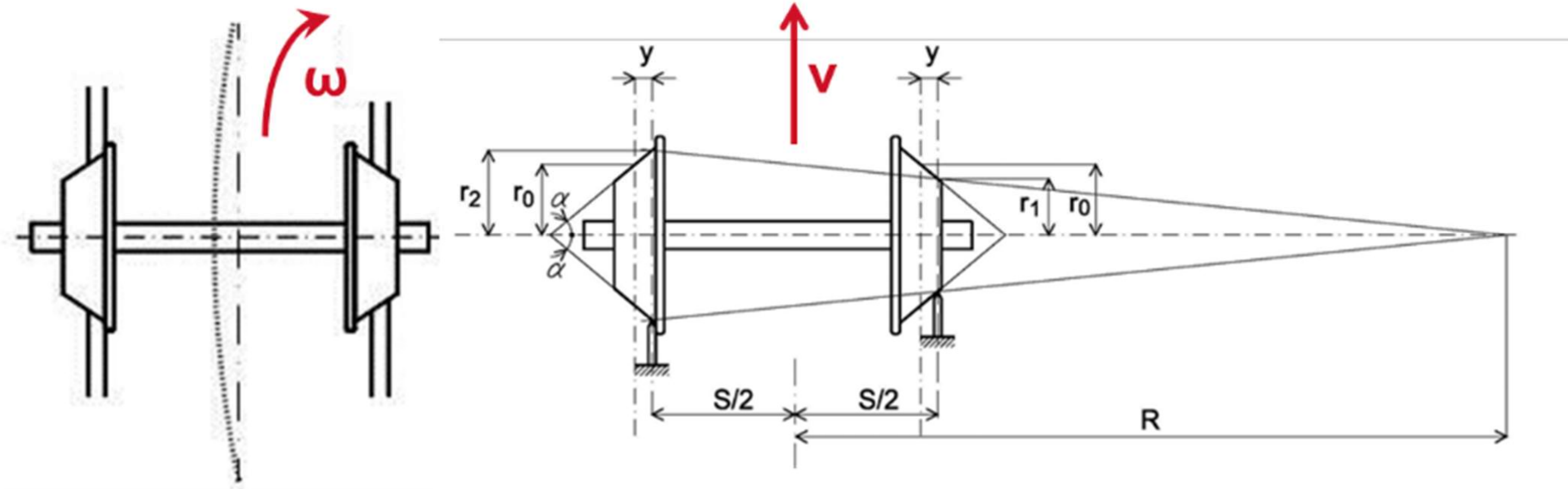
!

If the wheelset is transversally displaced by y, the two wheels run on two different rolling radii $\mathbf{r_1}$ and $\mathbf{r_2}$ (see the figure below)



Lateral dynamics: theoretical wheelset motion on straight track

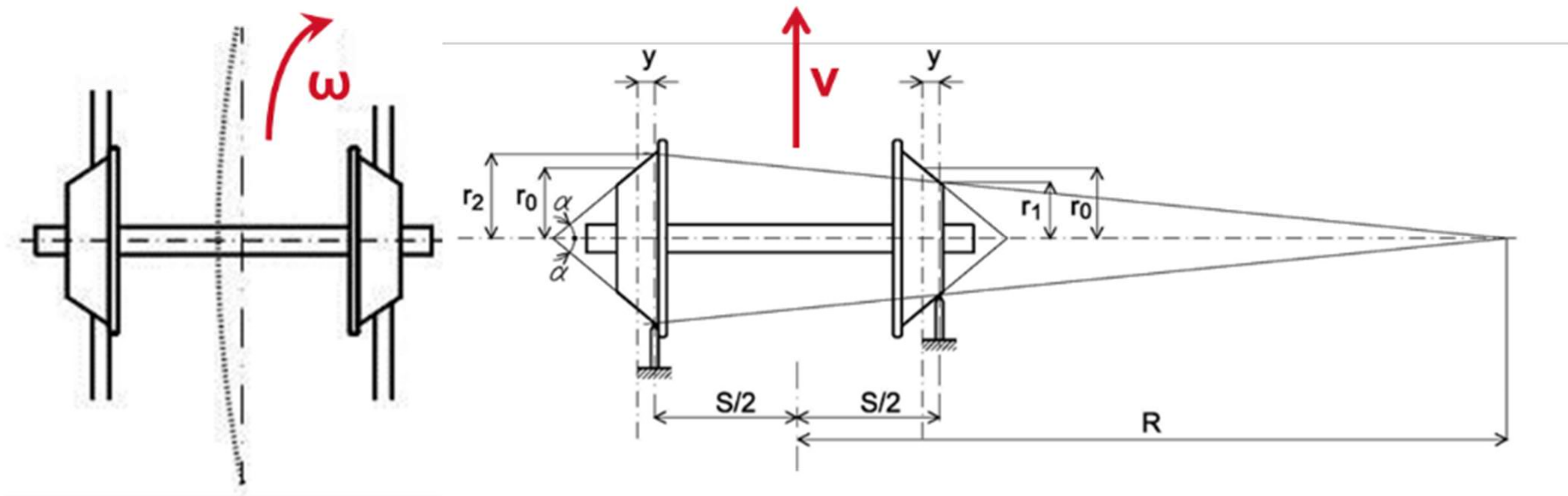
Therefore, under the assumption of pure rolling the wheel-set starts to follow a curved trajectory of radius R (see figure below).



Then, for the similarity of the two right triangles, we have ($\gamma=tg\alpha$)

$$\frac{r_2}{R+\frac{s}{2}}=\frac{r_1}{R-\frac{s}{2}} \rightarrow \frac{r_0+(\gamma\cdot y)}{R+\frac{s}{2}}=\frac{r_0-(\gamma\cdot y)}{R-\frac{s}{2}}$$

Lateral dynamics: theoretical wheelset motion on straight track



Where:
r_0: is the rolling radius of the two wheels in straight track and centred
y: is the lateral displacement of the wheel-set with respect to the centred (equilibrium) position
s: is the distance between the wheel-rail contact points in the centred (equilibrium) position (approx. 1500 mm for standard track gauge)
γ: is the wheel conicity (γ = tgα)

Lateral dynamics: theoretical wheelset motion on straight track

Remembering that the curvature is equal to:

$$\frac{1}{R} = -\frac{d^2 y}{dx^2} = -y''$$

we obtain:

$$y'' = -\frac{2 \cdot \gamma \cdot y}{r_0 \cdot s} \rightarrow \quad y'' + \frac{2 \cdot \gamma \cdot y}{r_0 \cdot s} = 0$$

that is a differential quadratic equation, the solution of which is the sinusoidal function as follows:

$$y = y_0 \cdot sen(\frac{2 \cdot \pi \cdot x}{L})$$

Lateral dynamics: theoretical wheelset motion on straight track

Where:

y_0: is the initial lateral displacement of the wheel-set from its centred position
L: is the wavelength of the sinusoidal motion

Substituting the quadratic derivative of the sinusoidal function in the formula:

$$y'' + \frac{2 \cdot \gamma \cdot y}{r_0 \cdot s} = 0$$

for L we finally obtain:

$$L = 2 \cdot \pi \cdot \sqrt{\frac{r_0 \cdot s}{2 \cdot \gamma}}$$

Key quantities affecting kinematic wavelength:

- **Conicity**
- **Wheel radius**
- **Wheelset gauge**

!

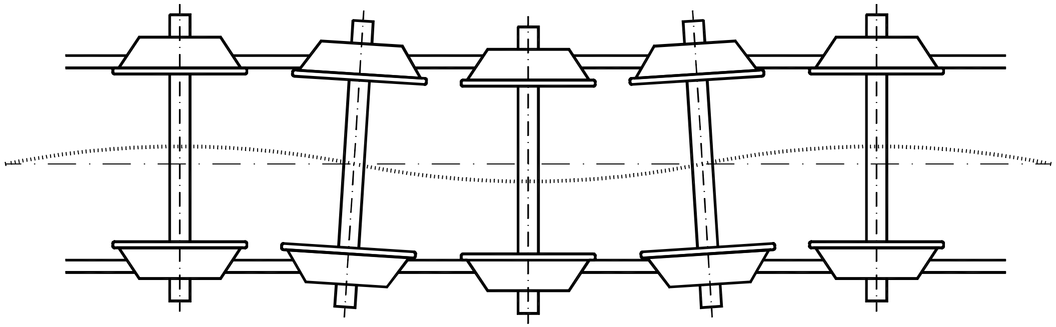
Lateral dynamics: theoretical wheelset motion on straight track

Being:

$$x = V \cdot t$$

where V is the translational speed of the wheelset in the x direction, it is possible to obtain the kinematic quantities (lateral speed and acceleration) of the motion of the wheelset centre of gravity (c.o.g.), which are the lateral oscillations ("**hunting motion**") shown in the figure below.

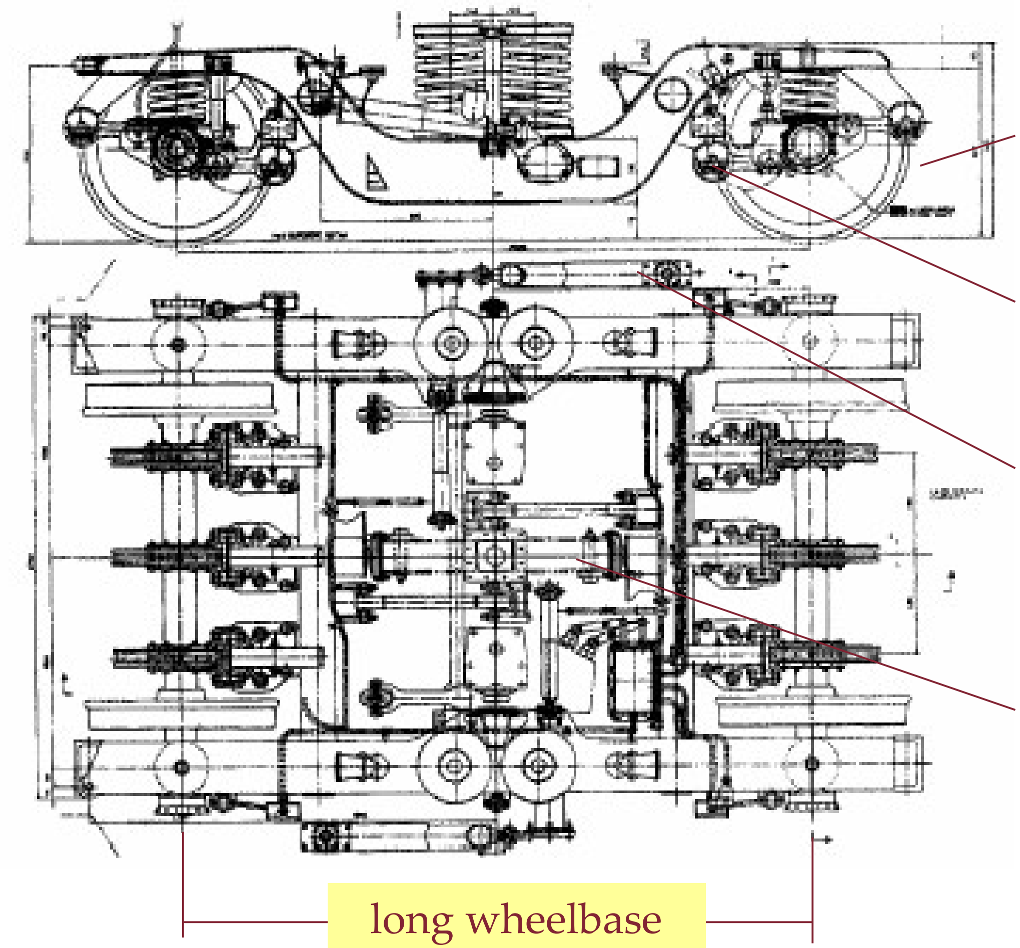
!



Hunting instability

- Slight hunting is always present when running
- It emerged as a problem in the 50s
- Now we know that when you put inertia in the Klingel equations, it leads to instability of the sinusoidal motion above a "critical speed"
- When hunting instability occurs, the driver is alerted
- Both wheel and rail profile geometry are important in this sense
- Klingel's formula is still used in the definition of "equivalent conicity" of a wheelset-track pair

Features of a high-speed bogie minimising the chances of instability



Low conicity (0,05 for conical profile, eg. TGV; 0,08 for wear profile S1002)

Appropriate long. and lat. primary stiffness

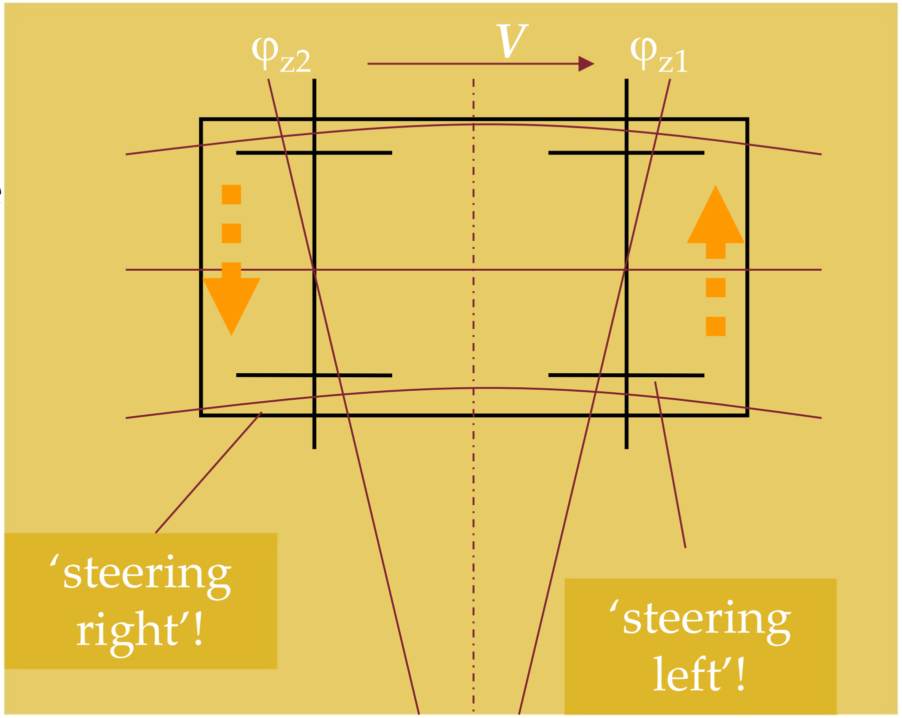
Sufficiently damped hunting motion (secondary yaw dampers)

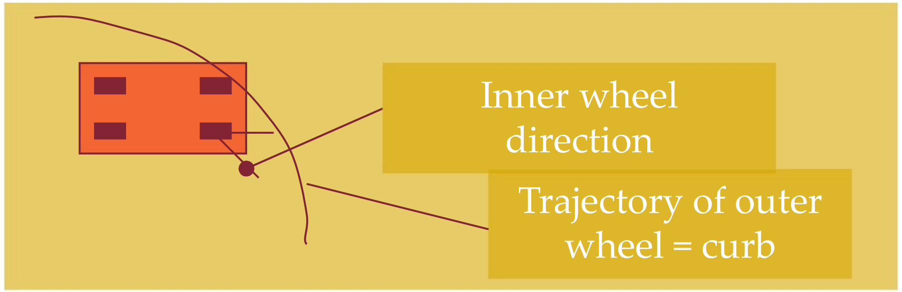
Low masses and moments of inertia (mass close to the centre axis, H frame, suspended traction equipment e.g. on carbody)

long wheelbase

Lateral dynamics – steady-state curving of a conventional bogie

- A symmetrical bogie attitude with no flange contact cannot be a state of equilibrium – the leading wheelset is forced outwards on the trailing wheelset is forced inwards by the adhesion forces
- The typical attitude resembles that of a car trying to climb onto a footpath with a high, slippery curb without steering (4 adhesion forces pointing outwards, 1 normal forces imposing the curved trajectory).

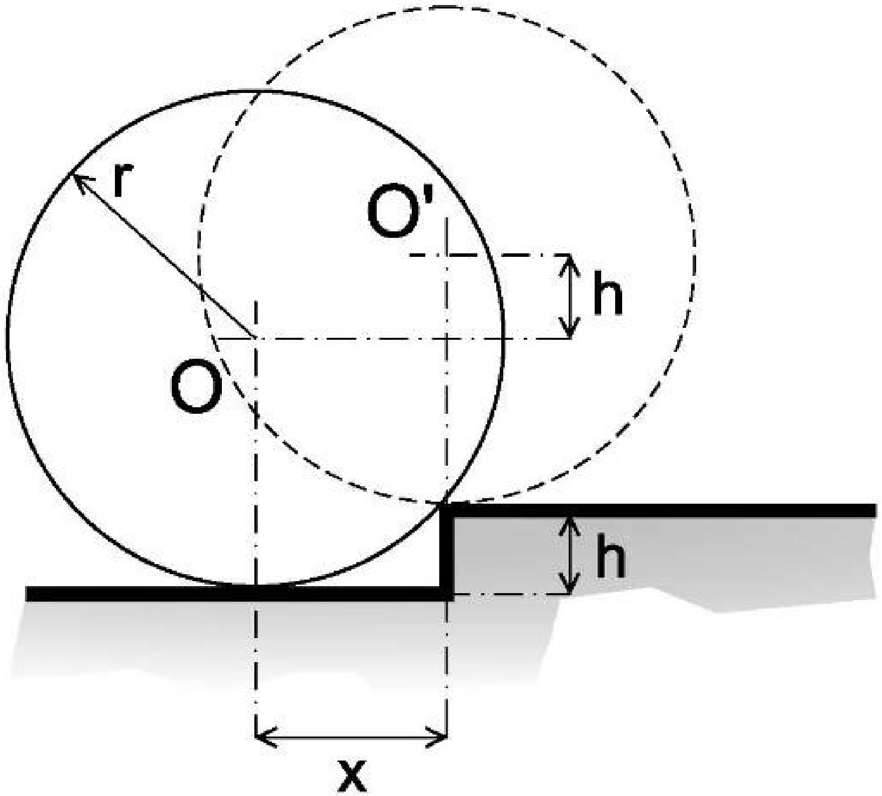




VE4. Suspension systems and vertical dynamics

Need for a suspension system

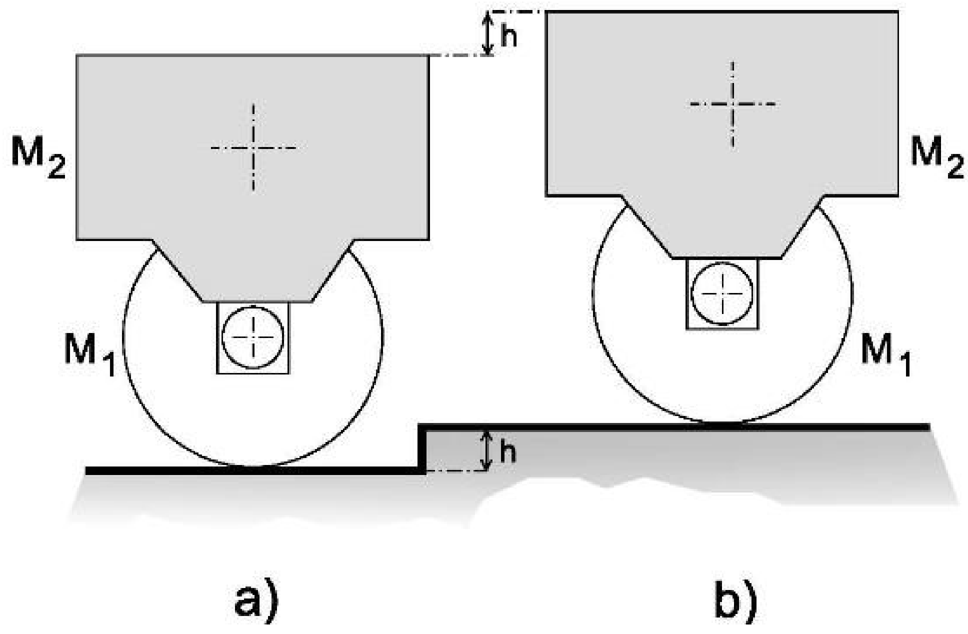
- An irregular rail profile can cause very high vertical acceleration (including impulse loads).
- Vertical acceleration depends on the longitudinal speed, wheel radius and amplitude of the irregularity.
- The effect of mass is to generate inertial forces applied to the bodies in motion, in addition to the static forces.
- Suspension systems reduce the effects of inertial forces.



Need for a suspension system

without suspension between vehicle body and wheel

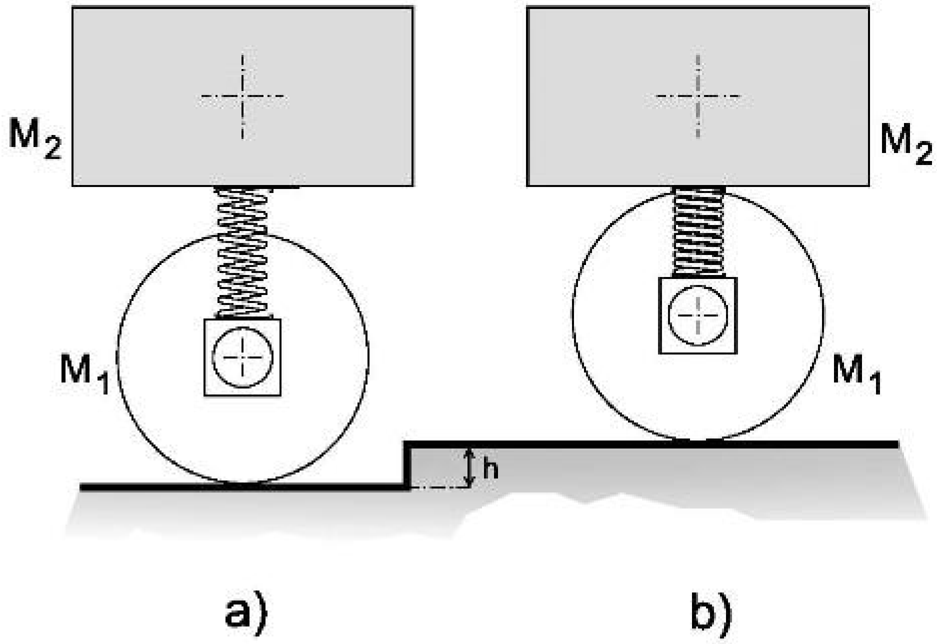
- $F =$ inertia force
- M_1= mass of the wheel
- M_2 = mass of the body on the wheel
- a = vertical acceleration of M_1 and M_2



Need for a suspension system

- M_1= mass of the wheel
  (unsprung mass)
- M_2 = mass of the body on the wheel
  (sprung mass)
- a = vertical acceleration of M_1
- a = 0 **ideal** vertical acceleration for M_2
- INERTIA FORCE
- $F_1 = a*M_1$
- $F_2 = 0$ ideally

with suspension between vehicle body and wheel



! **<u>To reduce inertia forces: insert suspension and reduce M1 (unpsrung mass)</u>**

Suspension oscillations

Effect of suspension

Suspension (or vehicle dynamics e.g. hunting) also introduces unwanted oscillatory movements: the frequency **f** of this movement depends on the **stiffness k** of the suspension and on the **sprung mass M**

!

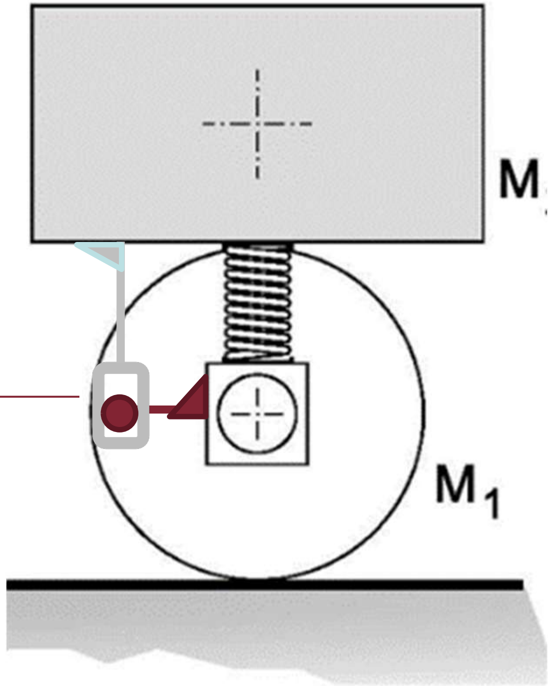
unit: N/m

$$M\ddot{z}(t) + kz(t) = 0$$

"free" vibrations

- z(t) = vertical oscillatory movement of the mass M

vertical bumpstop



Suspension oscillations

Solution of the differential equation

$$M\ddot{z} + kz = 0$$

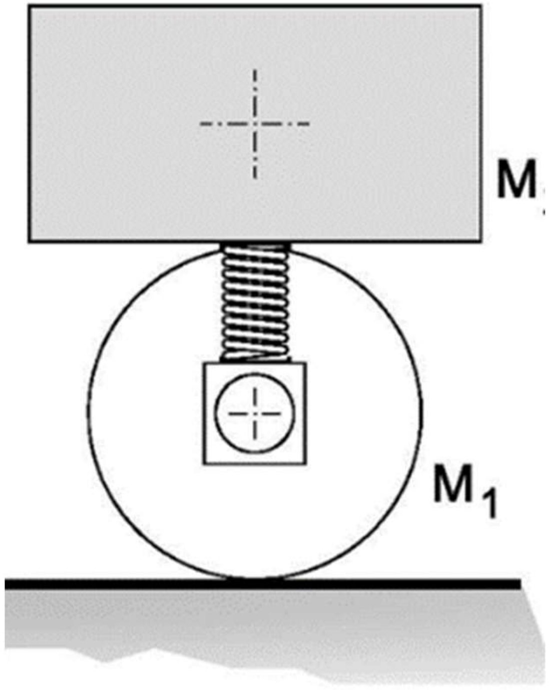
$$z = A\sin(\omega t);$$
$$\dot{z} = A\,\omega\cos(\omega t);$$
$$\ddot{z} = -A\,\omega^2\sin(\omega t)$$

$$-M\,A\,\omega^2\sin(\omega t) + k\,A\sin(\omega t)=0$$

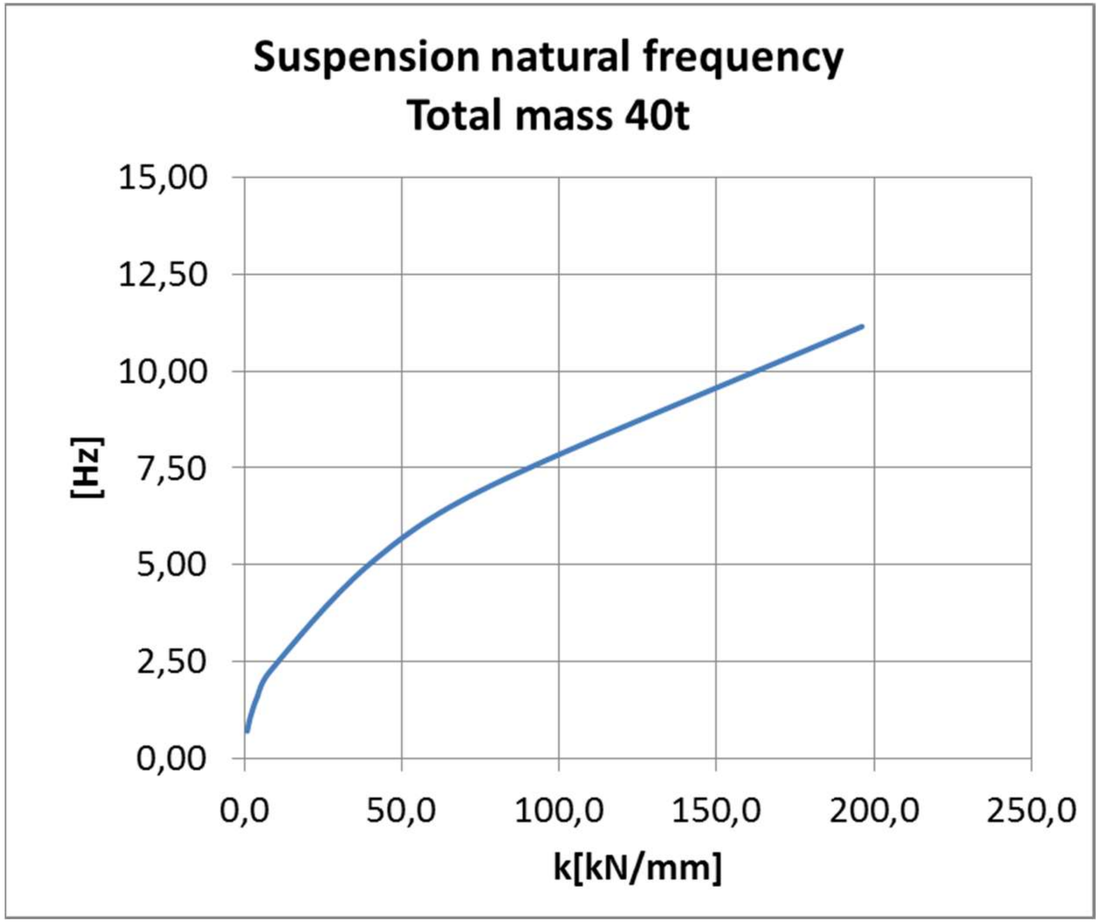
!

$$\omega = \sqrt{\frac{k}{M}};\ f = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$

undamped natural frequency



Suspension oscillations



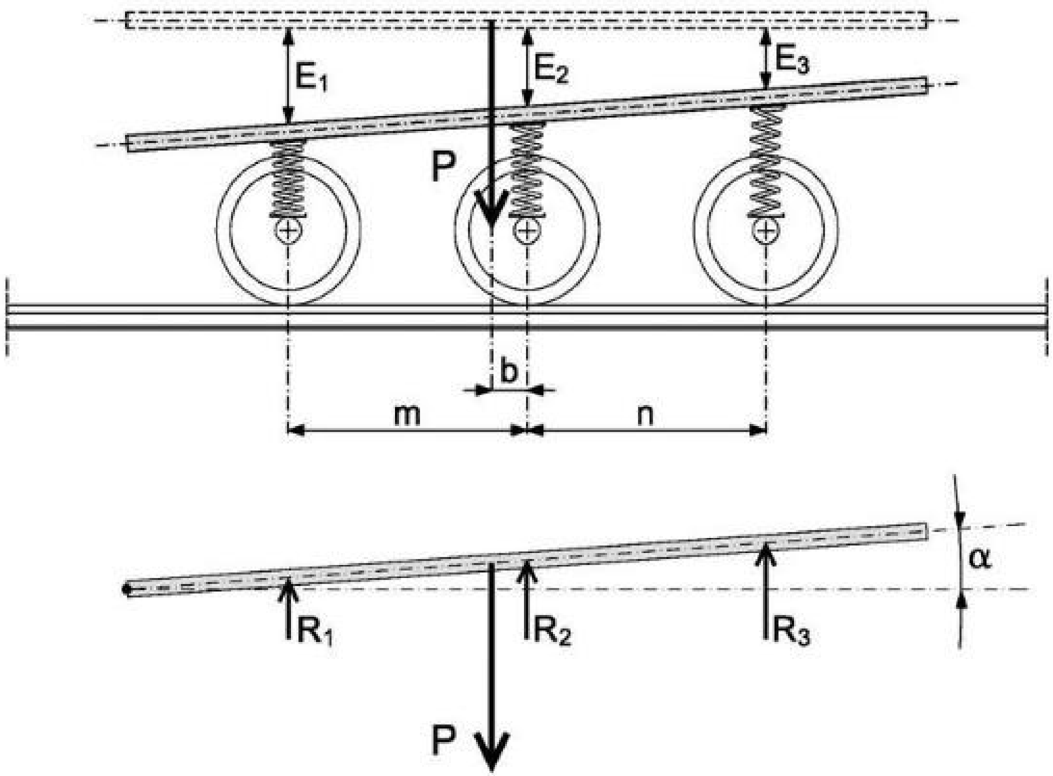
The amplitude of oscillations can be reduced by means of **dampers**

Axle load distribution

Load distribution with more than two wheelsets.

- Goal of the bogie design is to have an even distribution of load across the wheels.
- Load distribution depends on the stiffness of the suspension.

- Known parameters: k1, k2, k3, P, m, n
- Variables to be calculated: E1, E2, E3, R1, R2, R3
- Number of independent equations: 6



Axle load distribution

Equilibrium conditions

$$\sum F = 0;\ R1 + R2 + R3 - P = 0$$

$$\sum M = 0;\ \ R1 * (m + n) + R2 * n - P * (n + b) = 0$$

Deformation conditions

$$R1 = k1 * E1;\quad R2 = k2 * E2;\ \ R3 = k3 * E3$$

Geometric congruity condition

$$\frac{E1 - E3}{m + n} = \frac{E2 - E3}{n}$$

Effect of suspension parameters on lateral dynamics

- In the previous slides the focus, is on vertical dynamics.
- However, vertical suspension parameters cannot be varied without affecting the other directions (lateral, longitudinal plus rotations).
- The effect on lateral dynamics is particularly important: a low x-y plane suspension stiffness generally leads to a lower critical speed of the vehicle (see also p. 46).
- To visualise this effect, consider that a stiffness that tends to zero in this plane would be equivalent to having no suspension at all, thus individual wheelsets rather than bogies. This is a low-stability arrangement.

Suspension functions and requirements

Functions and requirements of the suspension

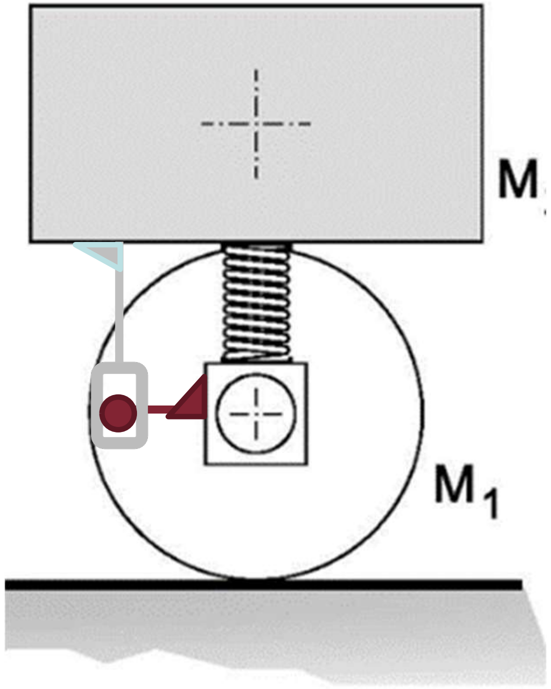
- To transmit forces between car body and wheels in vertical (z), lateral (y) and longitudinal (x) direction
- To limit the accelerations of the suspended masses
- To limit the amplitude of oscillations (damping, bumpstops)
- To allow the movement between car body and wheels without interference with wayside installations
- To allow coupling of cars by limiting their relative movement
- To distribute the loads as evenly as possible
- To have natural frequencies compatible with human comfort
- To comply with safety constraints

!

Suspension design

Under the maximum static payload ΔP of the car (e.g. max. passenger load), a maximum design static deflection Δz may be assumed (e.g. 85 mm), and thus a preliminary suspension vertical stiffness:

$$k = \Delta P / \Delta z$$



- This value determines preliminary values for the lateral and longitudinal stiffnesses, hence of the natural frequencies.
- The choice of components and their layout depends several factors, e.g. available space.
- Preliminary hunting stability considerations may be performed.
- Several iterations are usually needed to achieve a satisfactory design.

VE5. Running quality

General aspects

In the evaluation of physical and psychological comfort, measurable parameters and non-measurable parameters of personal nature (the human body's response to external inputs) have to be considered.

From the point of view of vehicle dynamics we refer in general to two types of comfort,

- comfort associated with the **mechanical vibrations** transmitted to the human body (**ride comfort**, concerning frequencies of between **0 and 50 Hz**)
- comfort associated with the vibrations transmitted through the air, **acoustic vibrations** in the range of **30 to 5000 Hz**, that can stimulate the human ear in the form of noise (acoustic comfort)

!

General aspects

The organs of the human body are differently sensitive to mechanical vibrations:

- **trunk** and **internal organs** are sensitive to frequencies between **2** and **9 Hz,**
- **eyes and spine** are sensitive to those in the **15- 50 Hz** range,
- **ears** are sensitive to frequencies higher than **30 Hz**.

Comfort evaluation criteria

The comfort conditions required of rail transport covers both passenger and operational staff.

The main causes that lead to the transmission of mechanical **air-borne** and **structure-borne Noise and Vibrations** (N&V) into the car body are:

- vibration of traction devices and auxiliary equipment (compressors, cooling fans, HVAC heating, ventilation, air conditioning)
- rolling noise and vibrations generated by wheel and rail roughness and irregularities
- impact noise from joints, Switches and Crossings etc.
- etc. etc.

To address in an easier way the problem, in the following we consider the particular aspect of **ride comfort**, which is linked to the mechanical vibrations produced by the irregularities of the track in the 0-50 Hz range.

Comfort evaluation criteria

For a correct evaluation of the degree of comfort of a railway vehicle caused by these vibrations it is necessary to establish a link between the subjective feelings of people subjected to vibration and physical quantities that measure the vibration.

The correlation between the subjective feelings and the vibration level can be expressed by **comfort indices**.

The perception of vibrations depends on and is in general proportional to **acceleration**.

Because of the randomness of the human response to the stimulus, different comfort indices and therefore different methods of evaluation of ride comfort have been defined.

!

The common basis of these methods is the analysis in the **frequency domain** of the accelerations measured in the car-body the attribution of a **weighting** that takes into account the human sensitivity to the harmonic components of the spectrum of the vibrations.

Norm UIC 518 and ride quality

(Test and approval of railway vehicles from the points of view of dynamic behaviour, safety, track fatigue and ride quality)

UIC 518 (Union Internationale des Chemins de Fer) deals with ride quality of the vehicle in relation to running safety and the stresses transmitted to the rail track. It has contributed to EN norm EN 14363 with a similar scope.

To this end the **vertical** and **transversal** accelerations are considered. They are measured in the vehicle body above the running gear (at body-bogie link or the axles for two-axle vehicles).

The vehicle is approvable for the purposes of ride quality if the measured acceleration, filtered with a band-pass filter between 0.4 and 10 Hz, respects the specified limits, indicatively:

- 2.5 m/s^2 as a peak value
- 0.5 m/s^2 as the root mean square value

ISO 2631 and vibrational comfort

(International Standard Organization. Guide to the evaluation of human exposure to whole-body mechanical vibrations)

The frequency range **1 - 80 Hz** is considered, setting the reference values with regard to the limits of exposure to the vibrational phenomena for people in good health, capable of performing normal activities (such as travel) and to bear the stress of a typical working day.

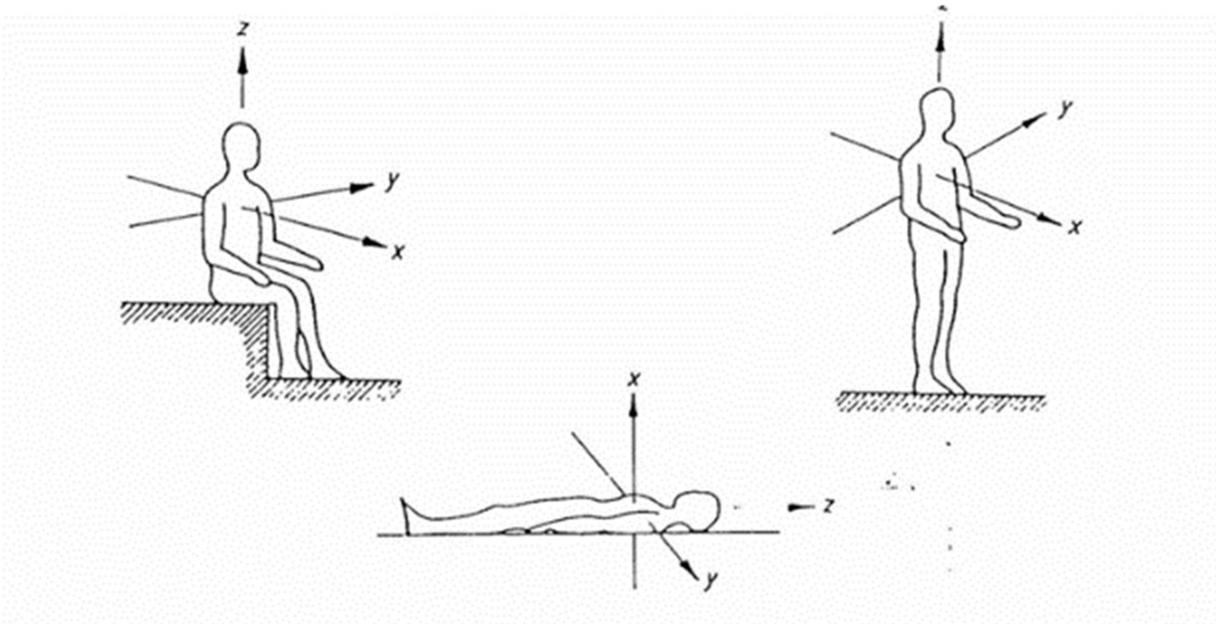
The limits apply to the level of vibration present in the point through which it is transmitted to the human body and therefore the acceleration measurements are made close to such point.

ISO 2631 and vibrational comfort

The effects of vibration on humans are related to four factors that characterise the vibration:

- frequency
- intensity
- direction relative to the spine
- exposure time

!



ISO 2631 and vibrational comfort

Three different levels exposure limit for each direction of measurement are defined:

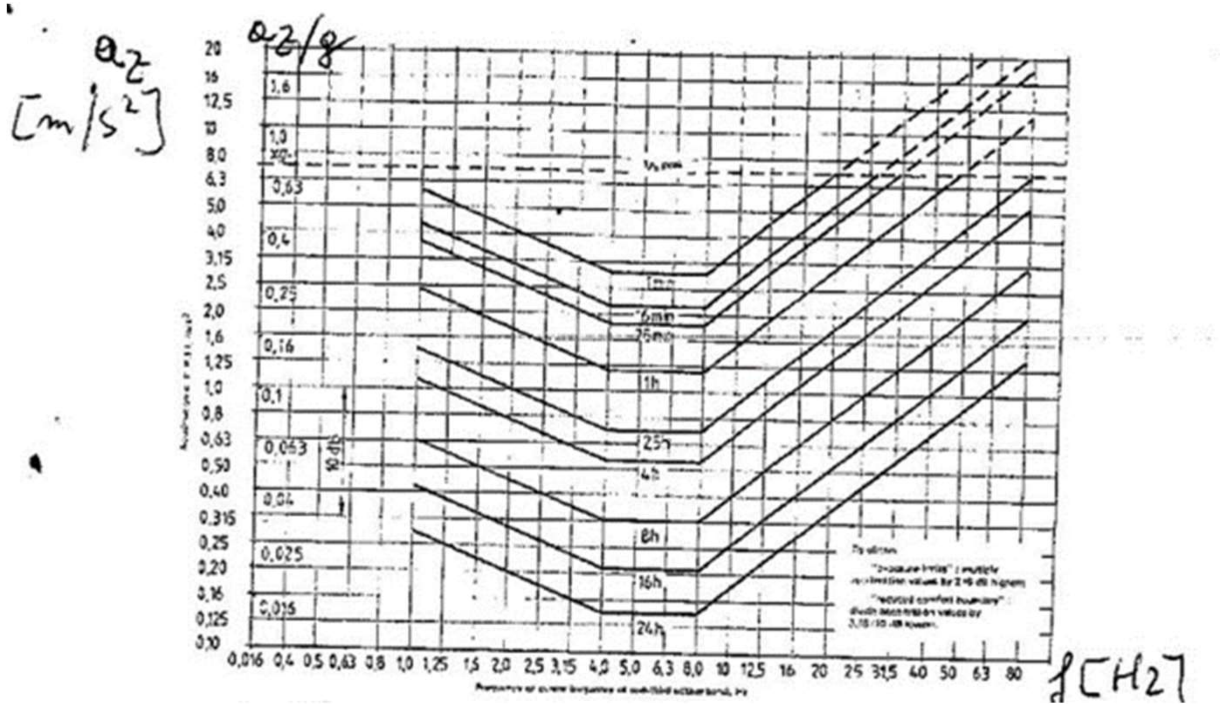
a) reduced comfort boundary (**comfort limit**); in transport that limit is associated with difficulty in performing activities such as reading and writing;

b) fatigue-decreased proficiency boundary (**efficiency limit**) beyond which fatigue causes a reduction in the efficiency of the body in carrying out various activities;

c) **exposure limit**, which is a safety limit, beyond which damage may occur to the person.

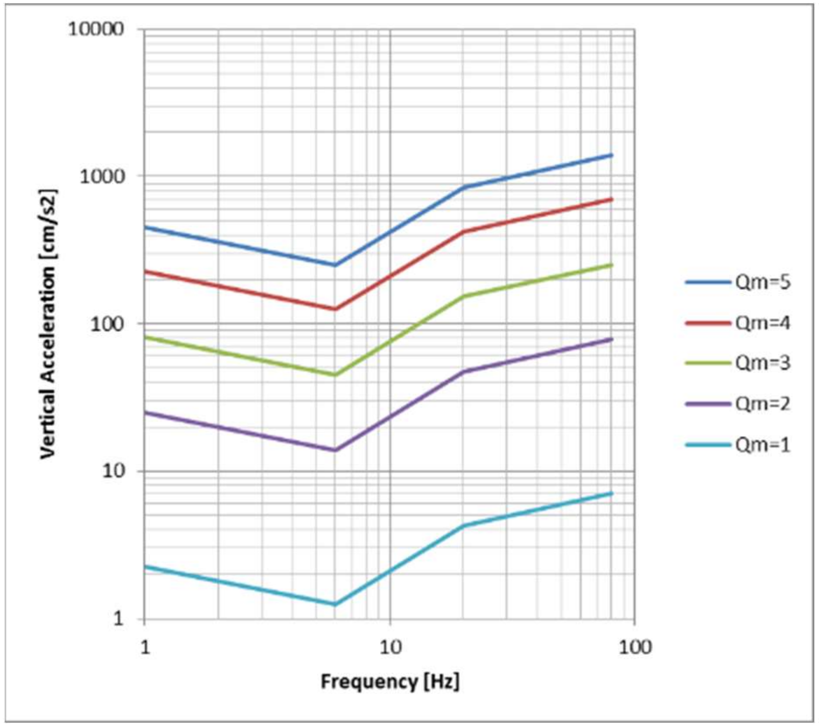
ISO 2631 and vibrational comfort

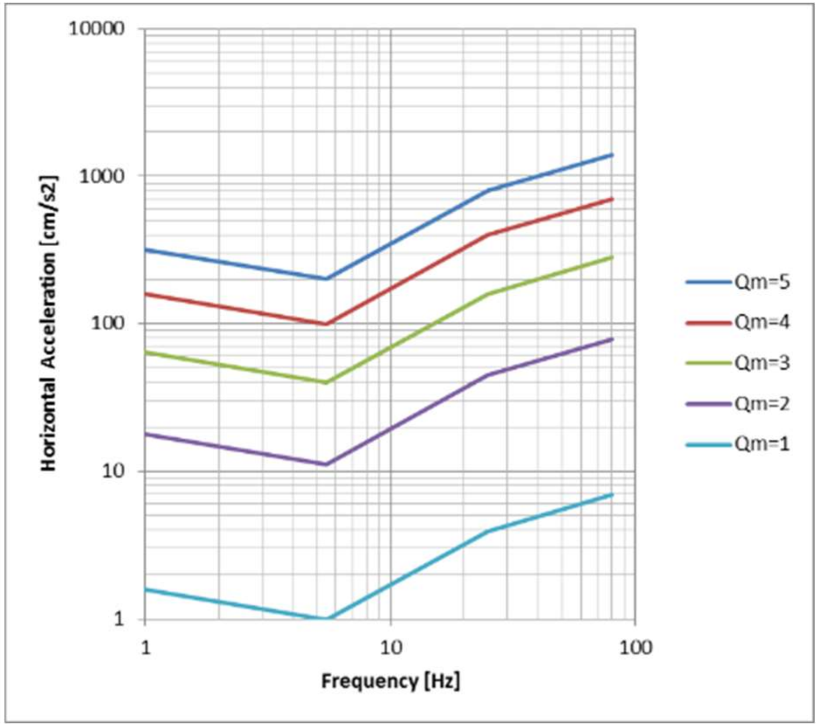
- The curves show the **limit of efficiency**, i.e. the limit of the acceleration (vertical root mean square) a_z tolerable before showing fatigue in function of the frequency of the vibration and the duration of exposure.
- The **comfort limit** is obtained by subtracting 10 dB to the levels proposed (just divide by 3.15 the value of the ordinate scale);
- The **exposure limit** is obtained increasing them by 6 dB (just multiply by 2 the value of ordinate scale.



Running quality indexes (example Sperling index)

Running quality index for vertical and horizontal oscillations





Running quality indexes (example Sperling index)

Ride evaluation scales – ride quality and ride comfort

Ride index Wz	Ride quality
1	Very good
2	Good
3	Satisfactory
4	Acceptable for running
4.5	Not acceptable for running
5	Dangerous
Ride Index Wz	Ride comfort
1	Just noticeable
2	Clearly noticeable
2.5	More pronounced but not unpleasant
3	Strong, irregular, but still tolerable
3.25	Very irregular
3.5	Extremely irregular, unpleasant, annoying; prolonged exposure intolerable
4	Extremely unpleasant ; prolonged exposure harmful

!

VE6. Longitudinal dynamics

Definition and purposes

Mechanical traction characteristic (or "traction curve"):
Traction force at wheel/rail contact vs vehicle speed

Main purposes:
- traction force such as to reach and maintain the design maximum speed
- traction force such as to minimise the time-interval from departure to arrival

The phases of motion to minimise travel times are:
1. Phase 1: constant acceleration from the start to the design speed
2. Phase 2: constant speed
3. Phase 3: constant deceleration from design speed to standstill

Applicable formulas

traction force at wheels

$$T(v) = M'a + R(v)$$

Acceleration

$$a(v) = \frac{T(v) - R(v)}{M'}$$

Power required at wheels

$$N(v) = T(v) * v$$

Installed Power

$$N = \frac{Max(N(v))}{\eta}$$

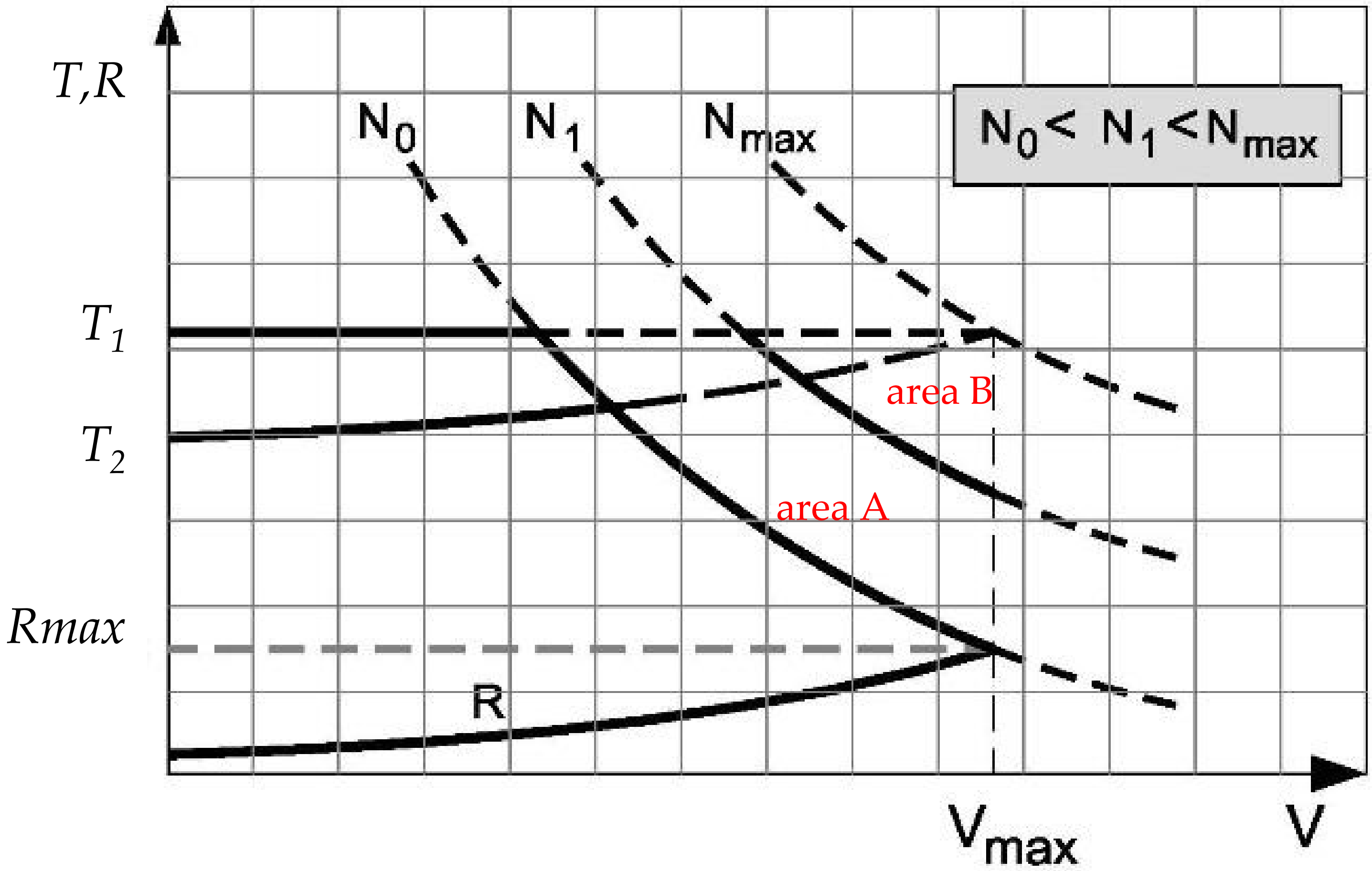
- a = acceleration
- M′=equivalent total mass (taking into account the rotating masses)
- R(v)= relationship between motion resistance forces and speed

$$R(v) = Mg * r$$

$$r = a + bv + cv^2$$

- η=efficiency of the transmission.

Traction curves



Area A: applications with few stops, power needed only to maintain top speed

Area B: applications with several stops, power needed to ensure high accelerations to top speed

Example A: freight locomotive (concentrated traction)

Example B: metro (distributed traction)

T_2 : traction force with a=constant; V ($0 \div V_{max}$) $\quad T_2(V) = M'a + R(V)$

N_{max} : Power at wheels $\quad N_{max} = T_{2max} * V_{max}$

Features of an ideal traction curve (1)

Follows the physical traction force limits at low speeds, either

- a_{max} depends on comfort = 1.0÷1.2 m/s^2

$$a \leq a_{max}$$

- adhesion

$$\frac{T}{P} \leq \varphi_{max}$$

Follows the power limit above the speed at which the limit is reached:

$$TV = const; T = \frac{const}{V}; \qquad hyperpolic\ curve$$

- With such a characteristic:
  - in the starting phase with constant acceleration, power increases with speed
  - in the constant velocity phase, or cruising phase, power does not vary with speed

Features of an ideal traction curve (2)

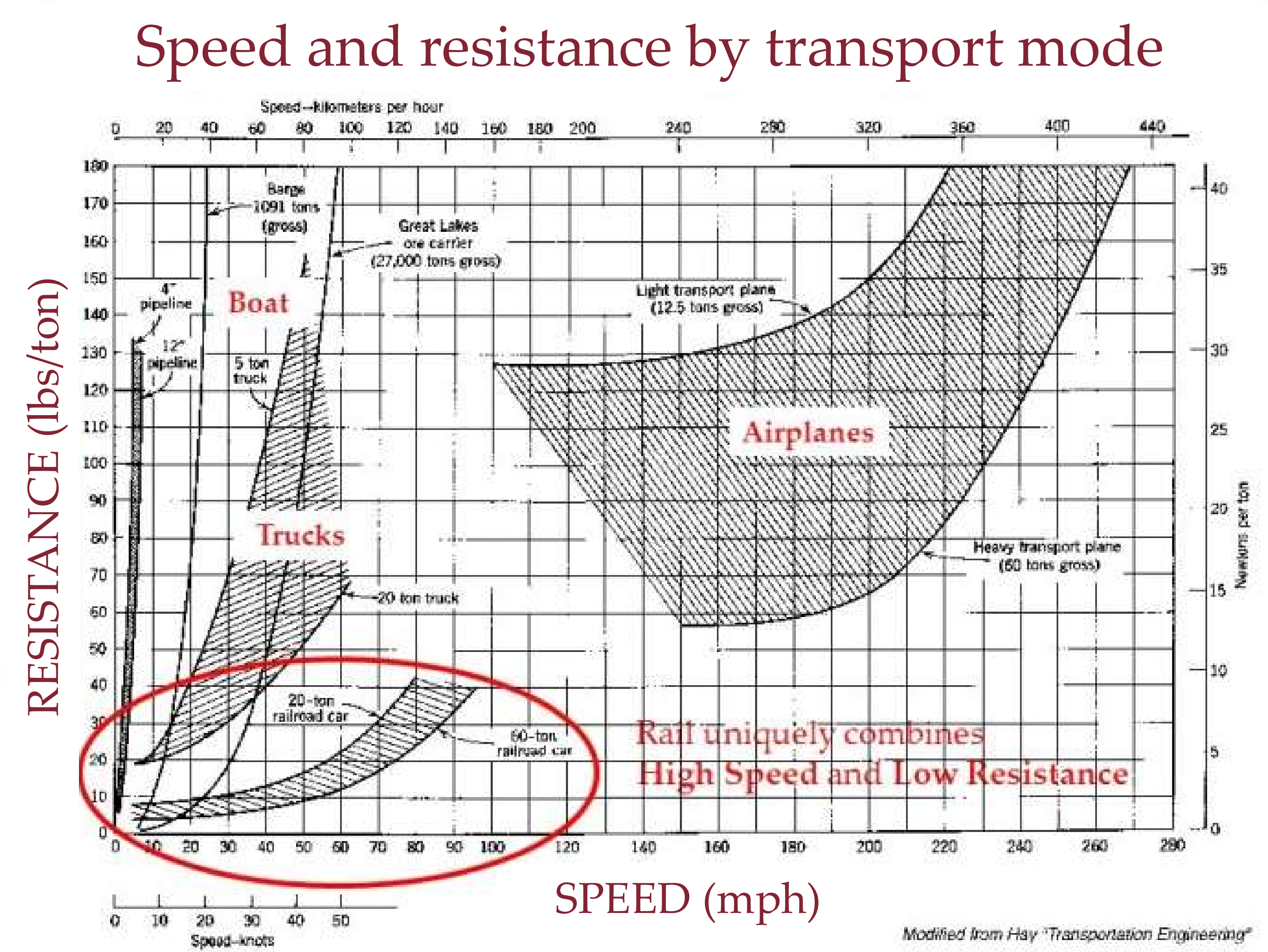
The traction curve is ideal because:

- maximum power is delivered at a wide range of speeds and not only at one value of speed → the traction equipment does not need to be overdesigned, it is used at its best ("best value for money")
- the characteristic is stable: if speed falls due to increase motion resistance, traction force will increase and compensate

The final design of the traction curve depends on type of service:

a) local passenger train: installed power depends mainly on the acceleration required in the starting phase (i.e. up to Vmax)
b) high speed trains: the installed power depends on required Vmax
c) freight train; the installed power mainly depends on motion resistances due in particular to the maximum required gradient

Motion resistances relative to other modes

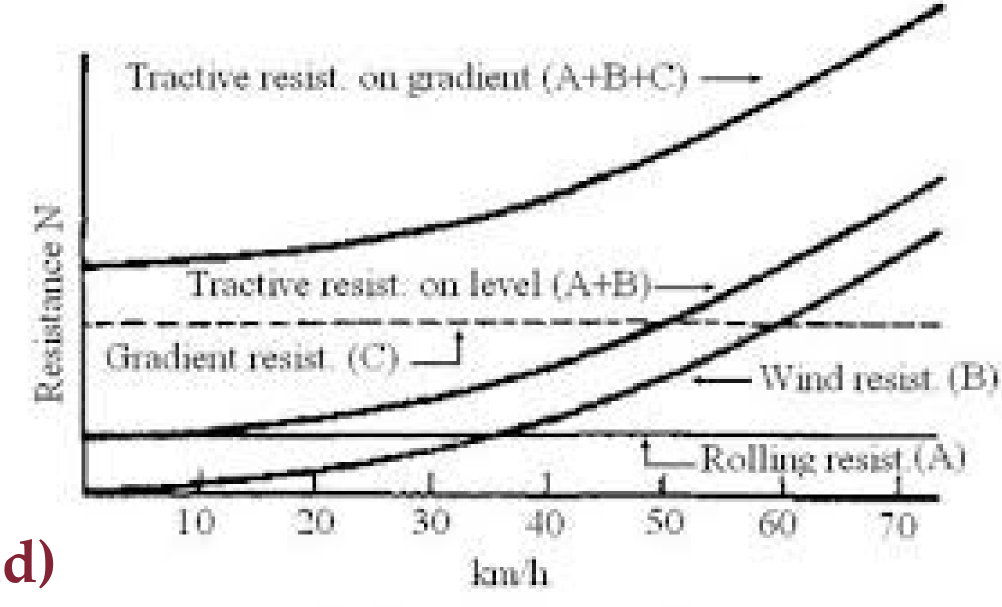


20

Typologies of resistances

Kinematics of motion
Flat
Straight
Uniform

→"Ordinary resistances"
Rolling
Aerodynamics (relative wind)



Tractive resistance curves

+ Slopes

Additional resistance due to gradient

+ Curves

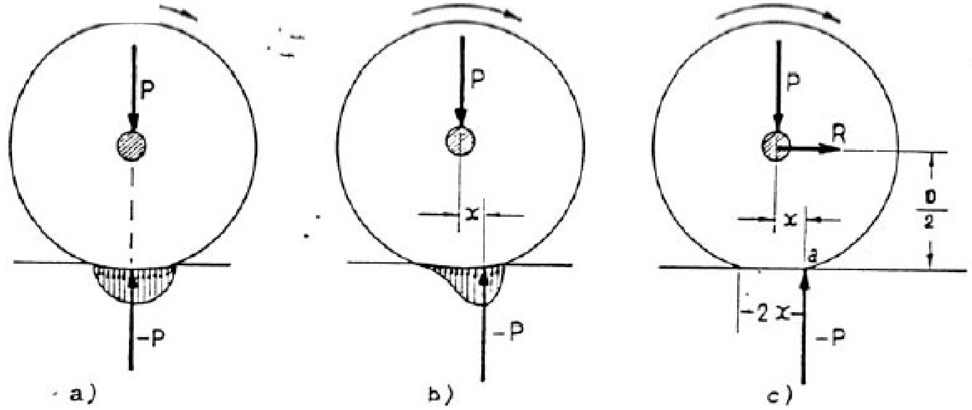
Additional resistance due to curves

+ Acceleration

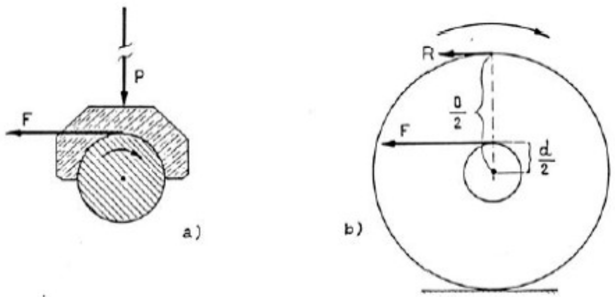
Additional inertial resistance

Rolling resistance

R_1) Deformability of wheel and rail

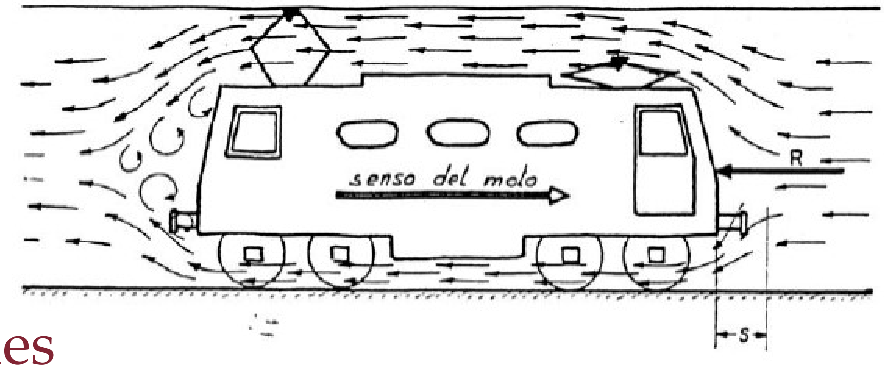


R_2) Friction in axle-box between journal and bearing



R_2 normally higher
Average amount: 2 N/kN (<< Aerodynamic resistances)
Higher at starting phase for overcoming initial friction resistances (12.5÷20.0 N/kN)

Aerodynamic resistance



Shape resistance
Air turbulences produced by vehicles
Depending upon vehicle shape:
1) Train rear features
2) Angle between longitudinal axis of vehicle and ground
3) Distance between vehicle body and ground
Lateral resistance
Friction between air stream and vehicle walls
Resistance due to air streams through vehicle
Air intakes, open windows, etc.
Global expression $R_a = \rho\, C_D S v^2/2$
- ρ = air density = 1.226 $Nm^{-4}s^2$ at sea level
- C_D = non-dimensional coefficient depending upon vehicle shape = 1.2÷1.4 for first vehicle of train, 0.8÷1.0 for following vehicles
- S = surface of frontal section in vehicle direction
- v = speed [m/s]

Global expressions for ordinary resistances

Binomial

Specific resistance $r_{ord} = a + bv^2$

Vehicles typologies	*a*	*b*
Locomotive + low speed train (*Clark*)	2.4	0.00100
Locomotive + medium speed train (*Erfurt*)	2.4	0.00077
Locomotive + high speed train (*Von Borries*)	1.6	0.00030 (1 + 50 / *V*)
Fast electric locomotives (Switzerland)	2.5	0.00030
Freight electric locomotives (Switzerland)	3.0	0.00050
Diesel-electrical locomotives (*Strahl*)	3.5	$0.00600\ S / P\ (1 + 12 / V)^2$
Speed freight wagons (*Strahl*)	2.5	0.00040
Mixed freight wagons (*Strahl*)	2.5	0.00050
Empty freight wagons (*Strahl*)	2.5	0.00100
Two axles passengers coaches (*Frank*)	2.5	0.00040
Two bogies passengers coaches (*Frank*)	2.5	0.00014
Articulated railcars (*Breuer*)	1.5	0.00500 *S K* / *P*

V = speed in km/h
P = total weight in t
S = main section in m^2
K = 0.045 for two elements; 0.650 for three elements; 0.710 for four elements

Trinomial

Specific resistance $r_{ord} = c + dv + ev^2$

Vehicles typologies	*c*	*d*	*e*
Electrical locomotives	24.00 / *P*	0.01000	0.003500 *S* / *P*
Metro trains (*Borisowsky*)	3.20	0.03400	0.000470
Multiple railcars (*Dover*)	1.83	0.01520	0.005349 *S* / *P*
Two axles pulled vehicles (*Sanzin*)	1.60	0.01840	0.000460
Four axles pulled vehicles (*Sanzin*)	1.60	0.00456	0.000456

P = total weight in t
S = main section in m^2

Slope resistance

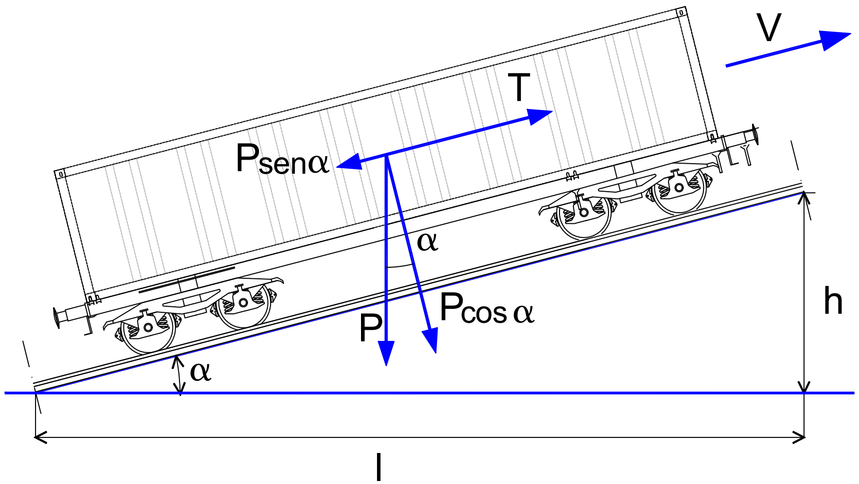
Limited slopes in railways

$sen\alpha \approx tg\alpha$

$i = h / l = \text{tg } \alpha$

$R_s = P\ i$

$r_s = i$ [N/kN] [kg/t] [‰]



Indicative maximum slopes in various transport systems

System	*Slope [‰]*
Main railways on plains	5÷8
Main railways on hills	15÷18
Main railways on mountains	20÷25
Secondary railways on mountains	30÷40
Narrow gauge local railways	35÷45
Urban railways (self-propelled vehicles)	60
Tramways	80
Cog railways	400
Funiculars	650

Resistance on curve (1/3)

Combination of mechanical effects

1) Overlap of translation and rotation around vertical axis passing through vehicle centre of gravity

Necessary energy increase $E = Jw^2/2$ to maintain speed unchanged

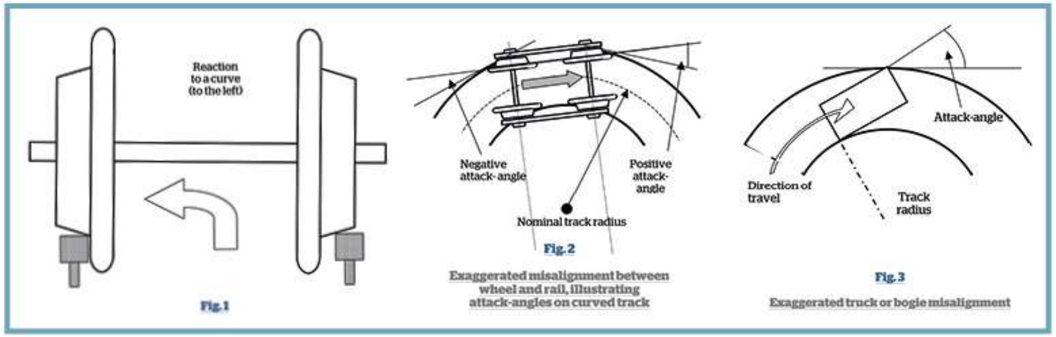
- w = angular speed; J = moment of inertia around rotation axis

2) Solid axle wheel-set

The external wheel has to cover longer distance than internal wheel

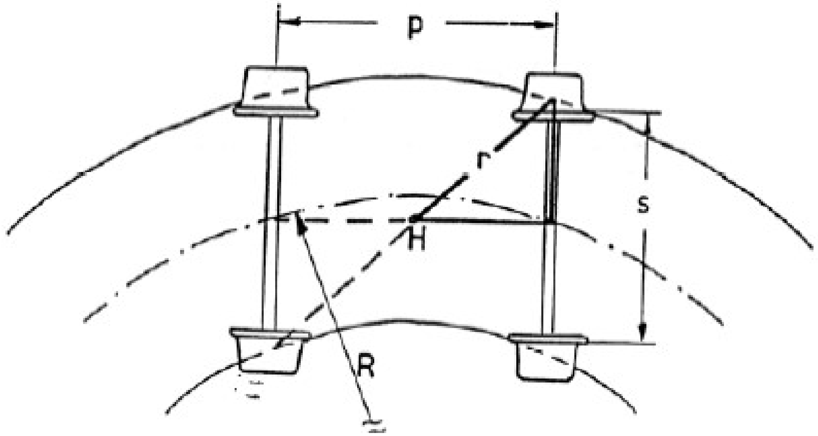
Two wheels obliged to run at the same angular speed

Difference only partially reduced by conical wheels causing creepage between wheels and rails requiring energy dissipation



Resistance on curve (2/3)

3) Axles of same wagon or same bogie permanently parallel
Vehicle rotation with lateral creepage between wheels and rails with consequent energy dissipation



4) Guidance of vehicle to run along the curve by rotating around the vertical axis passing by its centre of gravity
Contact between wheel flange and rail causing further energy consumption

Resistance on curve (3/3)

Comprehensive synthetic expressions

Von Rockl

Specific resistance $r_c = 1000\ a\ /\ (R - b)$

- a and b = constants depending upon curve radius and track gauge
- R [m] = curve radius

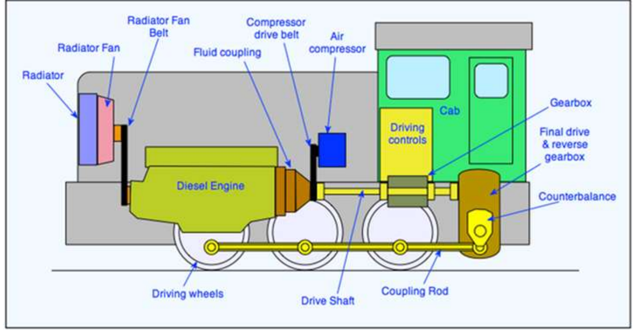
Track gauge (mm)	*Radius (m)*	*a*	*b*
1435	≥ 850	0.650	55
1435	250 ÷ 350	0.650	65
1435	150 ÷ 250	0.650	30
1000	≥ 60	0.500	30
900	≥ 60	0.380	17
750	≥ 40	0.350	10

Desdonits

Specific resistance $r_c = 500\ s\ /\ R$

- s = track gauge
- R [m] = curve radius

Inertial resistance (1/2)



Speed positive variation (acceleration *a*)

Additional resistance due to inertial effect: $R_i = (P/g)\,a$

Specific resistance [N/kN]: $r_i = 1000\,a/g \approx 102\,a$

Vehicle with engine – mechanical drive – wheels

Increase of:

- Translational kinetic energy
- Rotational kinetic energy of mechanically connected masses

$$E_{rot} = \sum_i \frac{1}{2} J_i\,\omega_i^2 = \sum_i \frac{1}{2} J_i \rho_i^2 \frac{V^2}{r^2}$$

ρ_i = gear ratio between rotation speed of single rotating mass i and rotation speed of wheels

J_i = moment of inertia of rotating mass i

r = rolling radius of wheels

$$E_{totale} = \frac{1}{2} m V^2 + \sum_i \frac{1}{2} J_i \rho_i^2 \frac{V^2}{r^2} = \frac{1}{2} m V^2 \left(1 + \sum_i \frac{J_i \rho_i^2}{r^2 m}\right) = \frac{1}{2} m V^2 (1+\delta)$$

Inertial resistance (2/2)

Inertial force

Taking into account the need to vary rotational speed of rotating masses

Substitution of effective mass m with equivalent mass $m\ (1 + \delta)$

Inertial weight taking into account inertia of rotating masses connected to wheels: $P_i = (1+\delta)\ P$

Specific resistance [N/kN]: $r_i = 1000\ (1+\delta)\ a/g \approx 102\ (1+\delta)\ a$

Inertial coefficients δ (indicative values)

Vehicles typologies	δ
Wagons and coaches	0.05
Steam locomotives	0.10
Railcars	0.05 ÷ 0.20
Direct current locomotives	0.20
Single-phase locomotives	0.30

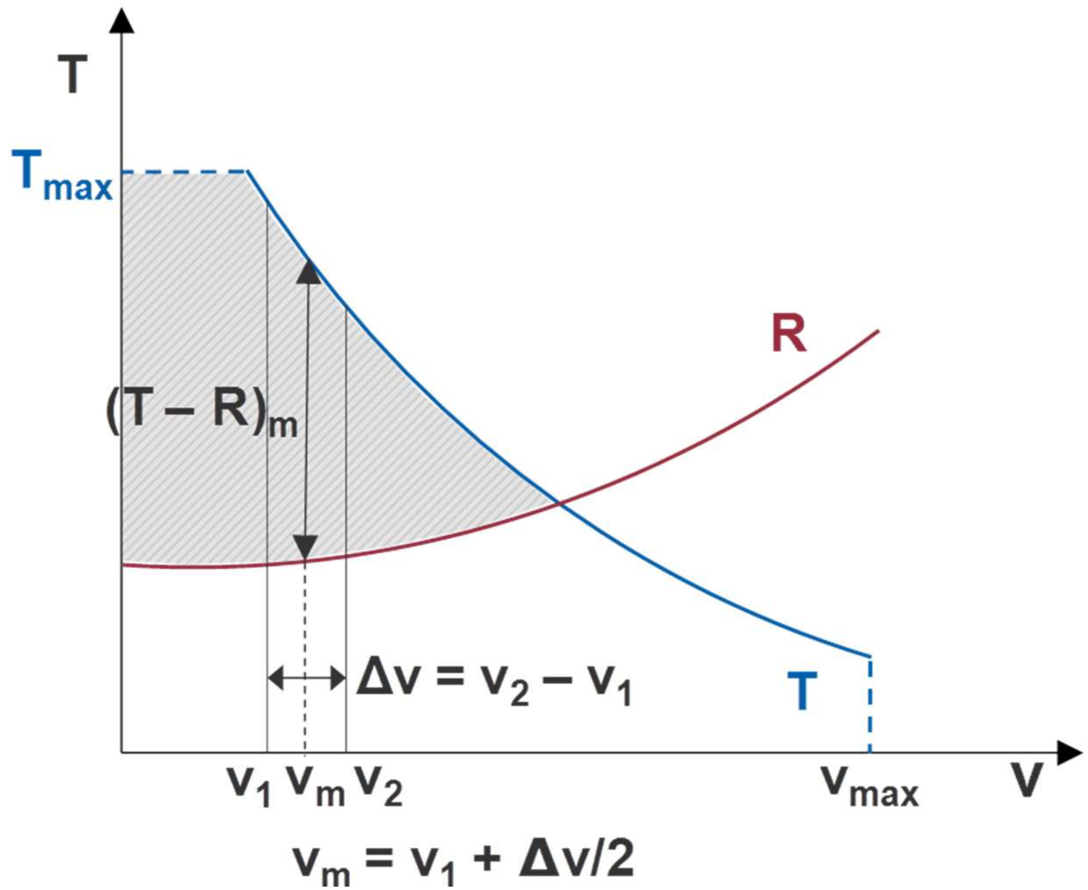
Maximum average acceleration [m/s^2]

Vehicles typology	*< 15÷20 km/h*	*< 60÷80 km/h*
Freight trains	0.20	0.10
Steam passengers trains	0.35	0.20
Electric passengers trains	0.45	0.30
Railcars	1.20	0.70
Metro	1.50	1.10

VE7. Commercial speed

From the traction curve to train kinematics

- Acceleration depends on the difference between the traction force and motion resistance. The acceleration is not constant in general: it varies with speed.
- Traction characteristic T of the vehicle, motion resistances R and acceleration force (T – R)



Basic formulas

- Motion consists of three phases: starting, cruising, braking.
- The commercial speed is obtained as the ratio between the overall distance travelled (stops included) and the time employed to run it.
- Assuming constant acceleration (a) and constant deceleration (d) the following formulas apply.

Starting

$$S_a = \frac{V_{max}^2}{2a} \quad t_a = \frac{V_{max}}{a}$$

Braking

$$S_b = \frac{V_{max}^2}{2d} \; t_b = \frac{V_{max}}{d}$$

Cruising

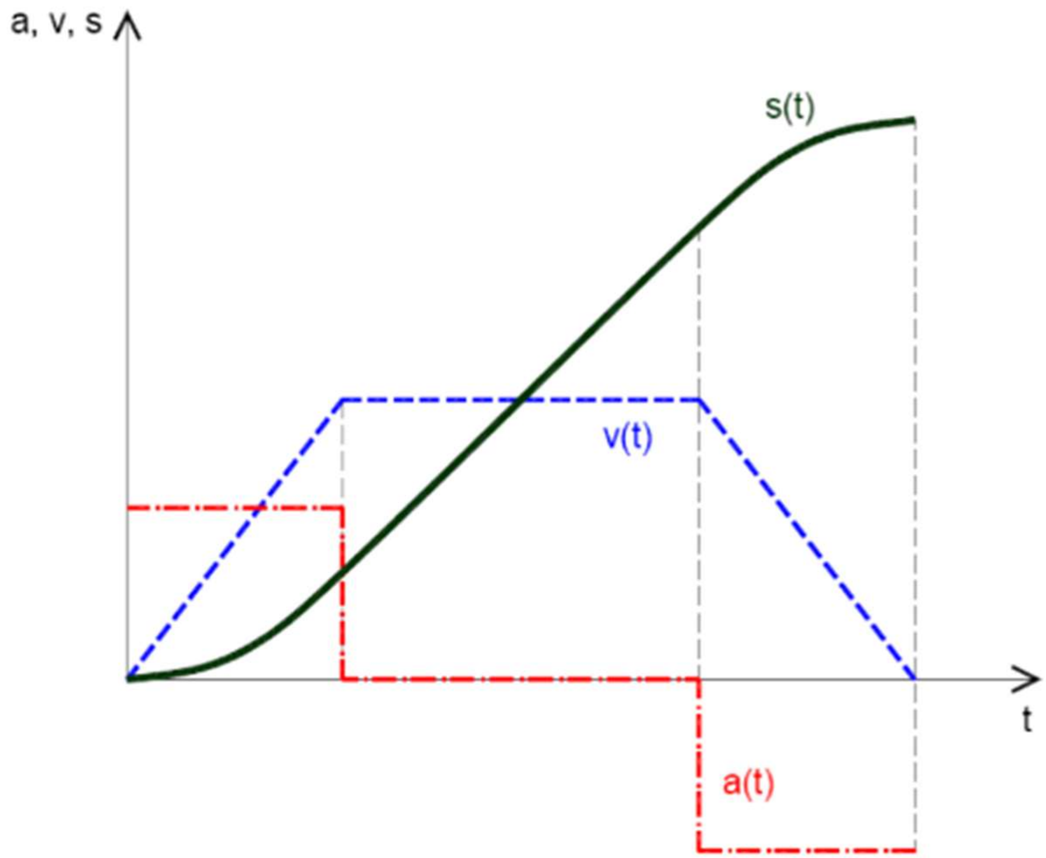
$$S_c = L - S_a - S_b \qquad t_c = \frac{L - S_a - S_b}{V_{max}} = \frac{L}{V_{max}} - \frac{V_{max}}{2a} - \frac{V_{max}}{2d}$$

Commercial speed (t_s: stop time)

$$V_c = \frac{L}{t_a + t_c + t_b + t_s}$$

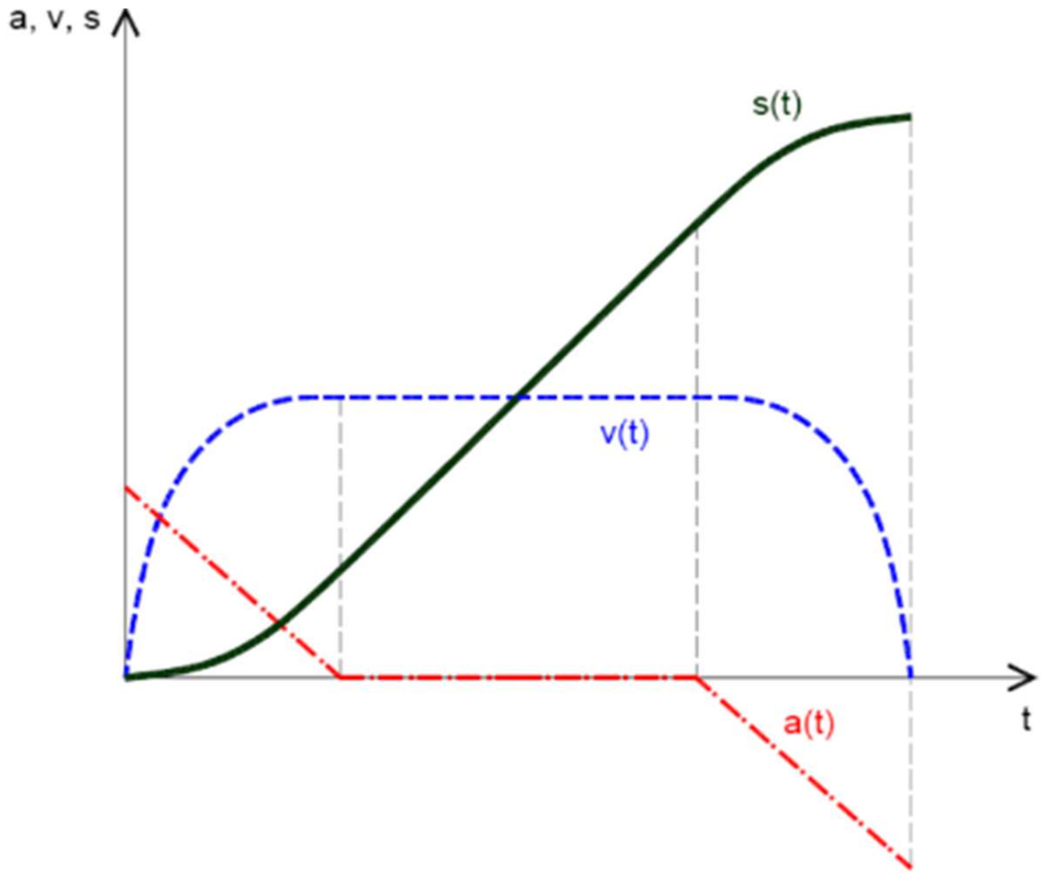
Typical graphical representation (1)

Space/time chart with constant acceleration (generally occurs when starting with low top speed, when T and R are almost constant)



Typical graphical representation (2)

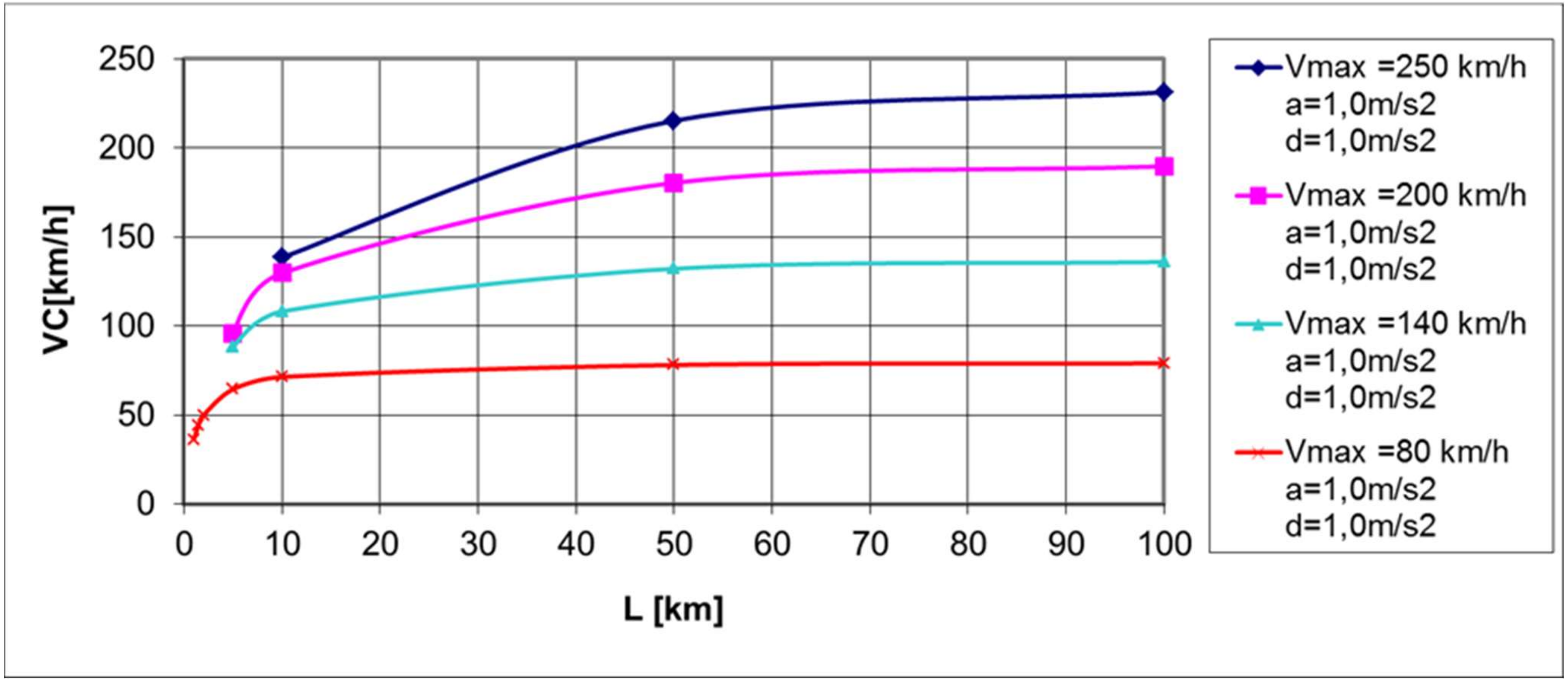
Space/time chart with the acceleration that decreases linearly (generally applicable for higher speeds, when the difference T-R is significantly decreasing)



Commercial speed = f(top speed,stop distance)

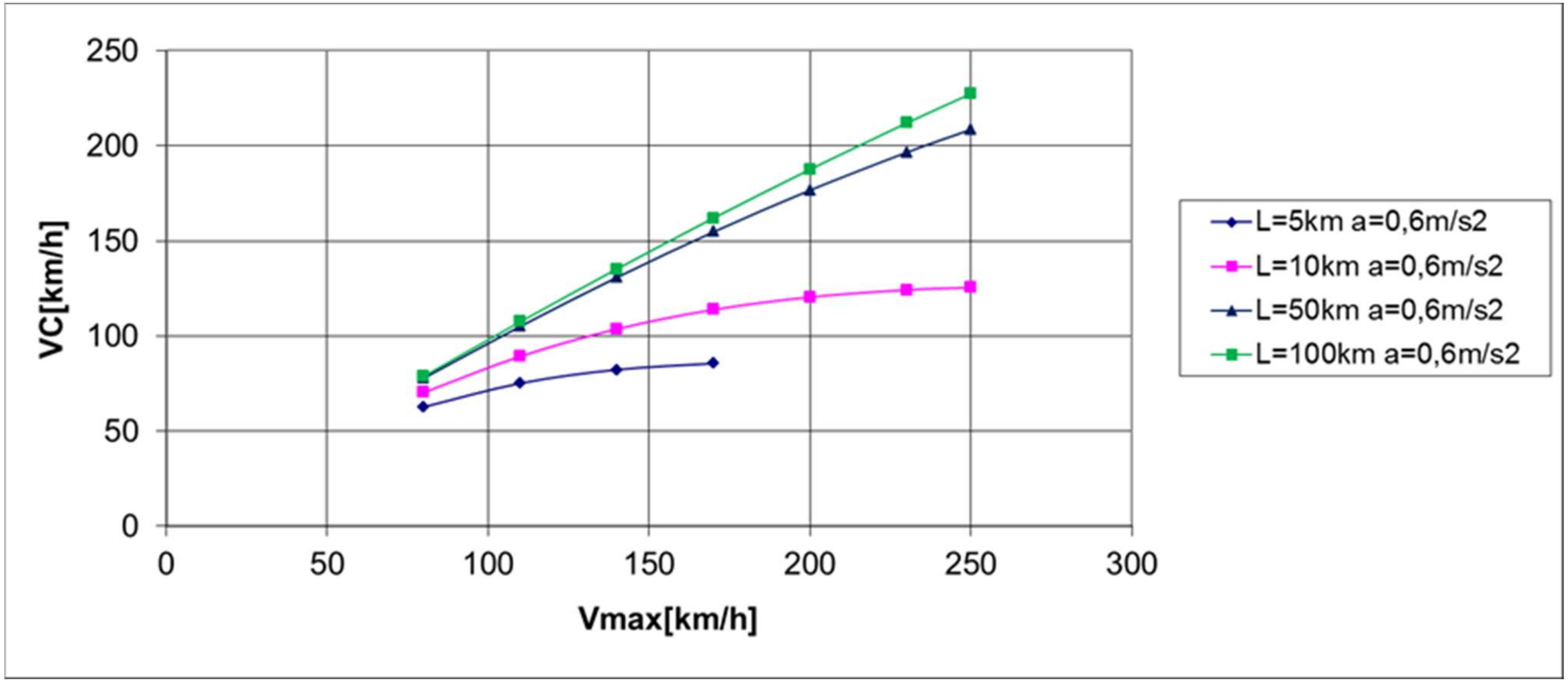
Assumptions

- Mechanical characteristic: acceleration equal to the maximum acceleration up to 40 km/h and then decreasing linearly up to the value of 0.2 m/s^2 at the maximum speed.
- Constant deceleration $d = 1.0\ m/s^2$
- Stop time $t_s = 30s$



Commercial speed = f(top speed,stop distance)

Assumptions (same as for previous slide except acceleration)



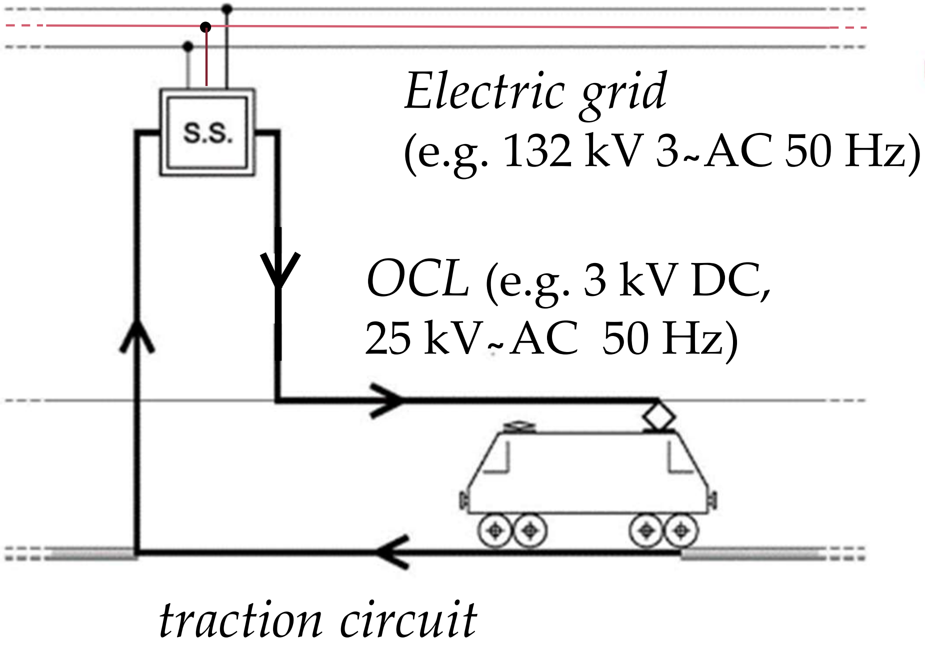
VE8. Electric Traction

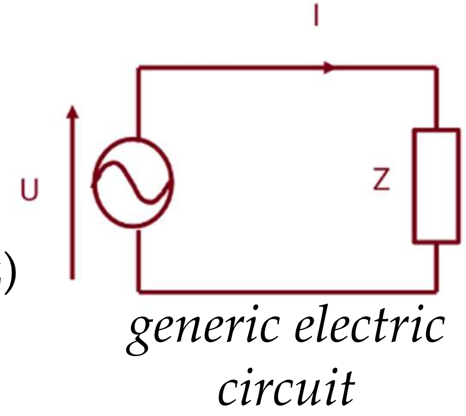
Traction circuit

Electric Traction

- Electric energy is derived from a contact line (**e.g.** overhead)
- Electric energy is fed to the traction motor through traction equipment (traction drive system).

!





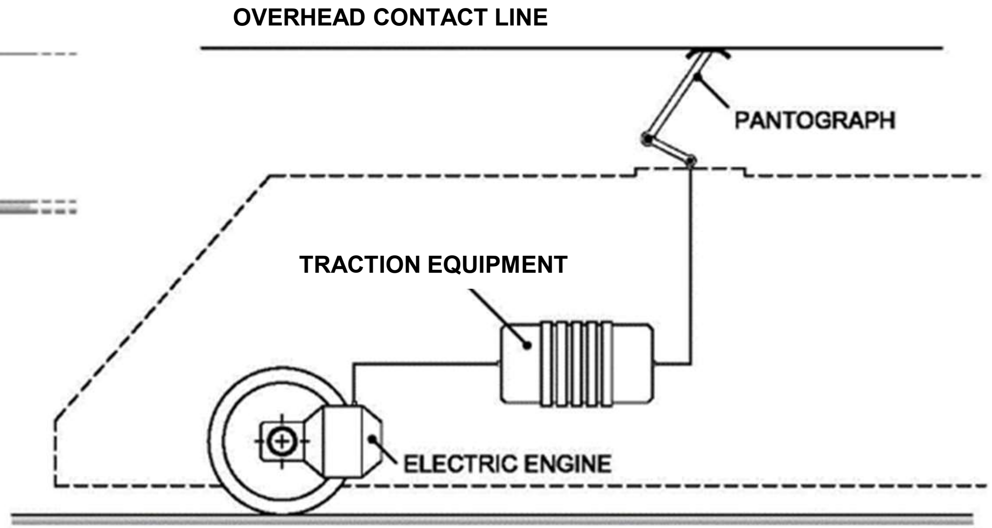
Ohm's law

$U = Z \cdot I$

$Z = Z_R + Z_L(f) + Z_C(f)$

Impedance (Ω) depends on:

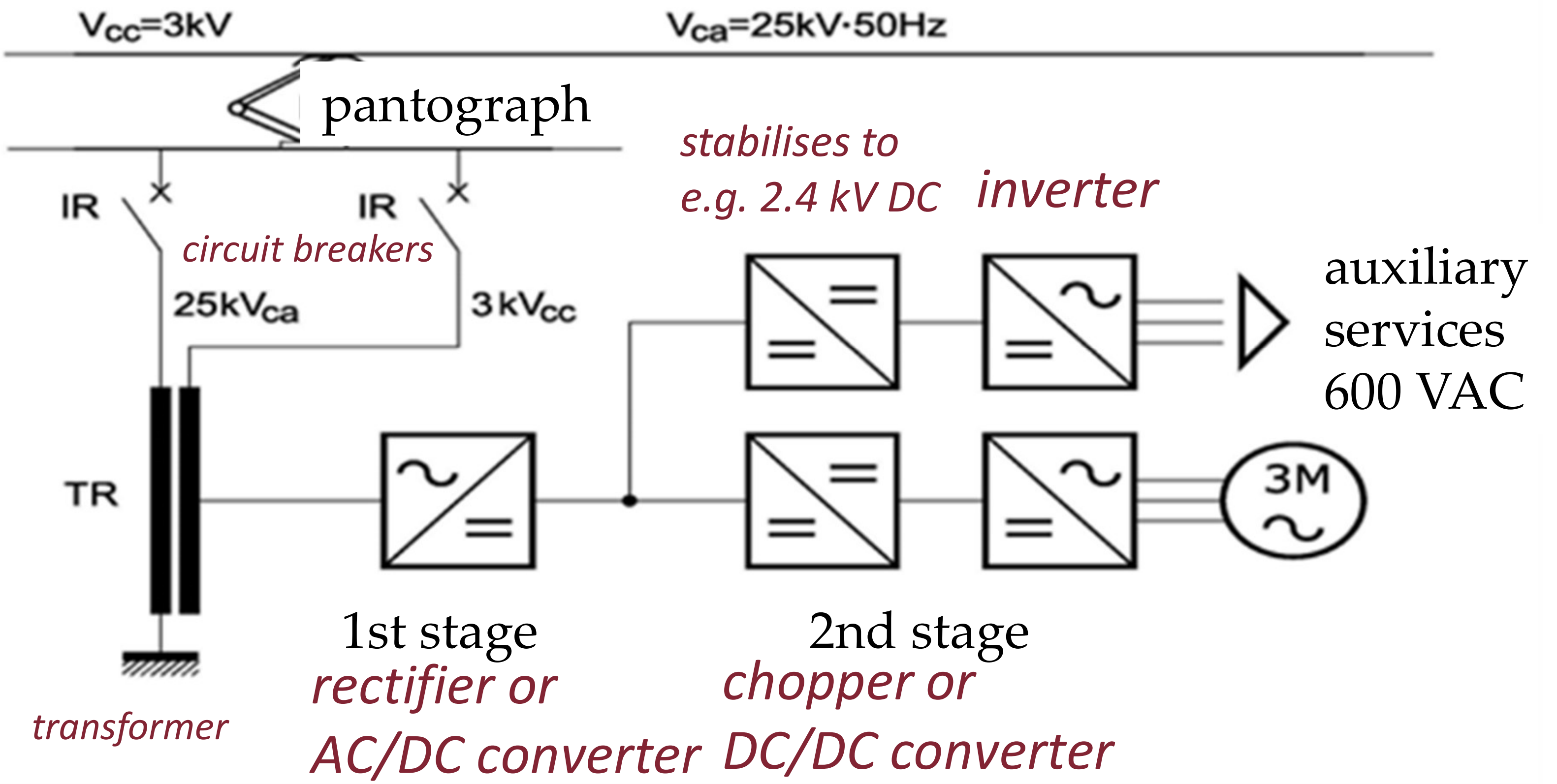
- resistance (Ω),
- inductance (H),
- capacitance (C)



Traction drive example

Traction drive system for dual-voltage High-Speed Rolling Stock (ETR 500).

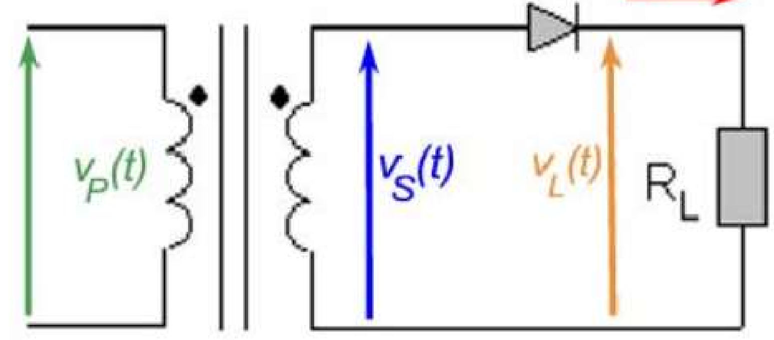
!



25 kV 50 Hz AC or 3 kV DC overhead power is turned into 3-phase AC with varying voltage and frequency by the traction drive

Basic components

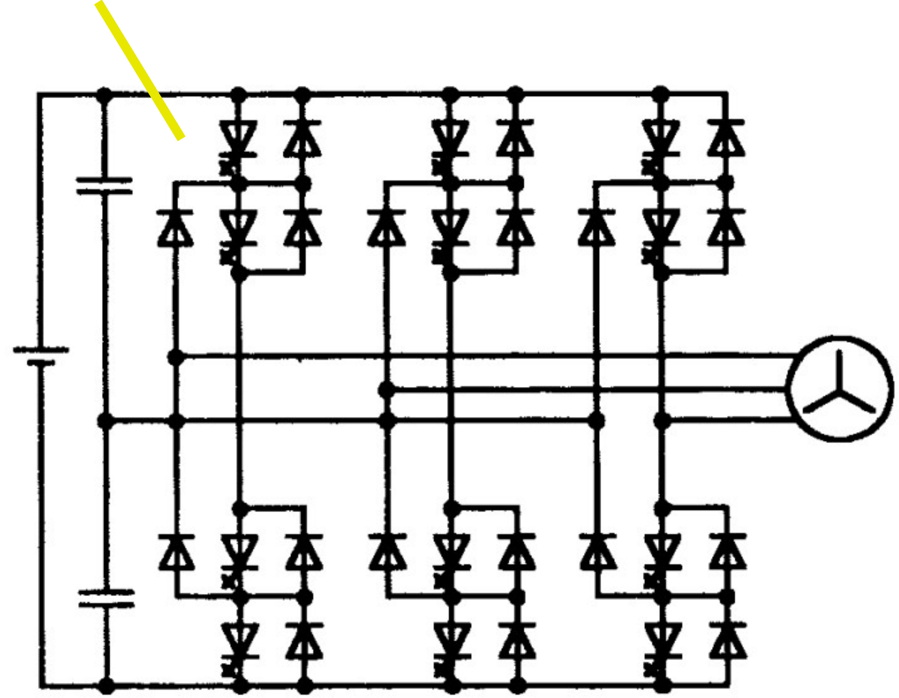
Power electronics for traction drives



This circuit turns a sine-wave input into a half-sine-wave output.

simple rectifier circuit

https://cds.cern.ch/record/987551/files/p133.pdf



inverter circuit

https://core.ac.uk/download/pdf/12528671.pdf

diode: allows current to flow only in the direction of «its arrow», when vs > vL

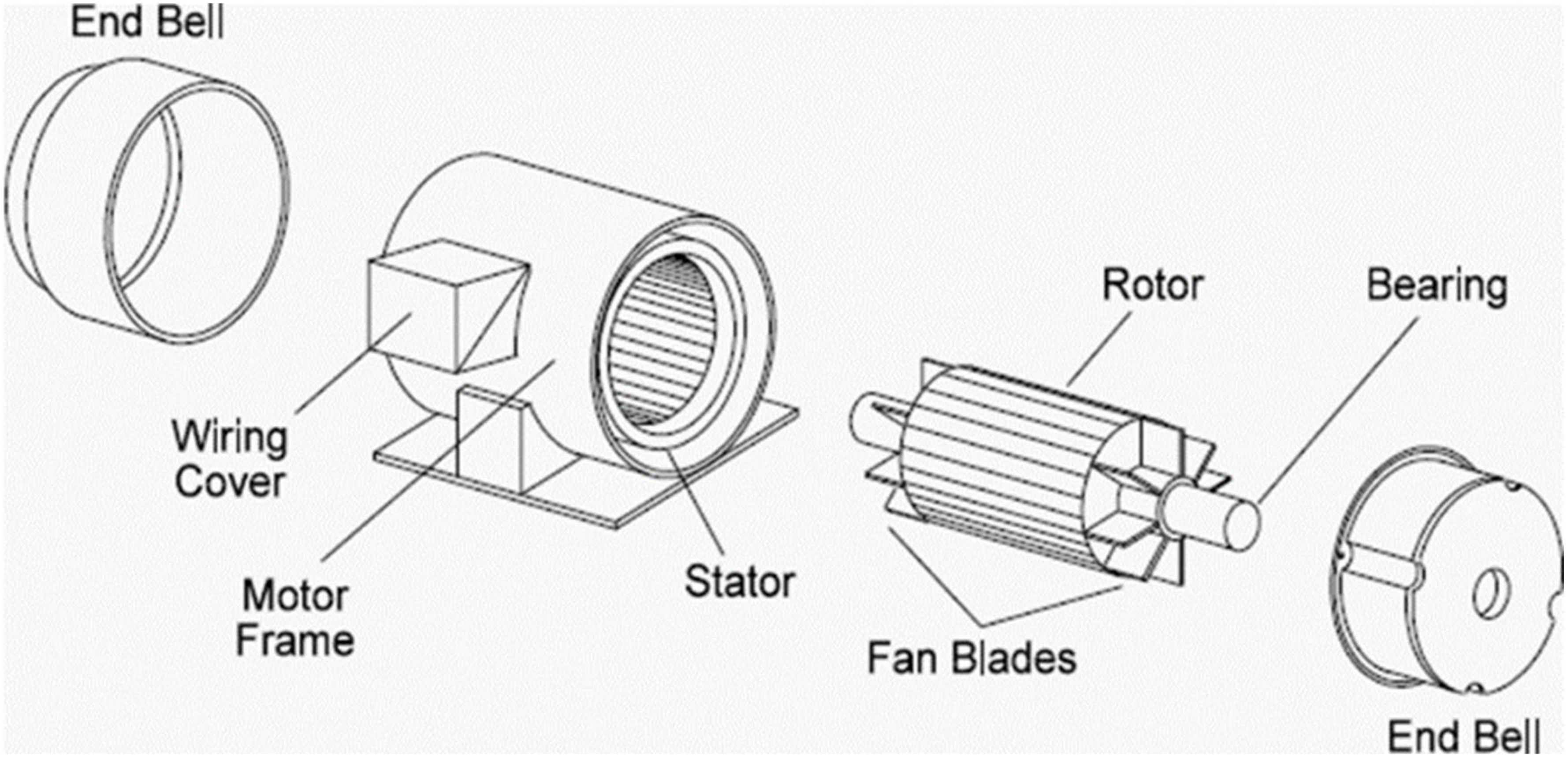
thyristor: acts as a controlled diode, the control logic may impede current flow even when voltage is favourable

Induction motors: basic principles

- A direct current (DC) in a conductor generates a magnetic field similarly to a permanent magnet; alternate currents generate alternating magnetic fields.
- (induction) A conductor in relative motion wrt a magnetic field is subjected to a voltage difference across it (therefore with «mobile» magnetic fields – e.g. alternating fields – and a stationary conductor, or a mobile conductor wrt a stationary magnetic field, one can «induce» a voltage – and consequently a current - in the conductor itself).
- Conductors carrying a current and immersed in a magnetic field are subjected to forces.
- In conclusion: by creating suitable magnetic fields with electric wires carrying current (coils composed of several windings e.g. on a «stator»), one can subject other wires or conductors carrying current (e.g. on a rotor) to forces and torques.

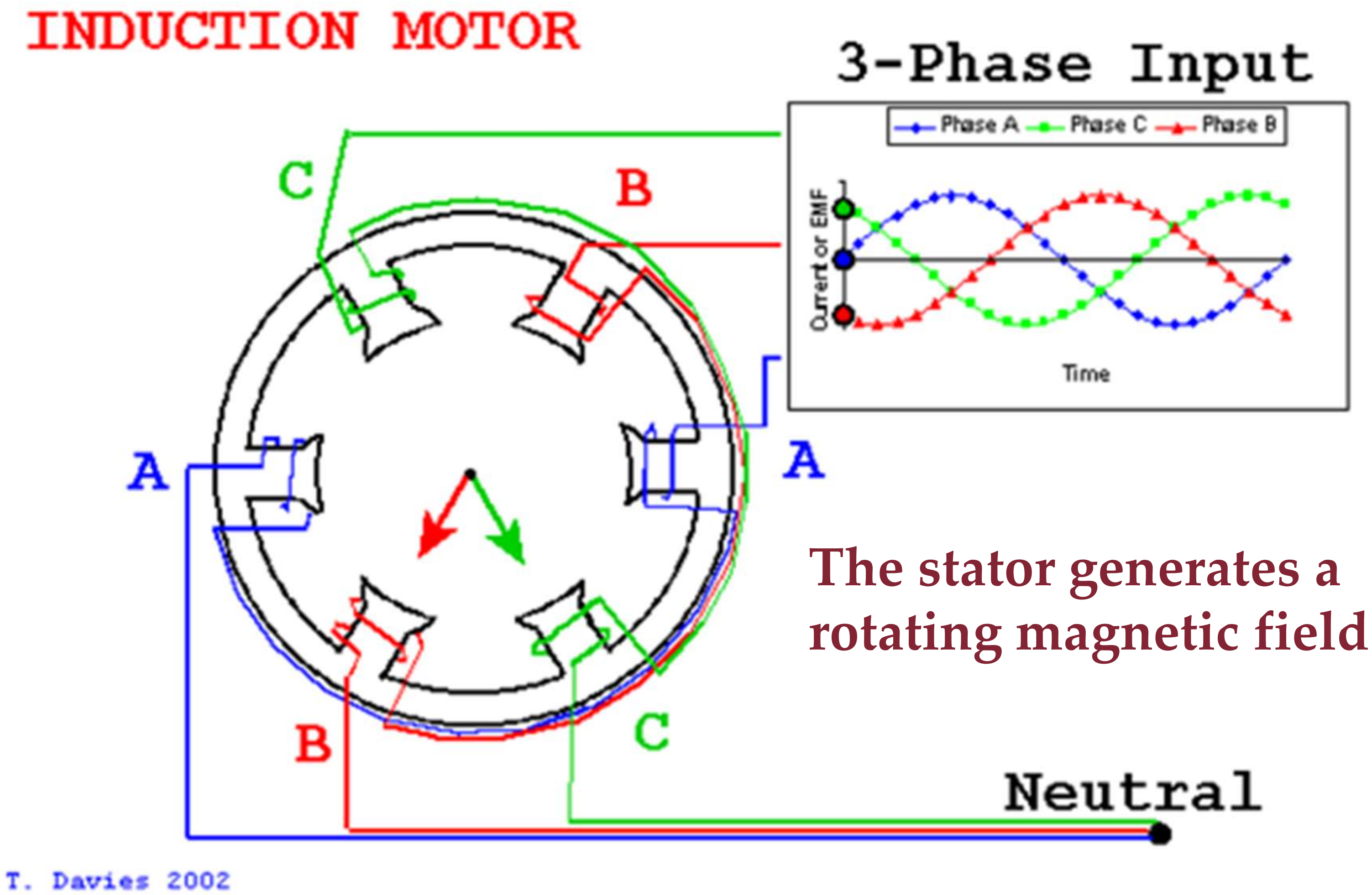
Asynchronous 3-phase induction motor (1)

!



http://electrical-engineering-portal.com

Asynchronous 3-phase induction motor (2)



!

The stator generates a rotating magnetic field

http://waitbutwhy.com 2015

Asynchronous 3-phase induction motor (3)

Basic functional relationships

$$n = \frac{60 * f}{p}$$
$$\omega = 2\pi f$$

where

- ω: pulsation (angular speed) of rotating magnetic field [rad/s]
- n: angular speed of the rotating magnetic field [revolutions/minute]
- f: frequency of the electric current [Hz]
- p: number of polar couples (per phase)

! When the rotor turns at a number of revolutions n1 lower than n (synchronous speed), the rotor rotates with a difference Δn = n – n1, which defines the **slip** of the motor s = (n – n1) / n and n1 = (1 – s) n. The rotor is subjected to an accelerating torque. **When slip is zero there is no induced rotor current and thus no torque transferred to the rotor**.

Asynchronous 3-phase induction motor (4)

Power

- Power transmitted from the stator to the rotor $P = 2\,\pi\,n\,M/60$
- Effective power $Pm = 2\,\pi\,n1\,M/60 = 2\,\pi\,n(1-s)M/60$
- The difference of the powers $Pj = P - Pm$, are the losses during operation of the motor.

$Pj = P - Pm = 2\pi nM/60 - 2\,\pi\,n1M/60 = 2\,\pi\,M(n - n1)/60 = 2\,\pi\,Msn/60 = Ps$

Torque

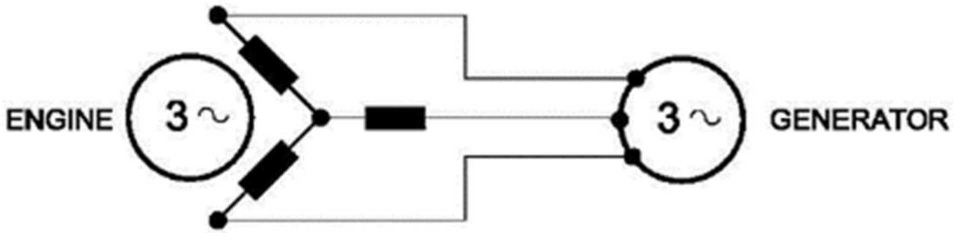
$$M_{max} \equiv \left(\frac{U}{f}\right)^2 \equiv \Phi^2$$

where

- M_{max} : maximum torque
- Φ: intensity of rotating magnetic field
- U: voltage

Asynchronous 3-phase induction motor (5)

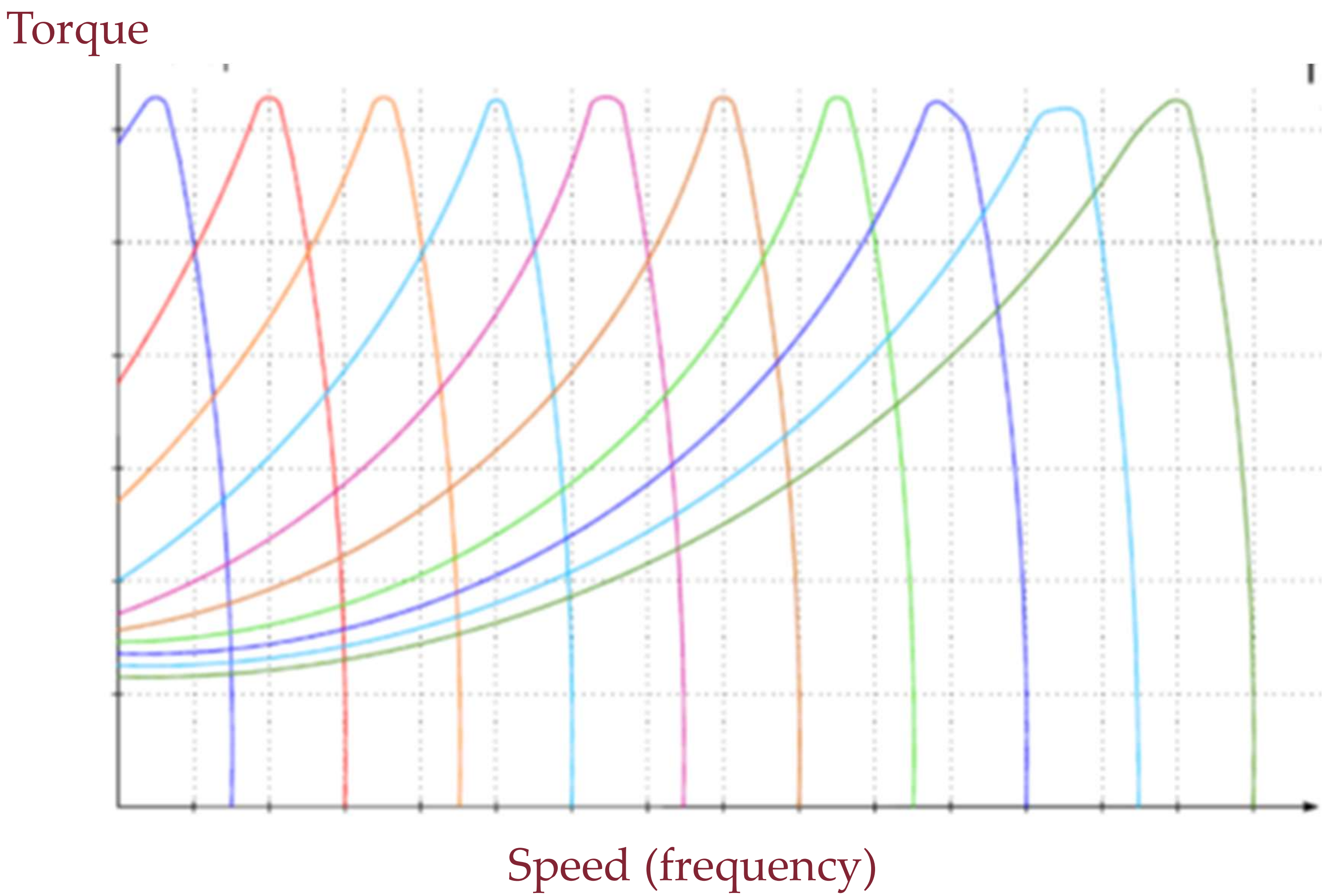
Mechanical characteristic with f=const., U=const.



not directly suitable for traction: it has to be adapted, nowadays thanks to power electronics (inverter)

Asynchronous 3-phase induction motor (6)

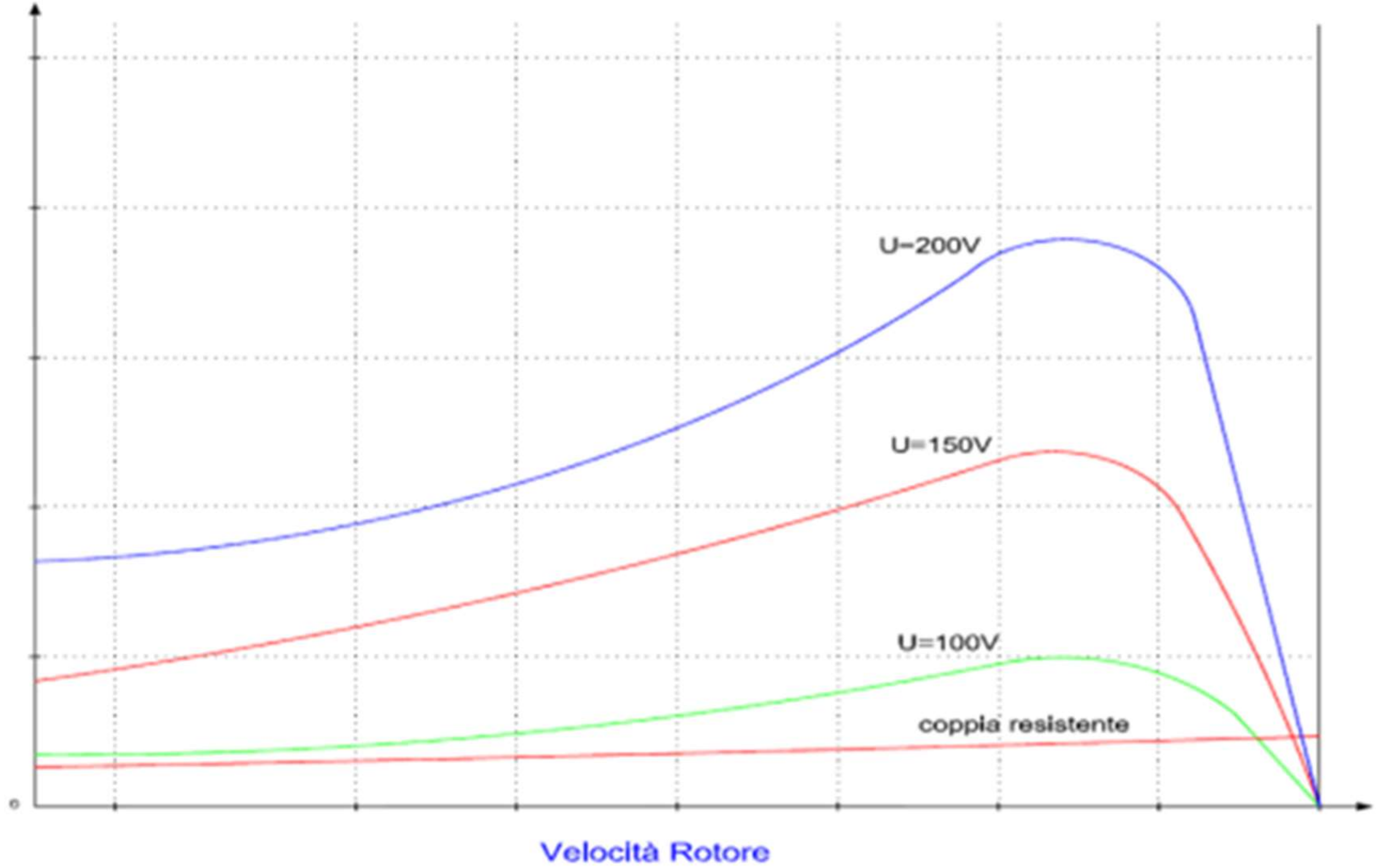
Torque curve as a function of U and f, keeping the ratio U/f constant.



Asynchronous 3-phase induction motor (7)

Torque characteristic with U and f constant and increasing slip (varying rotor speed).

Torque

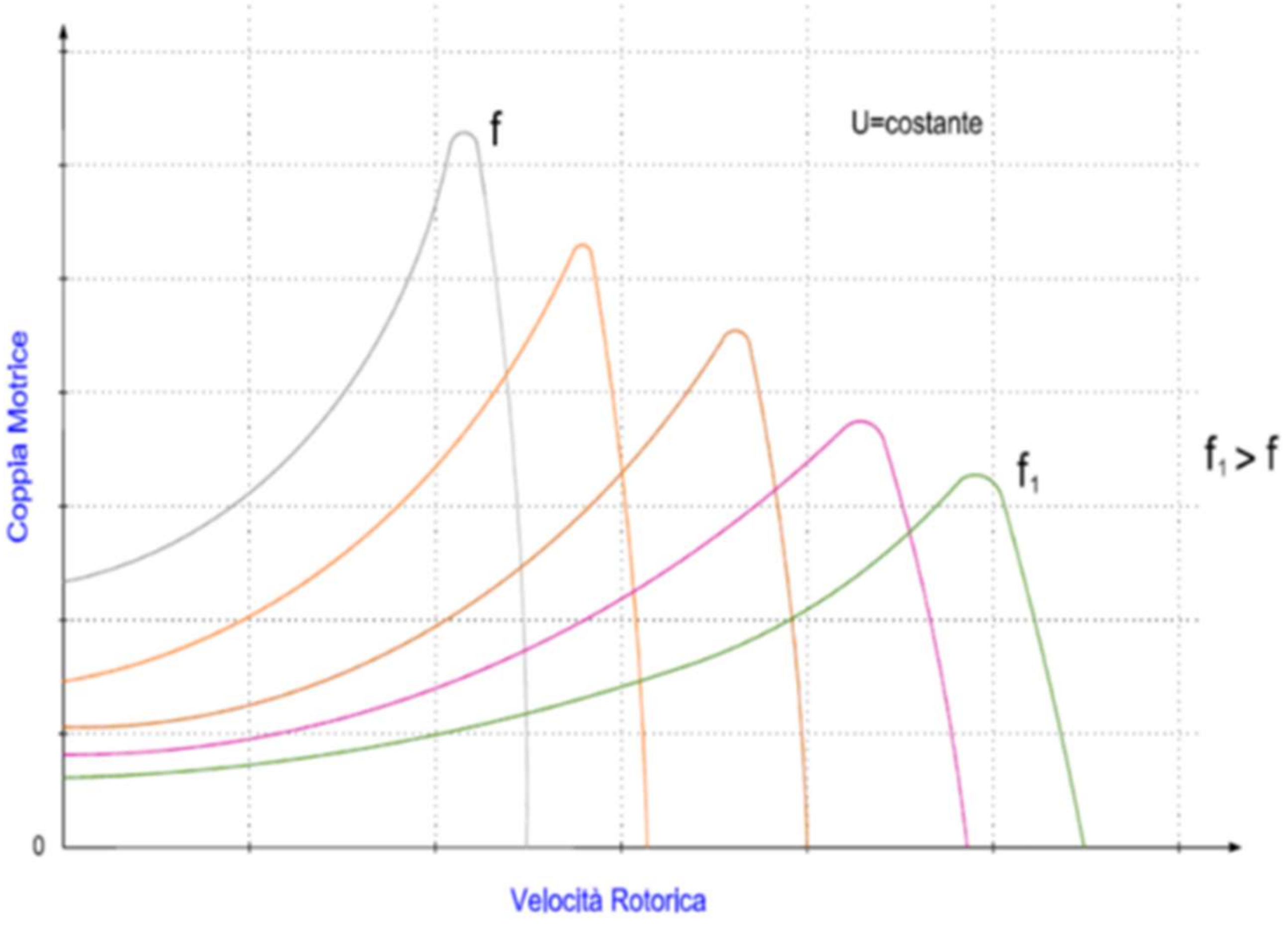


rotor speed (frequency)

Asynchronous 3-phase induction motor (8)

Torque curve as a function of frequency while maintaining constant voltage U

Torque



rotor speed (frequency)

Asynchronous 3-phase induction motor (9)

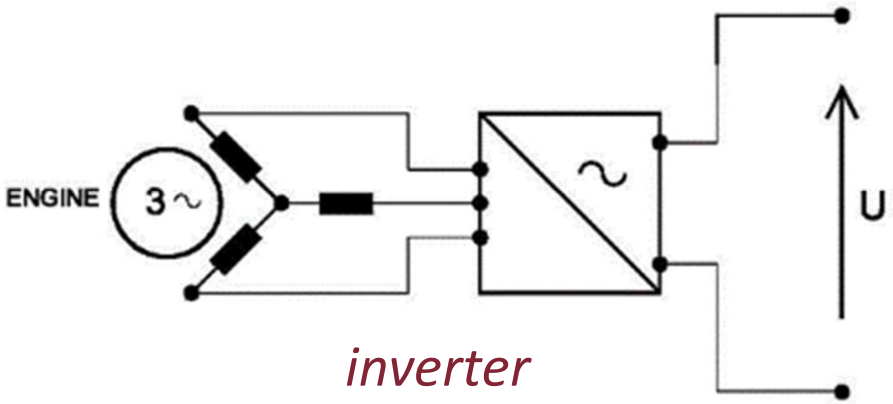
Asynchronous motor control

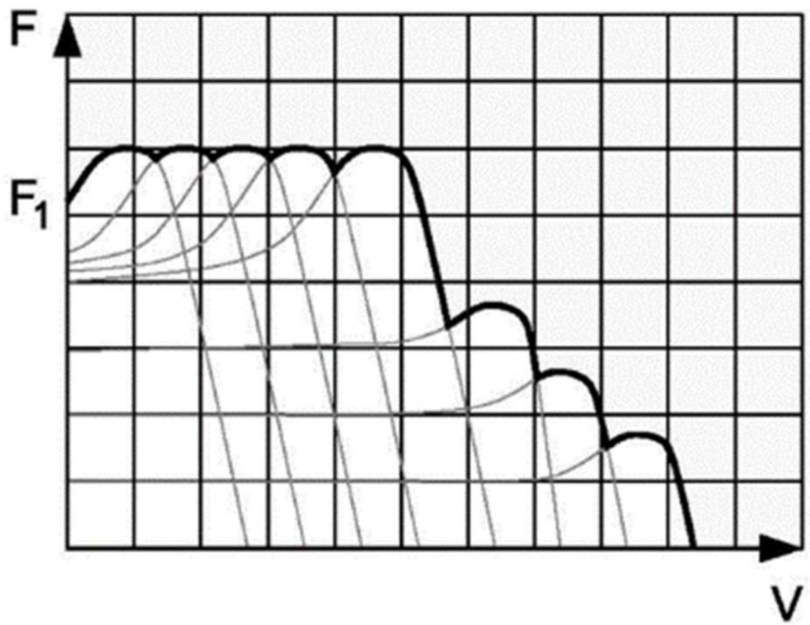
Phase 1 – Constant Force

- Frequency and voltage variation (inverter equipment) to have constant torque (proportional to U/f)

Phase 2 – Constant Power

- Constant voltage, frequency variation (inverter equipment) to have decreasing torque (proportional to U/f)

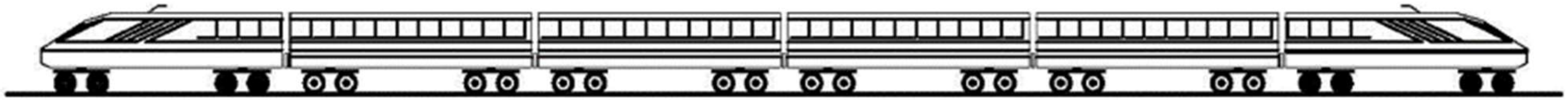




Motorised wheelsets

Fixed composition train (in black, motorised wheels).

- concentrated traction,
- distributed traction.



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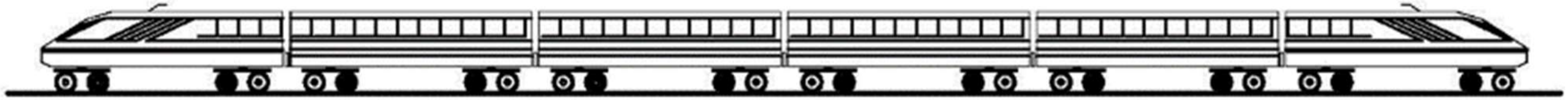


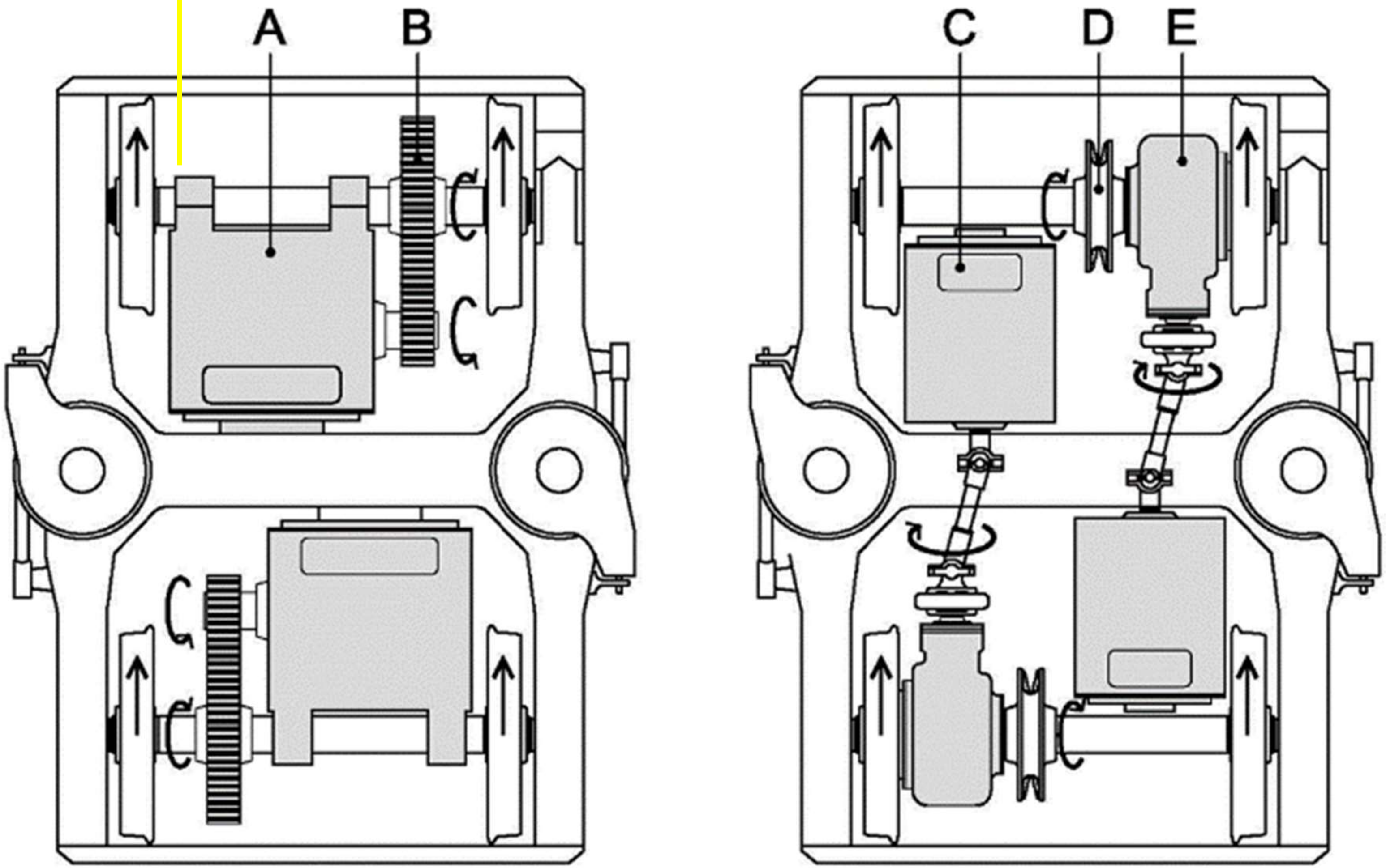
Bogies for electric traction

<u>Examples of motor disposition in the bogie</u>

A,C-Motor; B,E: Gear; D: Disk brake

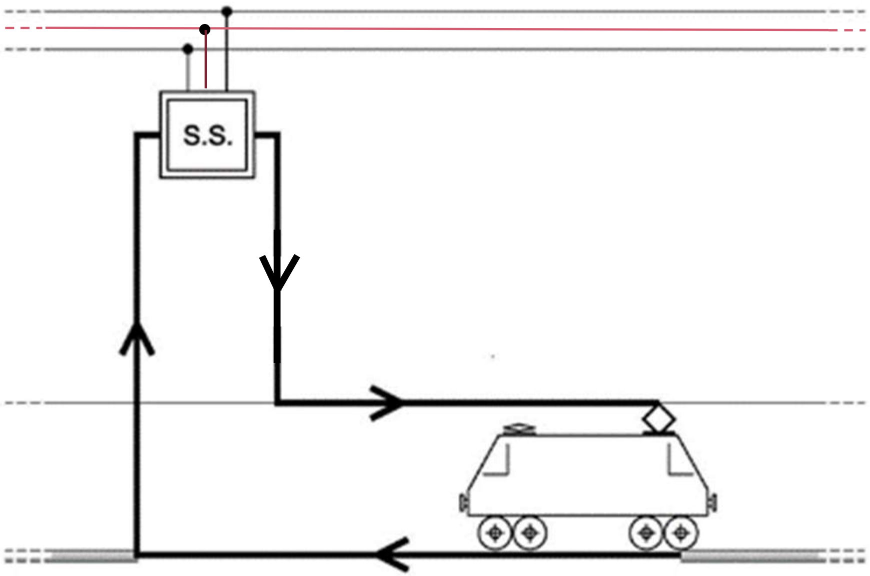
often: hollow "quill" drive

!



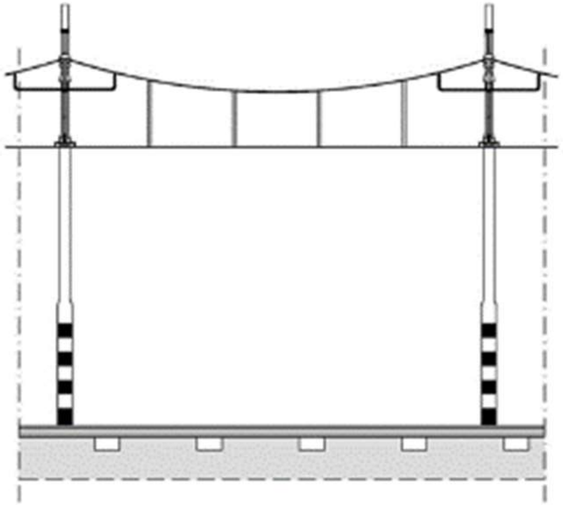
Electrification infrastructure

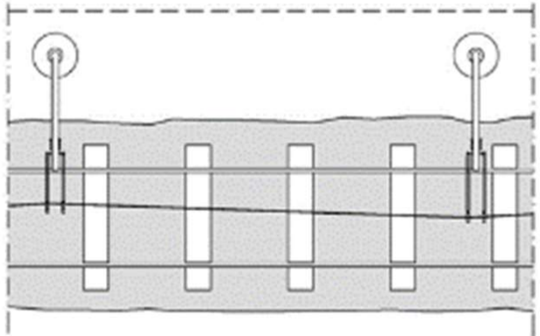
Electric traction systems typically comprise electrical substations that draw power from the national grid and feed Overhead Contact Lines (OCL). Power is transferred to the traction unit (loco, EMU) via a sliding contact of the on-board pantograph and the contact wire. The "traction circuit" is closed via the rails.



!

contact wire suspension

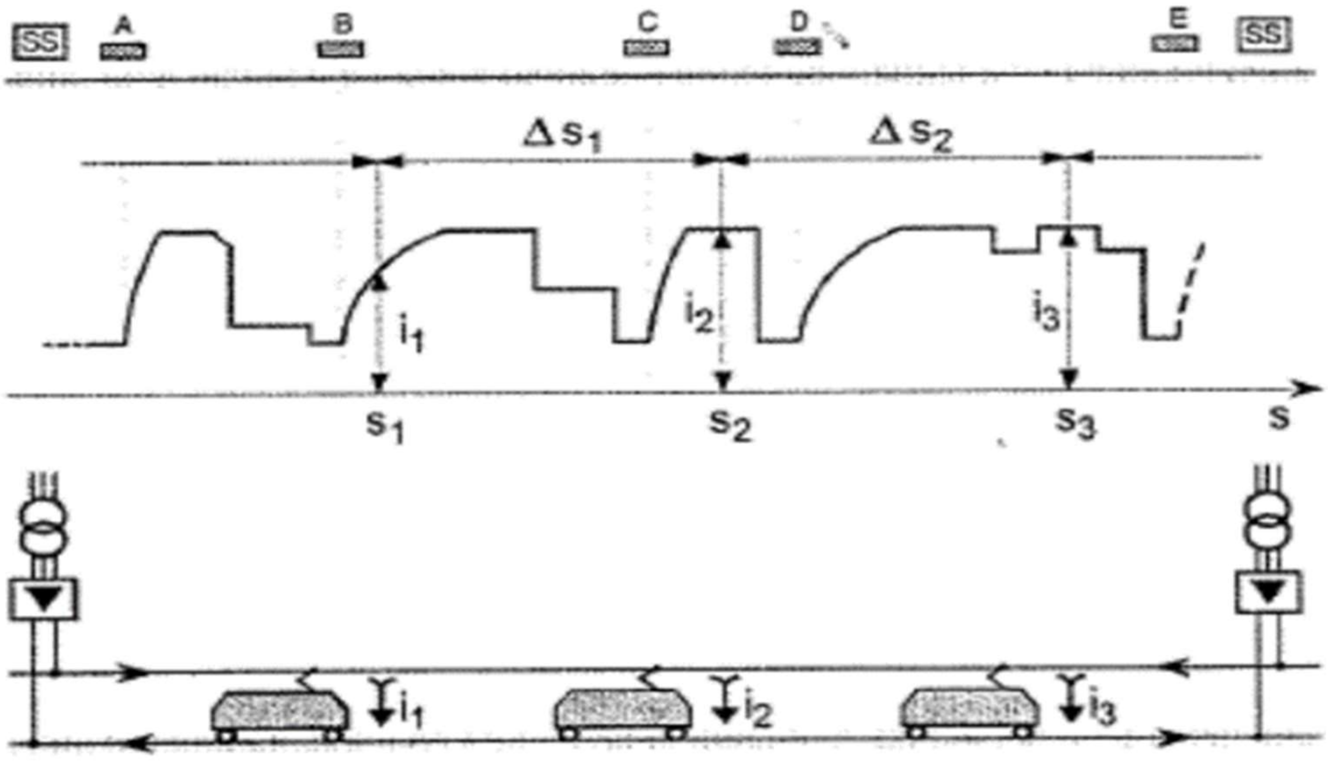




"stagger" of the contact wire

Effects of railway traffic (1)

The power to be installed in the substations should ensure that energy is delivered to all trains along the line, considering that many or all of them could be drawing their maximum power from the OCL, and also considering the electrical voltage drop due to the electrical resistance of the OCL.

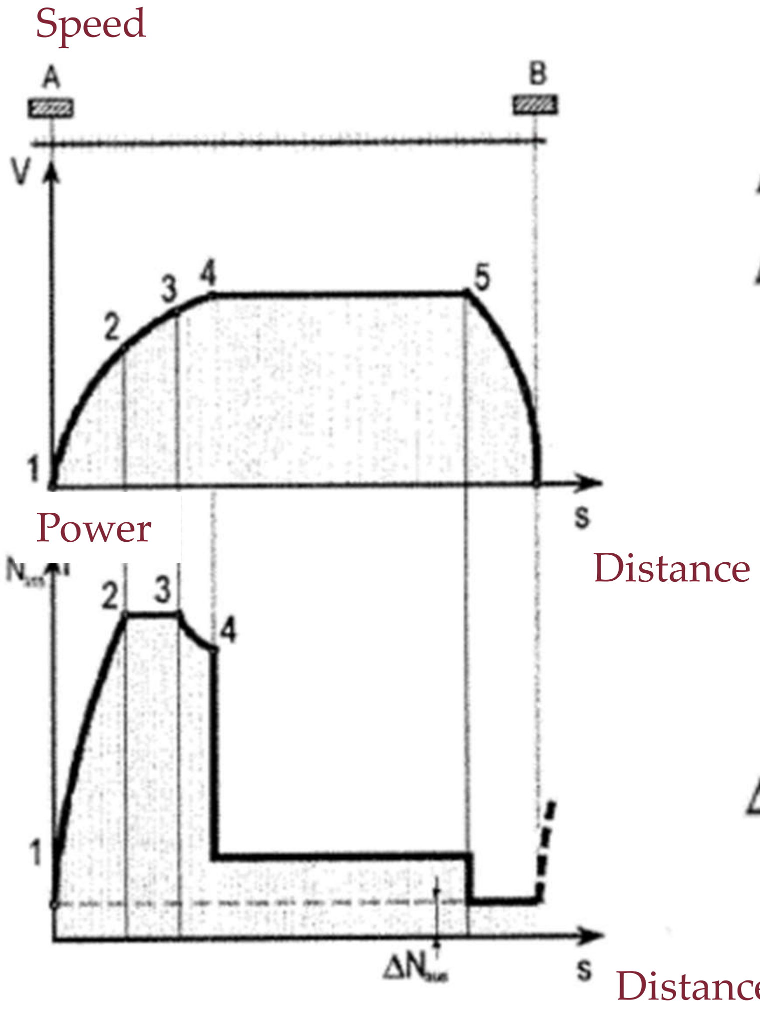


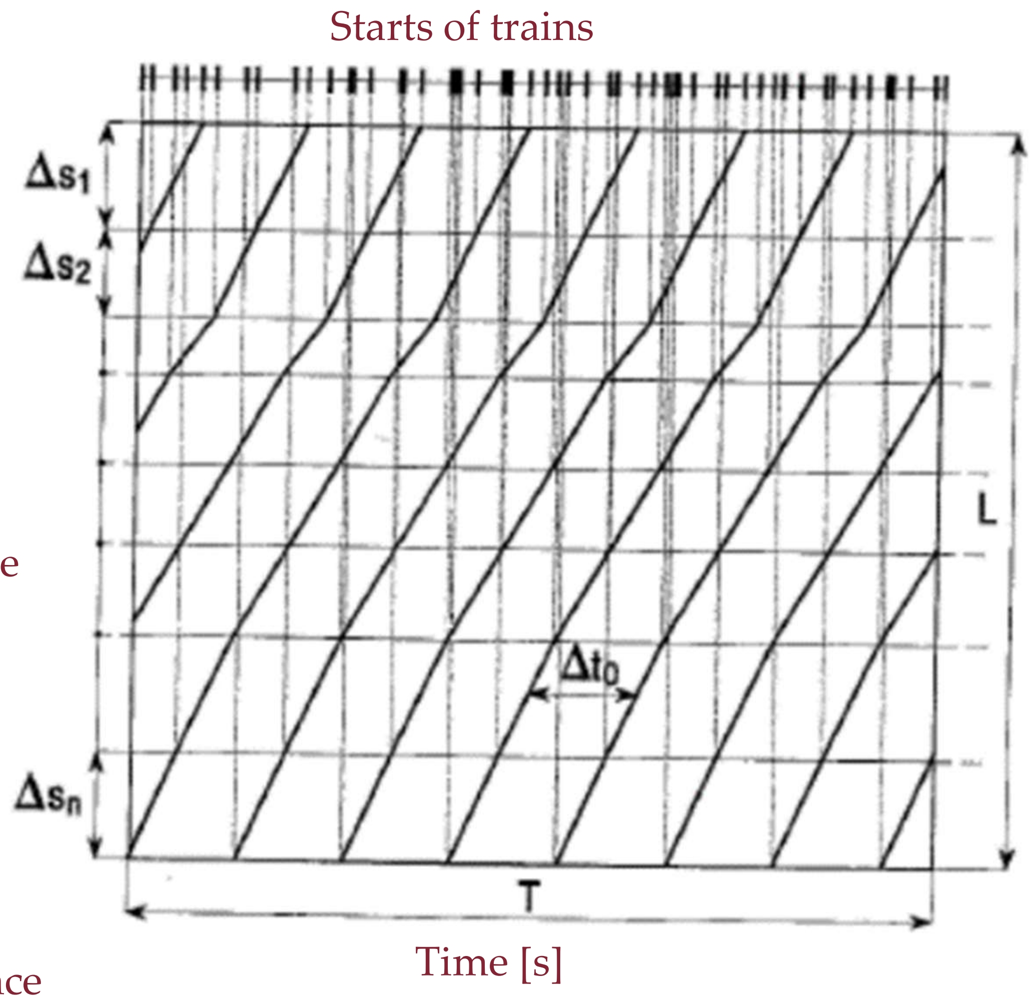
(source: Accattatis et al. Ingegneria Ferroviaria 4-2004)

Effects of railway traffic (2)

Speed and Electrical current versus distance diagrams.

Graphical timetable (i.e. time-space diagram)



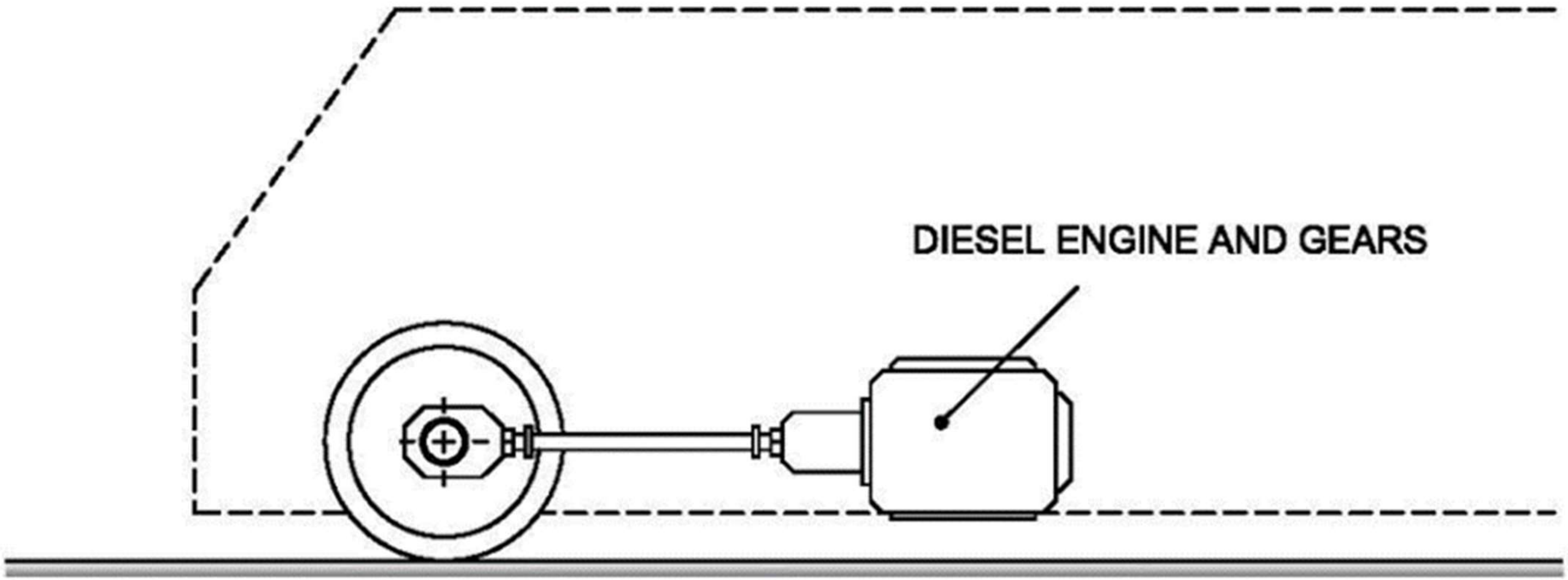


!

(source: Accattatis et al. Ingegneria Ferroviaria 4-2004)

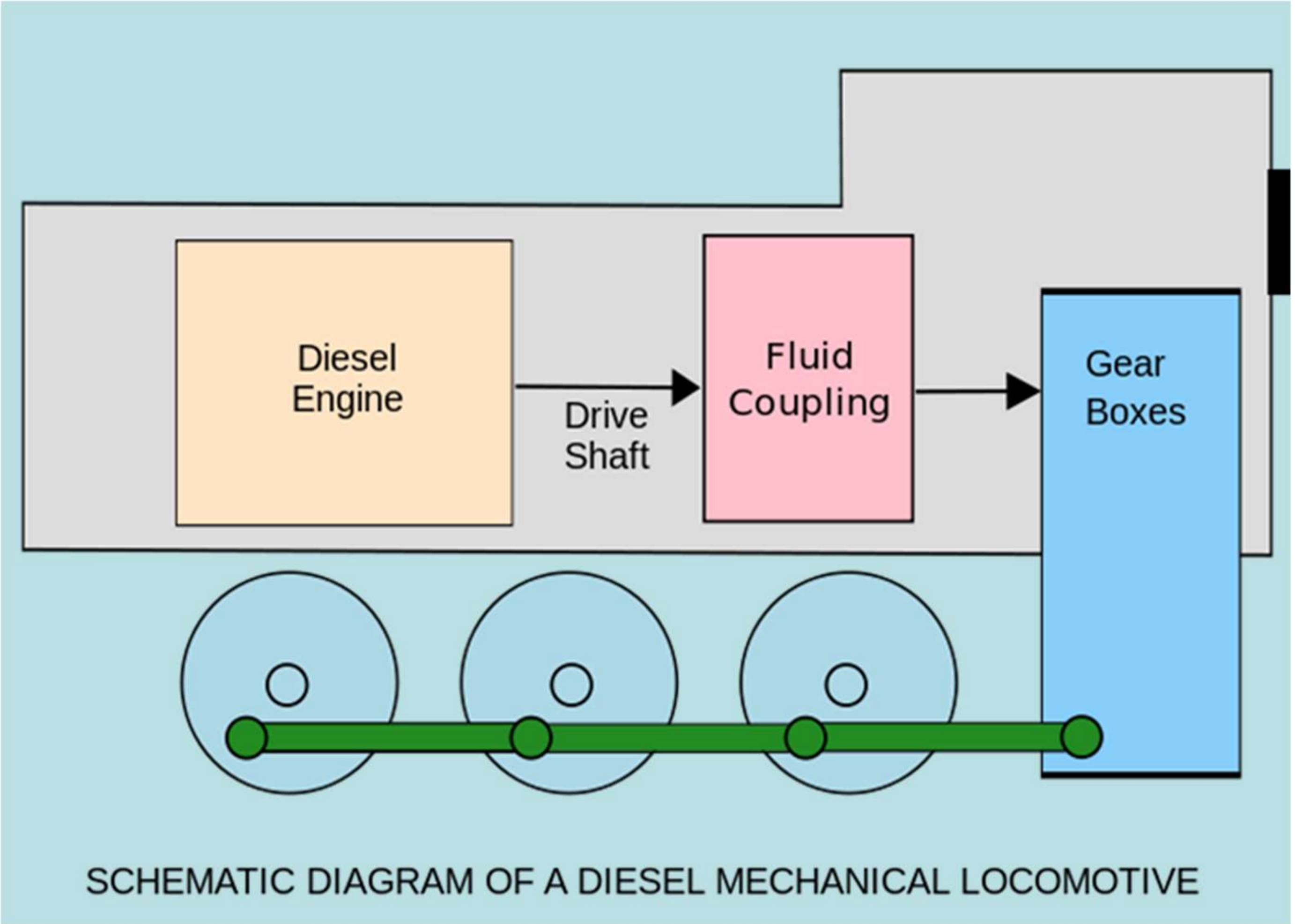
VE9. Diesel Traction

Diesel traction with mechanical transmission



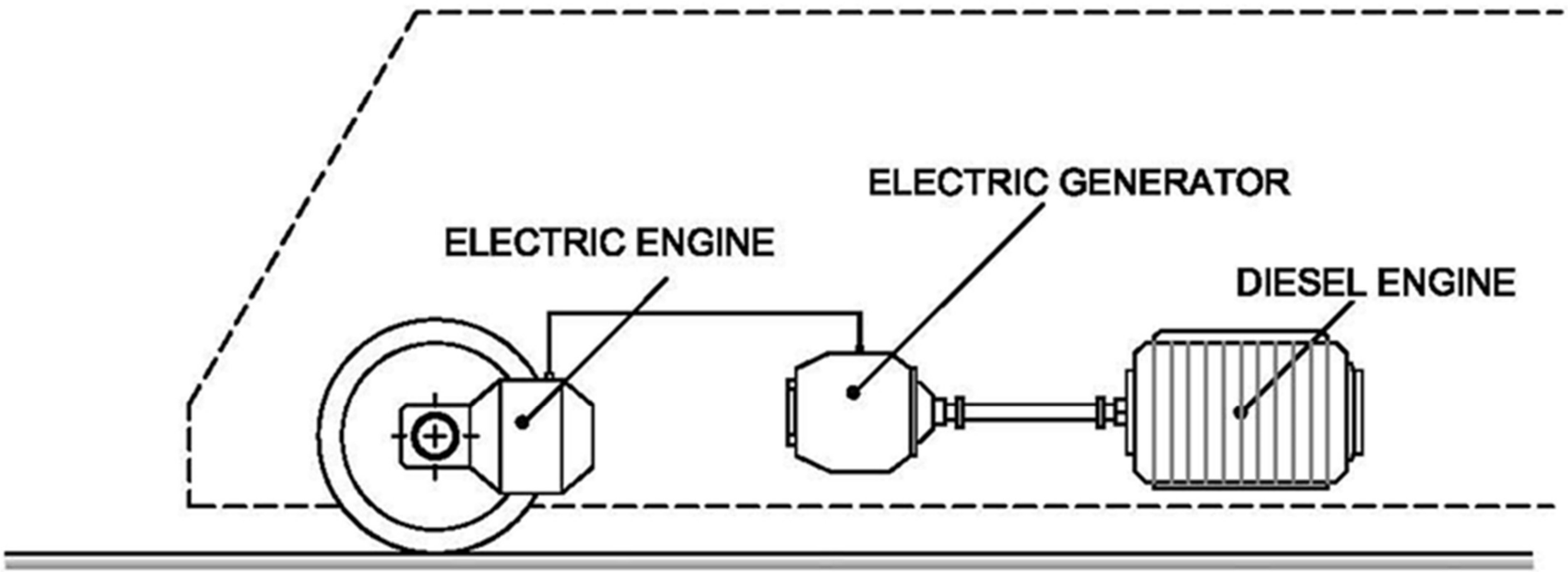
- mechanical transmission: between engine and wheel there are many gears that transform the parameters of power, torque and speed; this system is widely used in road vehicles

Diesel-hydraulic traction



(source: https://en.wikipedia.org/wiki/Diesel_locomotive - 5.11.2015)

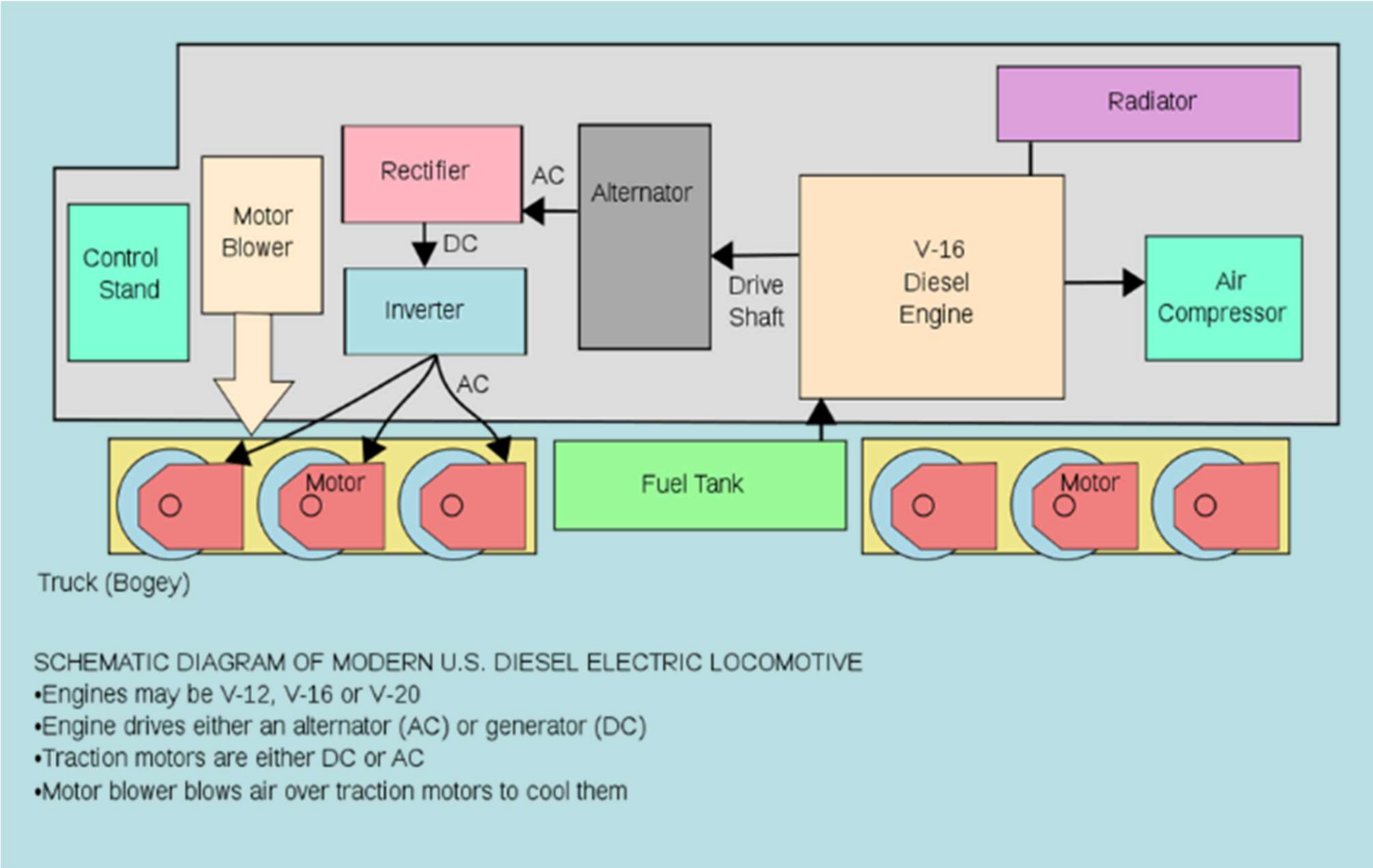
Diesel-Electric traction (1)



Advantages

- The Diesel Engine can work at maximum efficiency (constant "maximum torque" rpm).
- Electric control of the force is easier than mechanical control (with gear transmission) thus facilitating the achievement of constant power.

Diesel-Electric traction (2)



(source: https://en.wikipedia.org/wiki/Diesel_locomotive - 5.11.2015)

Transmission systems

In general the transmission system with diesel engine can be of three types:

- mechanical transmission: between engine and wheel there are many gears that transform the parameters of power, torque and speed; this system is widely used in road vehicles;
- electrical transmission, i.e. Diesel-Electric traction: a Diesel engine is connected to an electric generator that feeds the electric engines;
- Diesel-hydraulic: the Diesel engine is connected to a fluid coupling

Diesel-Electric Traction

- A Diesel engine is connected mechanically to an electric generator.
- The electric generator is connected electrically to an electric engine.
- The electric engine is connected mechanically to the wheel.

Advantages

- The Diesel Engine can work at maximum efficiency (constant “maximum torque” rpm).
- Electric control of the force is easier than mechanical control (with gear transmission) thus facilitating the achievement of constant power.

Diesel motor: torque and power

- Typical rotation speeds of a Diesel motor for railway traction are in the range of 500 ÷3000 revolutions per minute (rpm)
- The torque of a Diesel motor is approximately constant with rpm.
- Power thus increases with rpm.

If

$$C(n) = k$$

then

$$N(n) = k * n$$

N(n) is a straight line passing through the origin of the axes.

Where

- C = motor torque
- N = power at motor shaft

Transmission

Relationships between traction force and speed

1. Speed V of the vehicle and rotation speed ω of the traction motor

$$V = \omega r = \frac{2\pi n_w}{60} r_w; \; n_w = \frac{n_m}{\gamma}$$

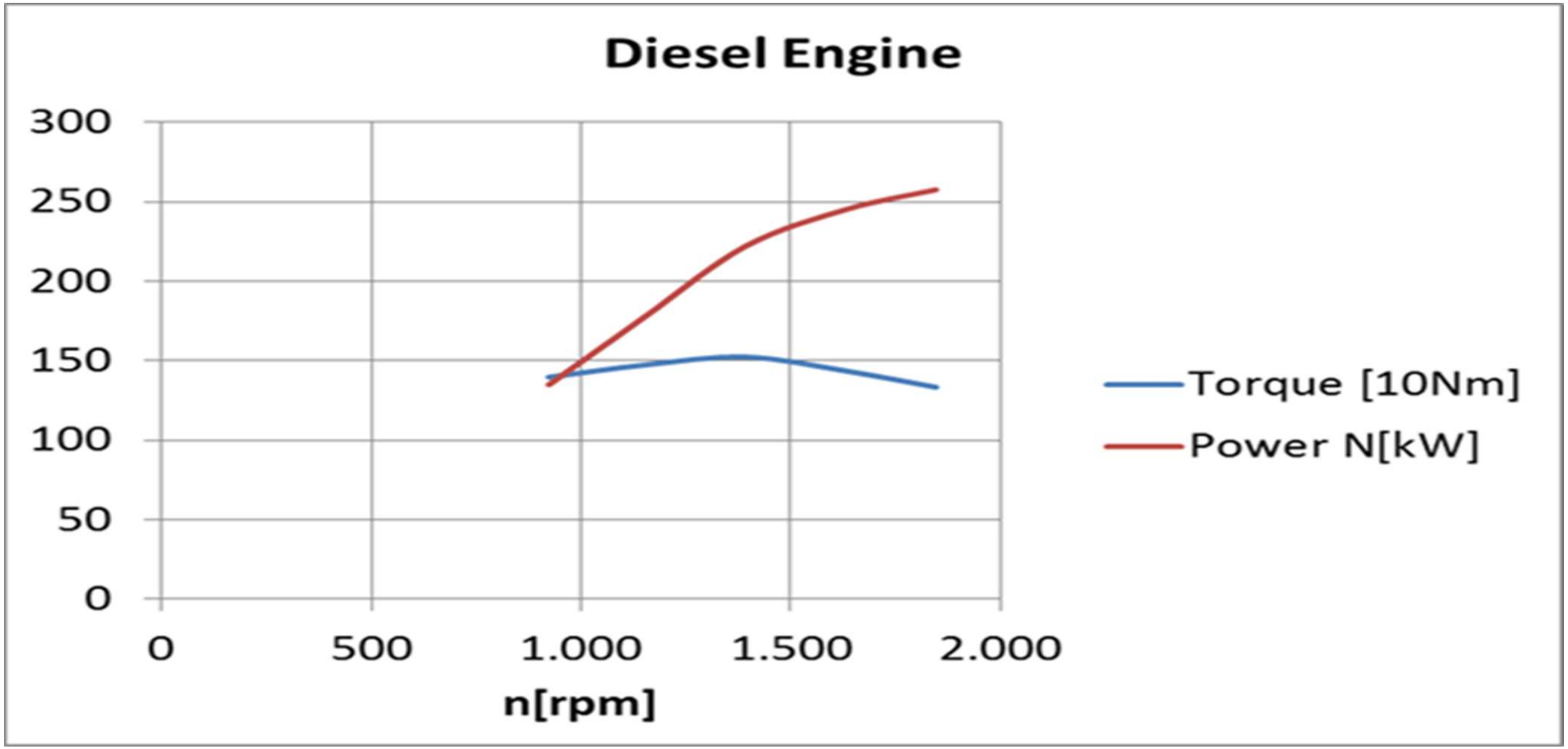
2. Traction force T at wheel and torque C at the motor shaft.

$$T = \frac{C\gamma}{r_w}\eta$$

where

- n_w = revolutions per minute of the wheel
- r_w = radius of the wheel
- n_m = revolutions per minute of the motor shaft
- γ = transmission ratio
- η = efficiency of transmission

Mechanical characteristics



- The traction curves a of a Diesel engine do not have an ideal form (i.e. not hyperbolic, constant power).
- To use this engine in transport it is necessary to vary the transmission ratio in order to approximate the constant power trend of an ideal characteristic: high force at low speed and vice-versa.

VE10. Braking systems

Braking system functions

The brakes have the function to adjust the speed of the train:

- to reduce speed
- to prevent speed increase on downhill sections
- to reduce speed to zero
- (to immobilize the train once it has stopped).

Correspondingly in the three cases we speak of:

- speed reduction to observe a speed limit (fixed, TSR Temporary Speed Restriction, signalling)
- endurance braking or retaininging,
- braking to a standstill.

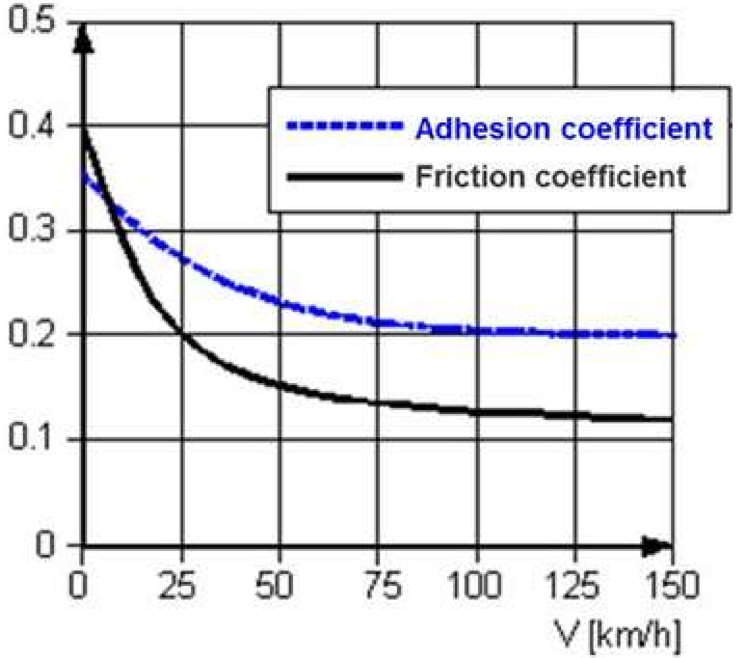
!

Reduction of the braking effect can be the cause of **hazards**.
For this reason nowadays braking systems use the maximum available adhesion, **each wheel/wheelset being equipped with its braking device**.
This is not usually done with traction motors.

! Types: block brakes

Block brake

- The braking action is obtained due to the friction force that is generated by pressing a cast-iron block against the rim.
- The braking intensity depends on the intensity of the pressing force and of the value of the block-rim coefficient of friction. The maximum value of the braking action must be in any case less than the maximum adhesion force that can be transmitted to the contact between wheel and rail.
- The adhesion coefficient and the brake block friction coefficient normally decrease with speed.



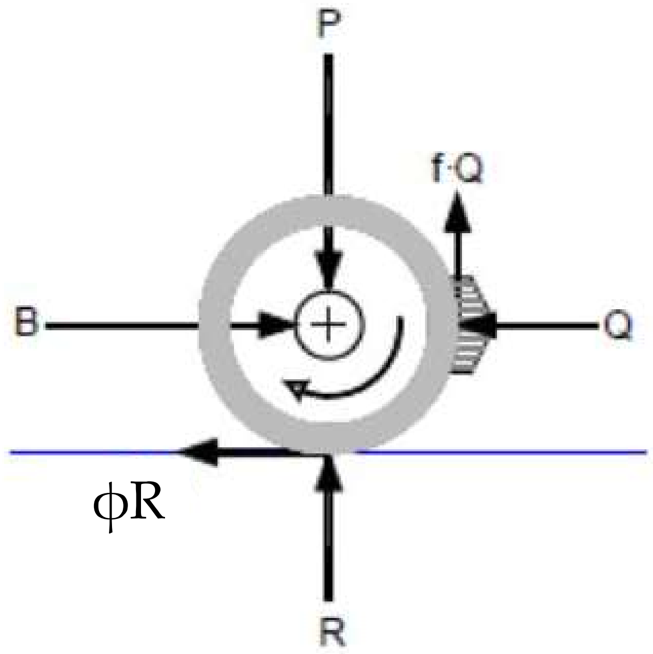
Types: block brakes

To remain within the limit of adhesion, the pressing force Q must respect the following relation.

$$Q \leq R\frac{\varphi}{f}$$

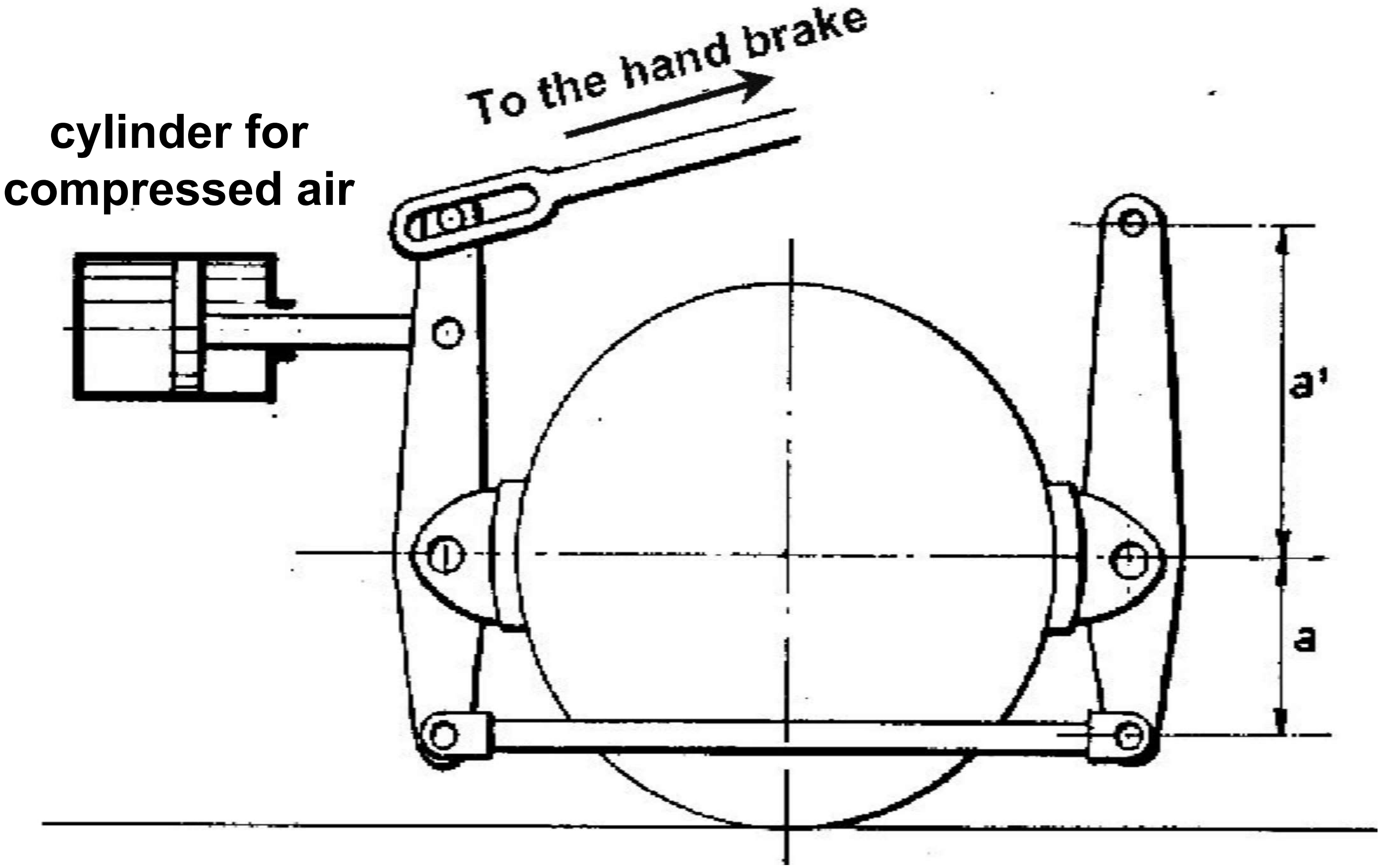
obtained by imposing the equilibrium to the rotation of the moments acting on the wheel.

If the force Q remains constant during the braking phase the previous ratio might not be verified and the wheel might lock. Force Q has to be reduced at low speeds to avoid this. At any speed the pressing force must be limited – nowadays Wheel Slide Protection systems are employed (see TSI Loc&Pas).



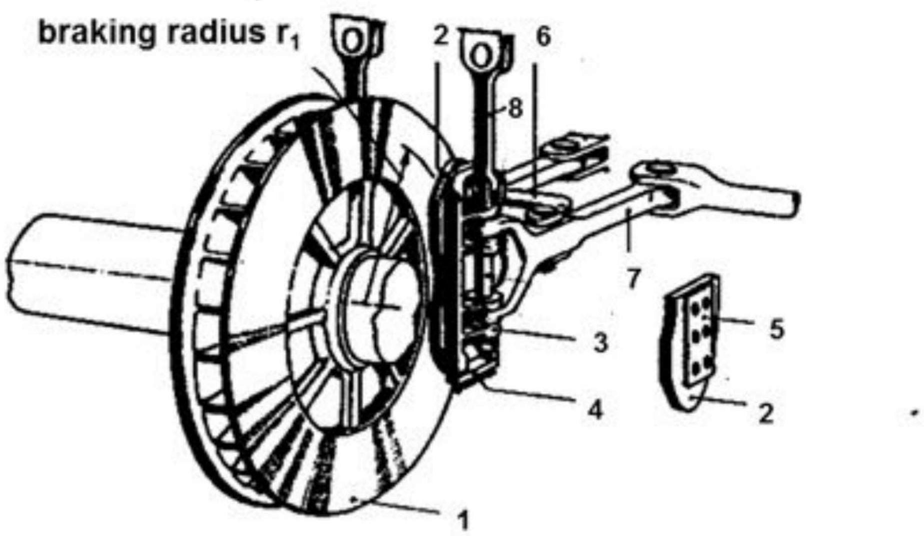
Types: block brakes

Example of linkage



Types: disc brakes

Example of Disc Brake



1 brake disc
2 resin gasket
3 gasket frame
4 gasket lockbolt
5 dovetail anchoring of the gasket
6 link of the levers
7 forked lever
8 hanger

Types: dynamic brakes

!

Electric brake (dynamic brake)

- The electric "dynamic" brake uses the principle of reversibility of the drive motors.
- The engines, by means of suitable connections, can operate as generators of electrical energy absorbing mechanical energy.
- Since electric energy cannot be accumulated it is dissipated in the vehicle by circulating current in suitable braking resistors.

Energy recovery is possible when

- at the same time there is a request of energy by another vehicle,
- for example when it has at the same time the acceleration phase of a train and the braking of another on the same route;
- in this case energy is transmitted from one train to another across the line of contact.
- This solution is used mainly in metropolitan railways in which, given the high intensity of circulation, these situations are very frequent.

Types: magnetic track brakes

- In some cases, typically especially for emergency braking, electromagnetic brakes consisting of longitudinal runners connected to the bogie frame are used.
- They are very close to the rails and parallel to them, generally arranged between the two wheels of a bogie.
- Between the pad and the rail there is an electromagnetic attraction force (e.g. due to eddy currents induced in the rails).
- Its effect is to create a running resistance due in part to friction and in part to the formation of eddy currents.

Brake system requirements

- The braking system must ensure that the brake action is always effective and that the risks of non-operation are minimized.

!
- For a train of several vehicles, nowadays brake control is required to be **single and continuous** thus allowing brake operation of all vehicles without the need for local interventions.
- Thus the link between a vehicle and the other should ensure both the transmission of traction forces and braking through the **drawgear**, and the continuity of the braking system.

!
- The possibility of drawgear failure also imposes the requirement of **automatic braking**: if any two vehicles of the train are separated by accident both resulting parts need to be stopped.

Brake system requirements

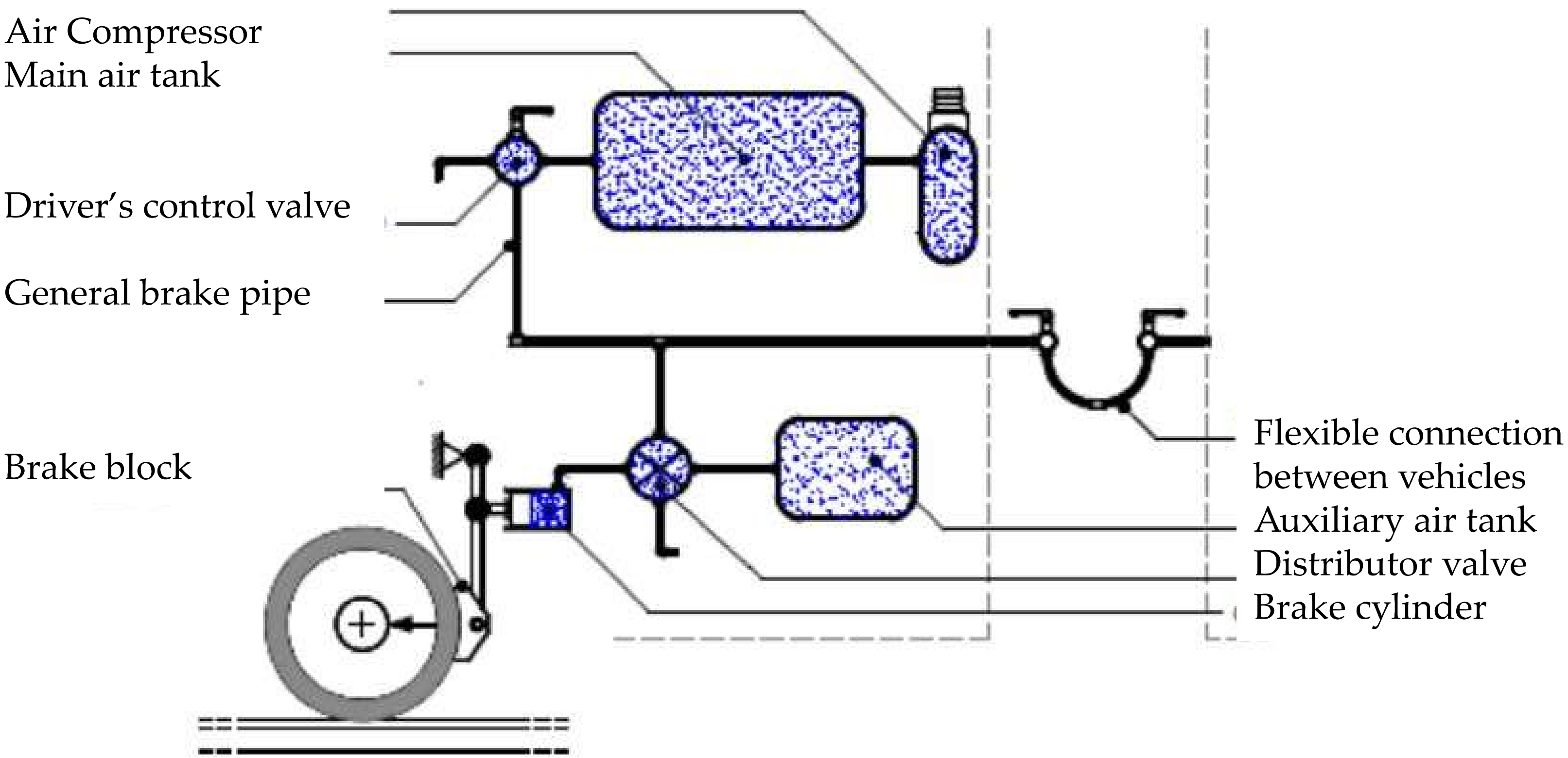
- Moreover, since the speed of the train must be appropriate to the different situations of the track and of movement, the intensity of the braking force shall be correspondingly adjustable both in the phase of braking both during the brake-release (**adjustability**).

!

- Finally, successive braking operations must be possible without any decrease in braking effectiveness (**inexhaustibility**).

Air brake system components

! The main system today for both service and emergency braking is of the **pneumatic type (air brakes).** In it the braking force is exerted by a cylinder actuated by compressed air. On each vehicle, including the locomotive, a brake pipe, an auxiliary tank, a distributor and brake cylinders are installed.



Air brake system components

! On the **locomotive** or traction unit are also located: the **compressor**, the **main tank** and the **driver's control valve**.

The system operates in depression:

- the general brake pipe is normally under pressure (about 5 bar);
- **pressure reduction** due to the driver operating the control valve **causes the braking action**, which occurs with intensity dependent on the general pipe pressure (maximum brake force at zero pressure).

The compressor and the main tank have the task of maintain the pressure within the system; the control valve regulates the intensity of the braking pressure inside of general brake pipe.

! The distributor connects the auxiliary tank with the brake cylinders that exert the braking action; the pressure therein is adjusted by the distributor in function of the pressure of the general brake pipe.

Air brake operation

Pneumatic brake operation is as follows:

- the action on the driver’s valve decreases the pressure in the pipe,
- the lowering of the pressure trips the distributor which sends air from the auxiliary tank to the brake cylinders

The opposite occurs during brake release:

- the action on the driver’s valve connects the main tank with the general brake pipe thus increasing its pressure;
- the increase in pressure sensed by the distributor disconnects the auxiliary tank and brake cylinders by placing the latter in communication with the atmosphere and restores the connection between the auxiliary tank and general brake pipe.

Air brake operation

!

- Every brake action tends to reduce the amount of air in the tanks, therefore, the required inexhaustibility is obtained through a compressor powerful enough to re-establish the initial pressure.
- Adjacent vehicles are connected by flexible connections so as to realize a single continuous pipe.

!

- The system is thus also "automatic" as required and, in this sense, **failsafe,** since the splitting of the train and flexible connections causes immediate braking action due to the rapid pressure decrease.

The disadvantages of this type of system are related to

- the inevitable leakages of air in the devices (tanks, distributor, valves, etc.) over a medium-long time span (order of hours)
- the propagation time of the pressure variations to all vehicles in the train; for very long trains - e.g. freight trains - these times may be of the order of tens of seconds capable of contributing to potentially hazardous relative longitudinal oscillations between wagons;
- in modern passenger trains the time delay issue is overcome by means of **electrical actuation** of the pneumatic system.

RAILWAY ENGINEERING
Lectures on Infrastructure & Operation
27/09/2023 - 22/12/2023

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IN0
Historical introduction and educational aims

<u>References</u>

- **Garda E., Gerbino A., Mangosio M. - *Italian railway stations heritage* – International Journal of Heritage Architecture, 2, 2, 324–334, 2018 (doi: 10.2495/HA-V2-N2-324-334)**
- **Cascetta E., Henke I., Di Bartolomeo L. – *The six transport revolutions and their evolutions. A brief history from the beginnings to the present day* – Ingegneria Ferroviaria 5, 389-418, 2021**
- **Cascetta E., Henke I., Di Bartolomeo L. - *The seventh transport revolution. Ongoing innovations and possible future scenarios* – Ingegneria Ferroviaria, 6, 461-494, 2021**

Definitions and origins

Transport system

Set of infrastructures, vehicles and services allowing mobility of persons and goods to perform social and productive activities of Society

Railway transport system

Fixed plants (infrastructures) + Rolling stock (vehicles) + Services (ensuring mobility of passengers and goods)

History of land transport systems

From prehistory: wheel discovery and rudimental use

History of railways

From 16th century (≈1530): miners of Tirol reducing efforts of horses in pulling wagons sets full of minerals by introducing sequences of tables under wheels of vehicles

Further historical technical steps

1738: Newcastle (England)

Substitution of wood with metal for guiding struts of mineral vehicles and adoption of wheels with border

1803: Pen-y-Darran (Wales)

Adoption of steam machine (by Watt, 1769) to pull mining trains

1825: Stockton – Darlington (England)

First public service of passengers with steam traction (*Locomotion*) and introduction of 1435 mm gauge standard

1829: Liverpool – Manchester (England)

First modern locomotive (*Rocket*) with tubular boiler and draught's chimney (48 km/h alone and 28 km/h pulling a 17 t train)

1838: USA

First telegraph plants following the Morse's invention

1839: Napoli – Portici (*Due Sicilie* Kingdom)

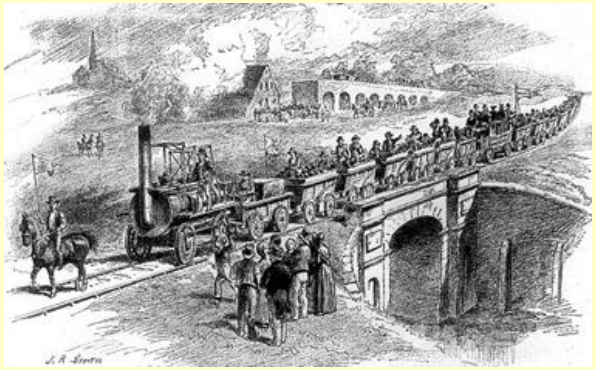
First *Italian* railway

1876: USA

Introduction of electric traction on tram lines

1897: Germany

First use of Diesel traction: engine built up by Krupp



First railway services operated in various countries

1825	United Kingdom	Stockton – Darlington
1830	USA	Charleston – Hamburg
1832	France	Saint Etienne - Lyon
1834	Ireland	Dublin - Kingstown
1835	Belgium	Bruxelles – Malines
1835	Kingdom of Bavaria	Nurnberg – Furth
1836	Canada	La Prairie – Saint John
1837	Russia	Saint Petersburg – Tzarskoe Selo
1837	Cuba	Habana - Bejucal
1837	Kingdom of Saxony	Leipzig - Althen
1838	Austria	Vienna – Floridsdorf
1838	Kingdom of Prussia	Berlin - Potsdam
1839	Kingdom of Due Sicilie	Napoli - Portici
1839	Netherlands	Amsterdam - Harlem
1840	Kingdom Lombardo-Veneto	Milano - Monza
1844	Grand Duchy of Tuscany	Pisa - Livorno
1846	Duchy of Lucca and Grand Duchy of Tuscany	Lucca – Pisa (first international service)
1846	Hungary	Pest - Vac
1847	Denmark	Copenhagen – Roskilde
1847	Switzerland	Zurich – Baden
1848	Kingdom of Sardinia	Torino - Trofarello
1848	Spain	Barcelona – Matarò
1851	Peru	El Callao - Lima
1853	India	Bombay - Thana
1854	Norway	Oslo - Eidsvoll
1854	Australia	Melbourne – Port Melbourne
1857	Egypt	Il Cairo - Alessandria
1857	Pope's State	Roma - Frascati
1857	Argentina	Buenos Aires – S.Josè de Flores
1860	South Africa	Durban – The Point
1872	Japan	Tokyo - Yokohama
1875	China	Shanghai – Wu Sung

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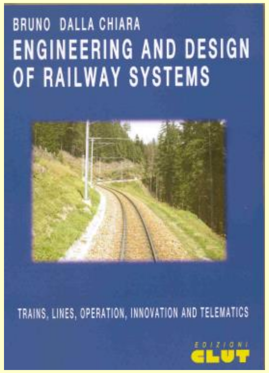
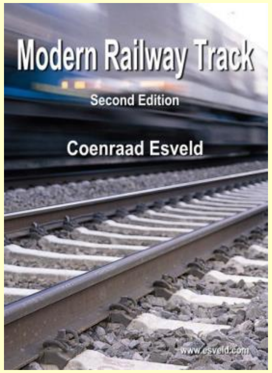
Infrastructure and superstructure

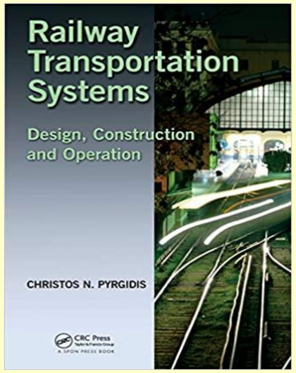
<u>References</u>

- **European Commission – *Commission Regulation (EU) No 1299/2014 of 18 November 2014 on the technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union* – 2014**
- **Sañudo Ortega R., Pombo J., Ricci S., Miranda M. – *The importance of sleepers spacing in railways* – Construction and Building Materials, 300 (2021) 124326 (doi: 10.1016/j.conbuildmat.2021.124326)**

<u>Relevant books</u>







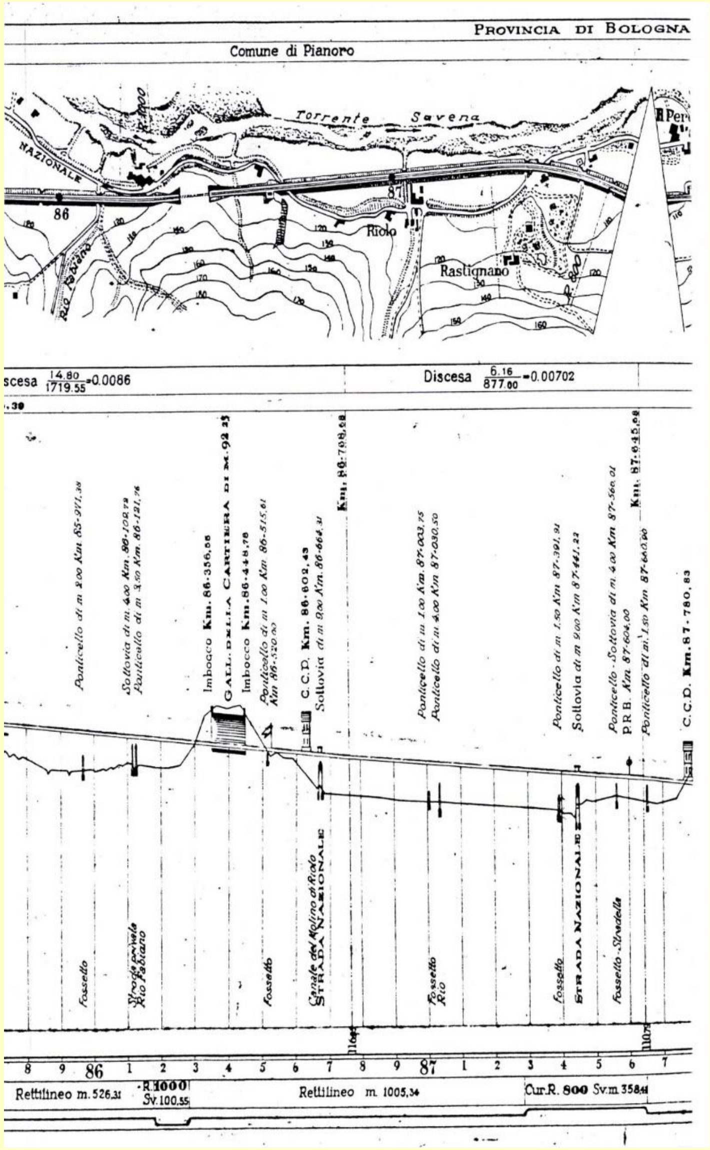
Key design elements

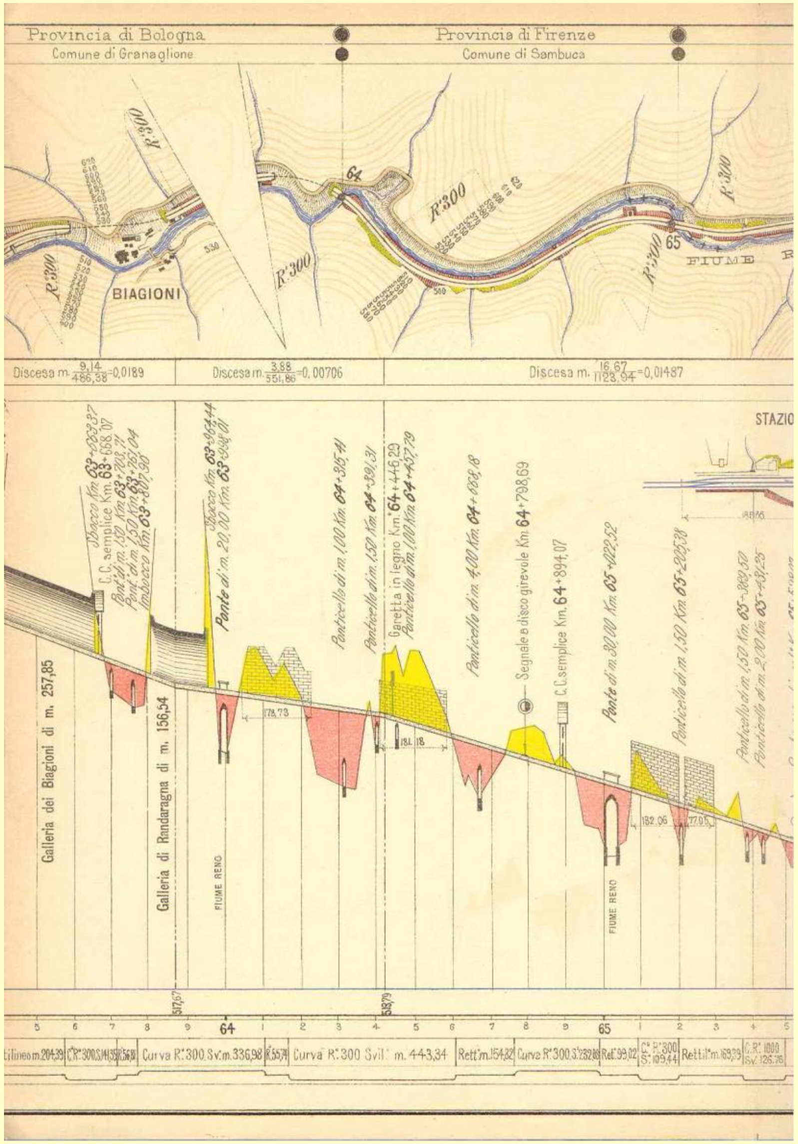
Geometry
Minimum radius of curves
Maximum slope of sections

Design criteria
Maximum allowed speed
- Effects of curves on transversal acceleration
Composition of trains (e.g., number and mass of pulled/pushed wagons)
- Effect on curves and slopes on motion resistances and required power

Geometrical representation
- Planimetry (e.g.,. 1:10,000)
- Longitudinal profile (e.g., 1:10,000/1:1000)
- Transversal cross-section (e.g., 1:100)

Planimetry of a railway line section





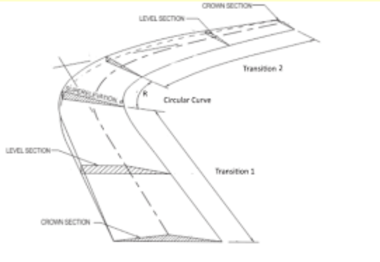
Features of geometrical representations

Planimetry

Alignment of tracks axes

Notation of extreme points of straights, circular and transition curves

Length and topographic peculiarities of railway landside



Profile

Rail alignment: tangent upwards to rail

Superstructure foundation surface

- Constant slopes and vertical connections with total lengths

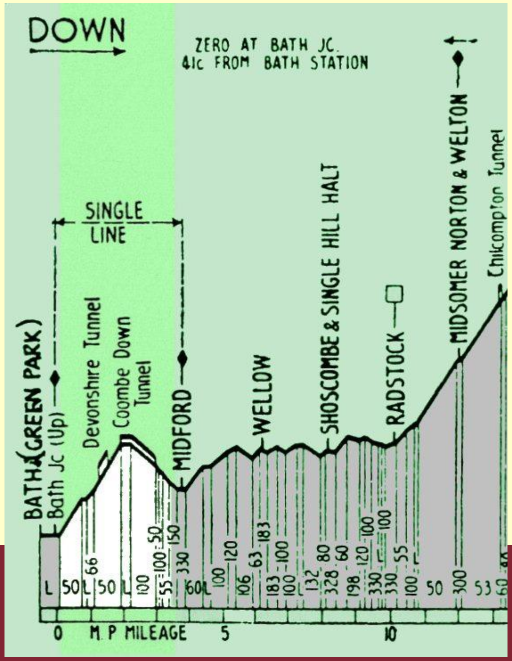
Natural surface

- Structures (bridges, viaducts, etc.)

- Level crossings

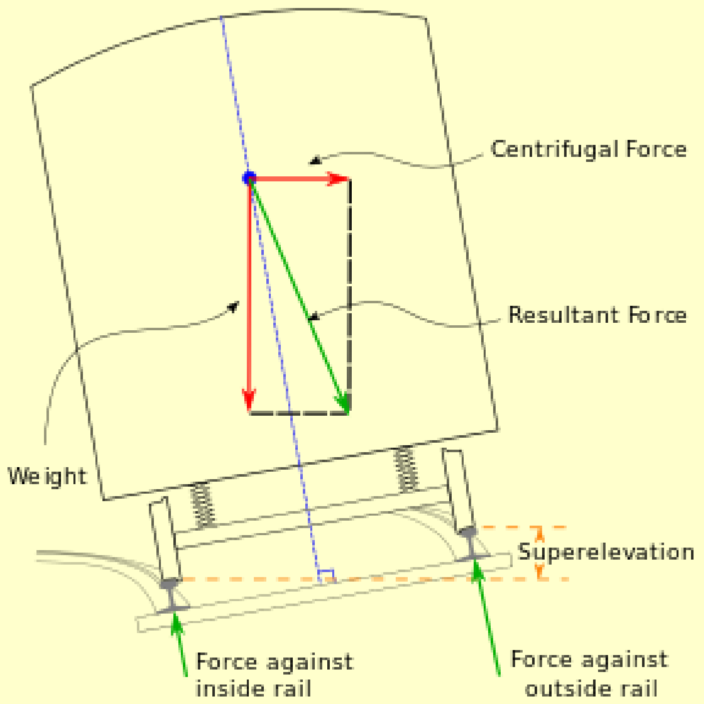
- Axes and external switches of stations

- Crossed administrative borders



Running along a curve

<u>Train exposed to centrifugal force</u>



<u>Effects</u>

Solicitation of the external (outside) rail
Reduction of passengers' comfort
Reduction of loads stability
Action in favour of over-tilting
 - Very extreme conditions

$$F_c = m \cdot a_c = m \frac{v^2}{R}$$

Link between maximum allowed speed and curve radius

$$v = \sqrt{R \cdot a_c}$$

Acceleration constraints due to comfort: 0.6-1.0 m/s²
- Much more restrictive than over-tilting and derailment risk

Maximum allowed speed along curve

<u>Typical acceleration limits</u>

$0.6\ m/s^2$: ordinary passengers trains and freight trains

$0.8\ m/s^2$: light vehicles (electric/diesel railcars)

$1.0\ m/s^2$: metro (short trip duration = tolerable transversal acceleration)

$1.0\ m/s^2$: high-speed trains (high passengers comfort onboard)

$1.5\ m/s^2$: tilting trains

<u>Super-elevation of external rail (*Cant*)</u>

Reducing transversal acceleration acting on passengers

- Residual *unbalanced* value parallel to vehicle floor

Limited due to wide speed range

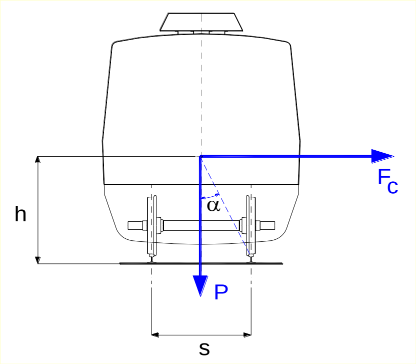
- Slow trains suffering of centripetal force for excessive super-elevation)
- Maximum cant for freight and mixed traffic (TSI): 160 mm

  (unbalanced acceleration: $0.6\ m/s^2$) $V = 4.62\sqrt{R}$

  (unbalanced acceleration: $1.0\ m/s^2$) $V = 5.15\sqrt{R}$
- Maximum cant for passenger traffic (TSI): 180 mm

Equilibrium of vehicle running along a curve

Without super-elevation of external rail



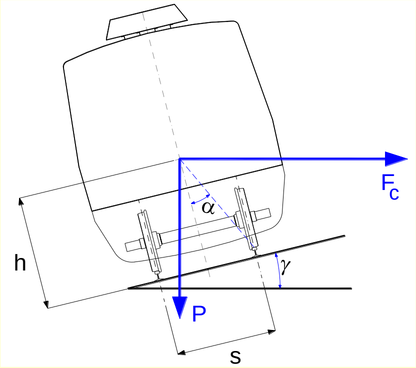
Weight: $P = mg$

Centrifuge force: $F_c = [(P/g)v^2] / R$

Not over-tilting condition

$$\frac{v^2}{R} \leq gtg\alpha \qquad tg\alpha = \frac{s}{2h}$$

With super-elevation of external rail



Extreme condition: not over-tilting

$$\frac{v^2}{R} \leq gtg(\alpha + \gamma)$$

Stability against derailment

Increased by the wheel flange

$$\left(P\frac{V^2}{gR}\right)_{unbalanced} \leq f_{transversal} P$$

Maximum speed along a curve

Super-elevation = 160 mm

Curve radius [m]	*V [km/h] for $a_{unbalanced} = 0.6\ m/s^2$*	*V [km/h] for $a_{unbalanced} = 1.0\ m/s^2$*
250	70	80
325	80	90
400	90	100
450	95	110
550	105	120
650	115	130
750	125	140
875	135	150
950	140	160
1000	145	165

Transition curves with variable radius

<u>Prevention of sudden variation of transversal acceleration passing from straight to curve or vice-versa</u>

Dimensioning criteria

- To keep linear the variation of transversal acceleration (*jerk*)
- To perform progressive height variation of external rail

<u>Maximum variation of acceleration</u>

0.14-0.40 m/s^3

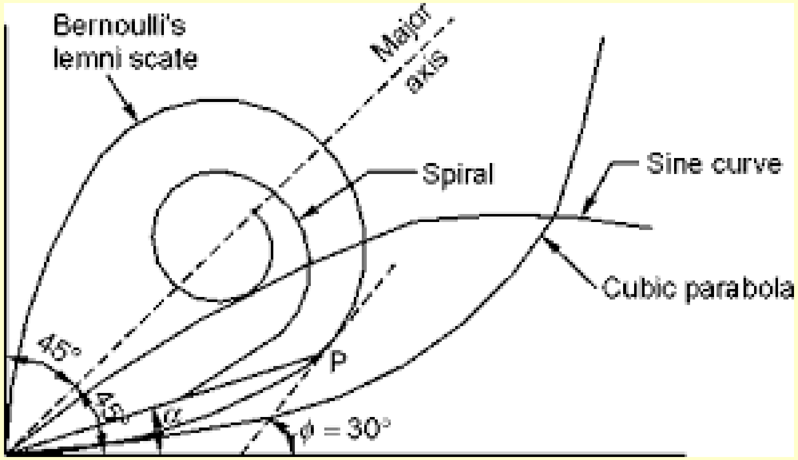
e.g., RFI: 0.14-0.21 m/s^3 (0.26 m/s^3 for high-speed lines)

<u>Most used transition curves</u>

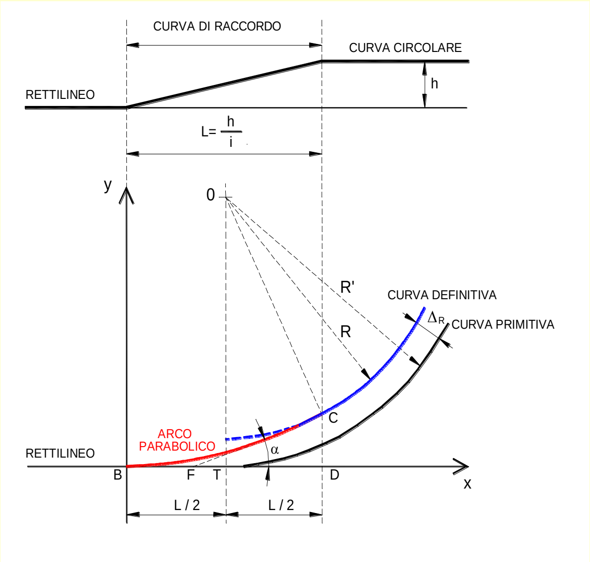
Cubic parabola (traditional)

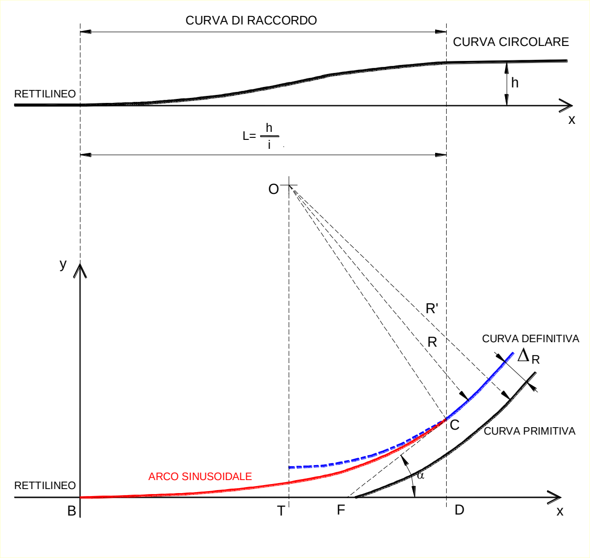
Sinusoidal (over 200 km/h)

Partial spiral (clothoid, used for roads)



Cubic parabola vs. Sinusoidal





Cubic parabola transition

$y = x^3 / 6LR$

$1/\rho = 1/RL$

R = final curve radius

ρ = curvature

L = projection of curve on X axis

S = mileage point

Minimum extension depending on maximum rotation speed (0.02-0.03 rad/s)

Sinusoidal transition

$1/\rho = 1/2R\ [2S/L - 1/\pi \text{ sen } 2\pi S/L)]$

Start and finish with horizontal tangent (*jerk* = 0)

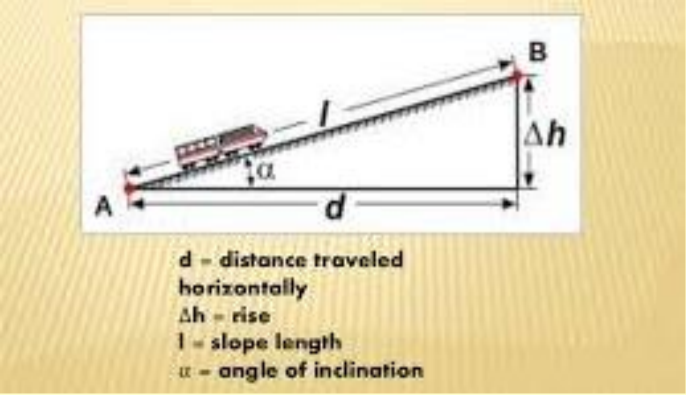
Double maximum variation at $S = L/2$

Tolerated thanks to short duration

Profile layout

Slope measurement

Trigonometric tangent of angle α lying on vertical surface between line and horizontal alignments [‰]



$$tg\alpha = i = 1000\ \Delta h \ / \ d \ [‰]$$

Typical slope values

12‰ = Maximum for speeds over 160 km/h

35‰ = Maximum for ordinary lines

70‰ = Maximum for secondary lines

140‰ = Maximum compatible with standstill of a braked locomotive (not relevant for operation due to uncertainties in friction and adherence)

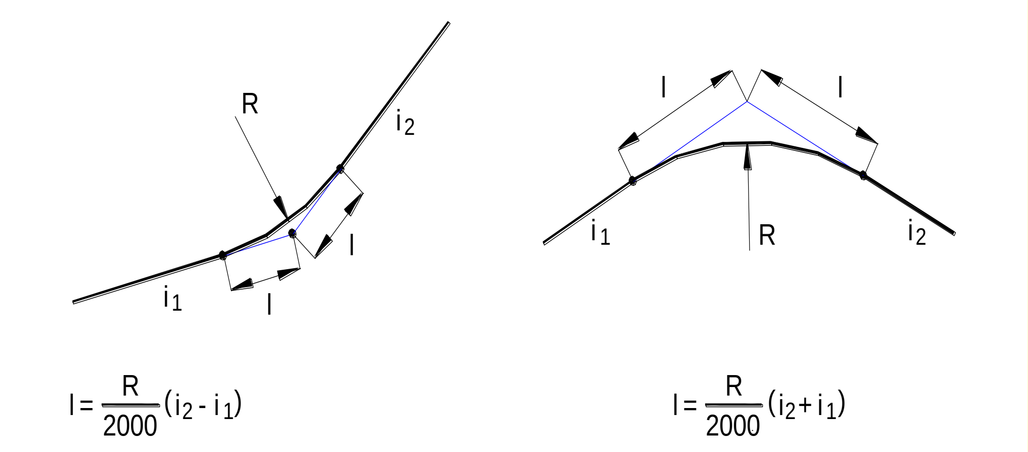
480‰ = Maximum for cog systems: Pilatus mountain, Luzern (CH)

> 480‰ = Rope systems (funicular railways or cable cars)

Vertical transition

<u>Prevent sudden variation of vertical accelerations</u>

Vertical circular transitions between concordant/discordant slopes



<u>Radius depending upon tolerated gravity acceleration variation</u>

RFI: 0.40 m/s^2

SNCF: 0.44 to 0.49 m/s^2 (convex) and 0.59 m/s^2 (concave)

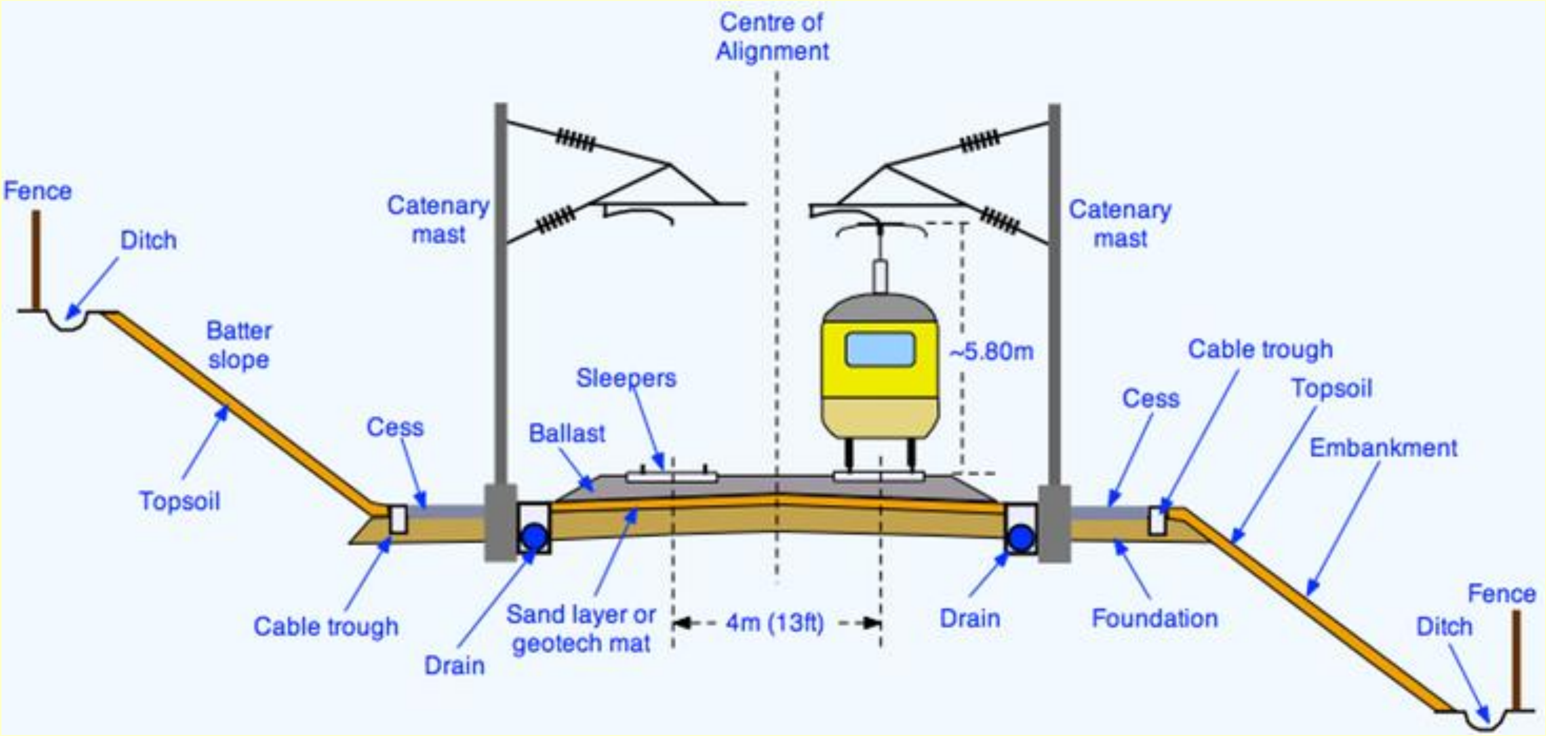
$$R = v^2 / a_v$$

Normally adopted R > 2000 m

Difference between following slopes ≤ 5‰

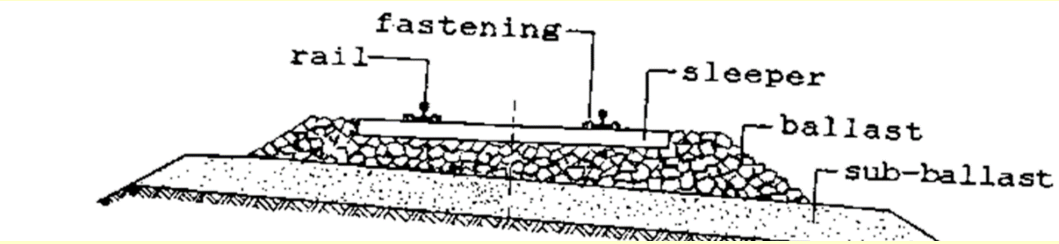
- slopes > 5‰: intermediate one with variation < 3‰ and length > 500 m

Transversal section



Superstructure elements

Rails
Fastenings
Ballast
Sleepers



Superstructure tasks and solicitations

Tasks

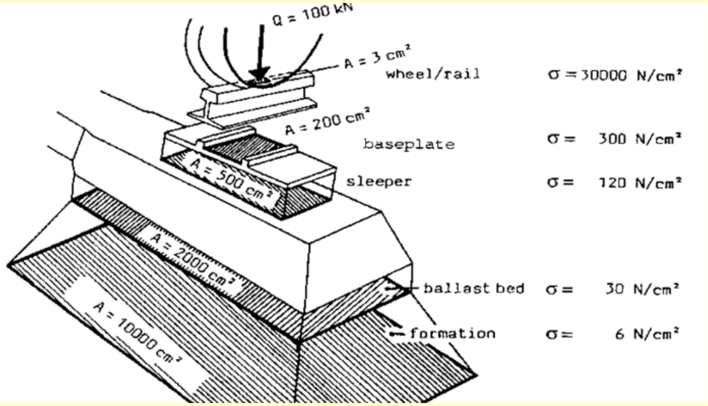
1) Progressive distribution of loads concentrated on rails into loads spread on soil to make stresses compatible with resistance of materials
2) Guidance of vehicle along desired trajectory
3) Hosting technological equipment for traffic management
   - Signaling (track circuits)
   - Traction energy (current return circuits)
   - Track-train communications (conveyed waves)

Solicitations

X) Longitudinal forces
   - Acceleration and braking strains
   - Co-actions resulting by thermic variations

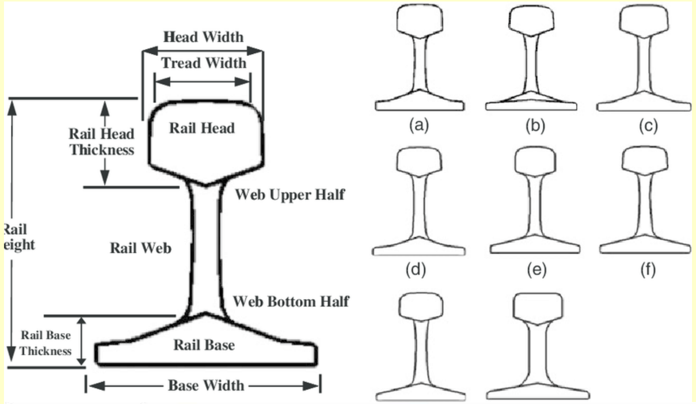
Y) Transversal forces
   - Centrifuge acceleration along curves
   - Rocking motion on the straights

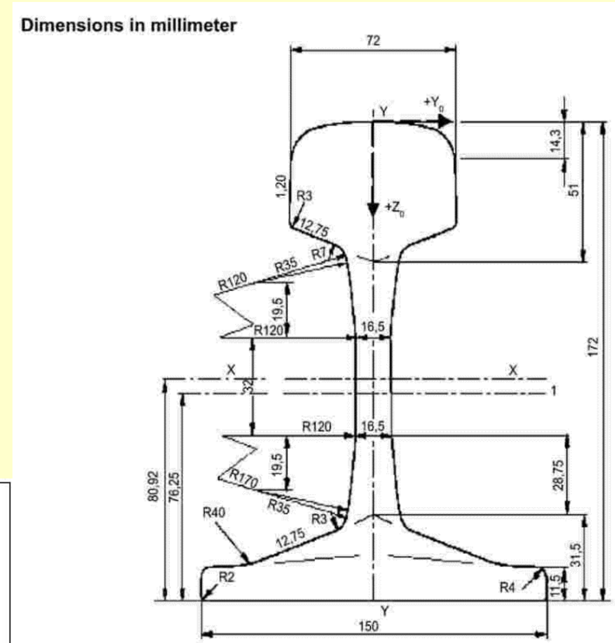
Z) Vertical forces
   - Static and dynamic loads from train

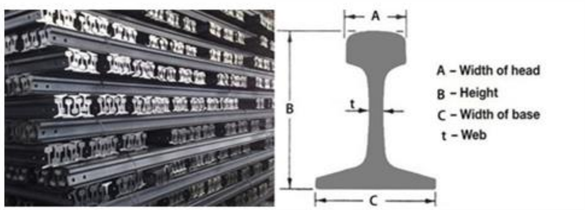


Rails

Profiles and dimensions





Product Image							
Product Name	UIC Standard Steel Rail						
Standard	UIC860-O						
Model	DIMENSION				Weight	Material	Length
	A(mm)	B(mm)	C(mm)	t(mm)	(KG/M)		(m/PC)
UIC 50	70	152	125	15	50.46	900A/1100	12-25
UIC 54	70	159	140	16	54.43	900A/1100	12-25
UIC 60	74.3	172	150	16.5	60.21	900A/1100	12-25

Key

1 Centre line of branding

Cross-sectional area:	76,70	cm^2
Mass per metre:	60,21	kg/m
Moment of inertia x-x axis:	3 038,3	cm^4
Section modulus — Head:	333,6	cm^3
Section modulus — Base:	375,5	cm^3
Moment of inertia y-y axis:	512,3	cm^4
Section modulus y-y axis:	66,3	cm^3

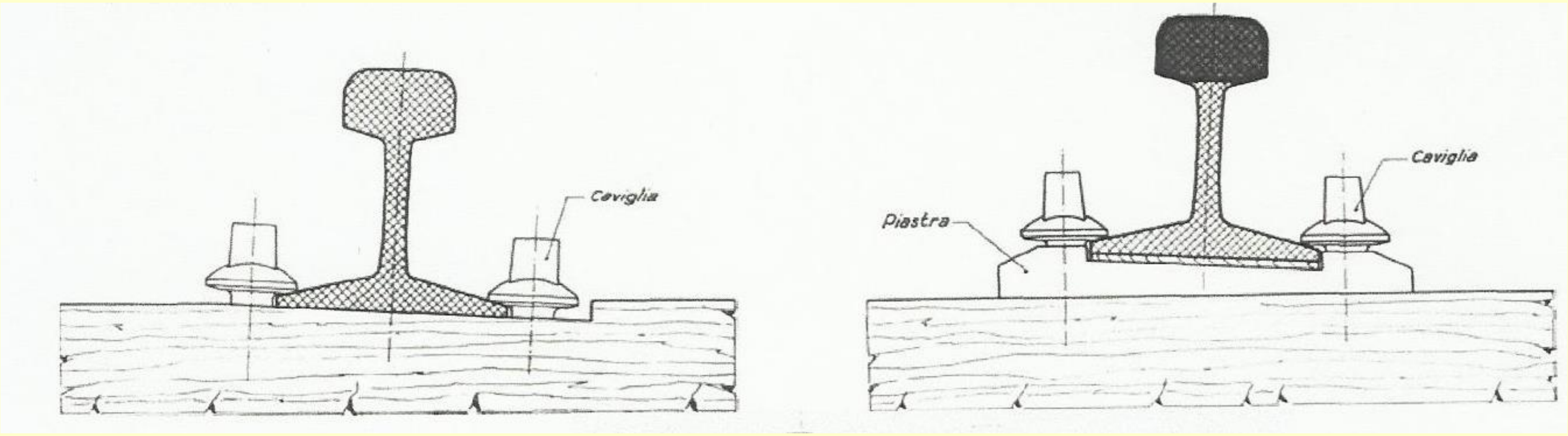
https://www.youtube.com/watch?v=YMkHcJ-EJtw

https://www.youtube.com/watch?v=ZuR5QTlfOzk

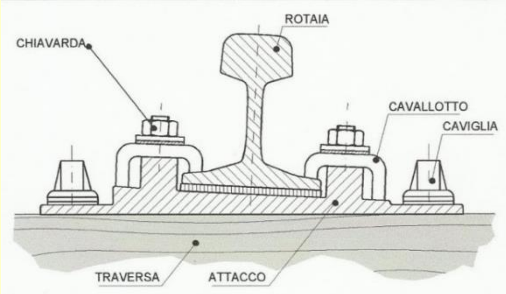
Fastenings

Direct laying + Direct fastening

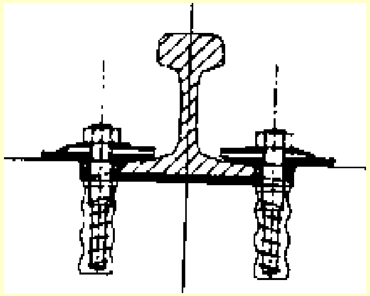
Indirect laying + Direct fastening



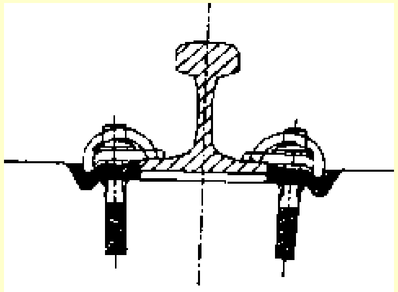
Indirect laying + Indirect fastening



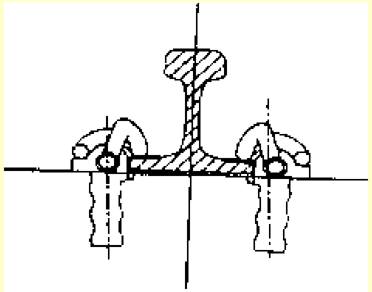
Rigid K



Nabla



Vossloh



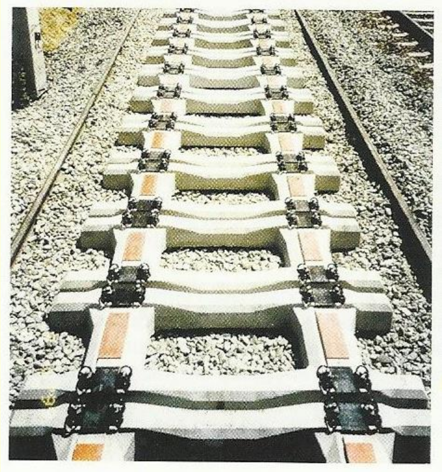
Pandrol

Sleepers

Wooden

Single block reinforced concrete

Double block reinforced concrete



Frame

Large

Ballast vs. ballast-less solutions

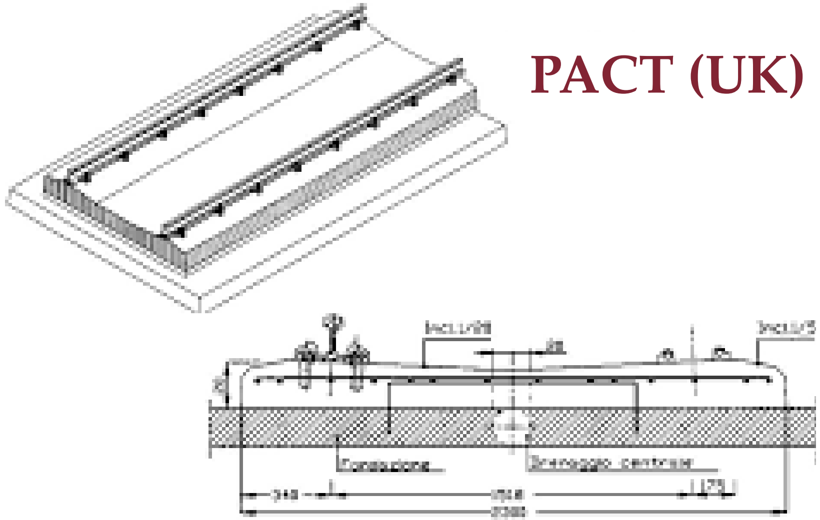
Homogeneous and durable features

Internal friction angle ≥ 45°

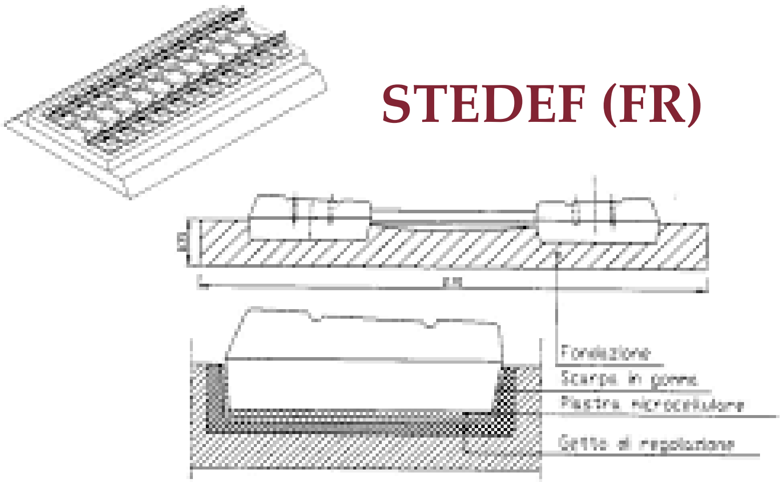
Density ≥ 1500 kg/m^3




Ballast-less superstructures

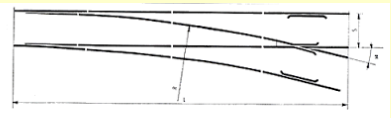


PACT (UK)

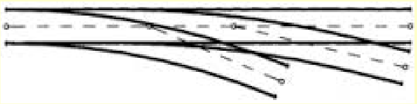


STEDEF (FR)

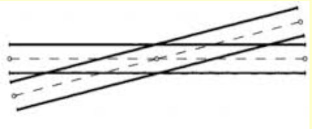
Communications among tracks



Simple switch



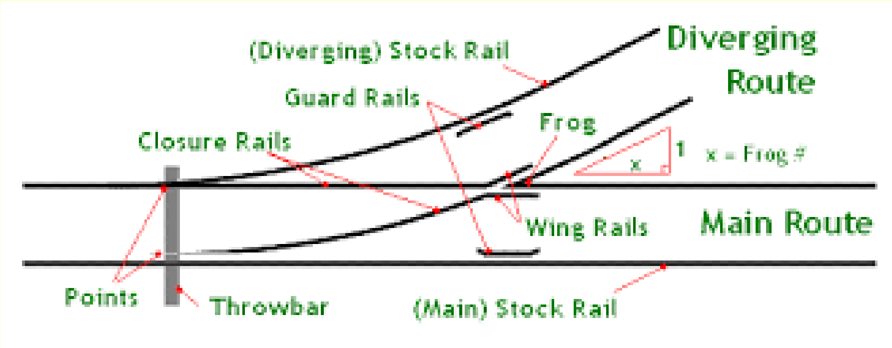
Multiple switch

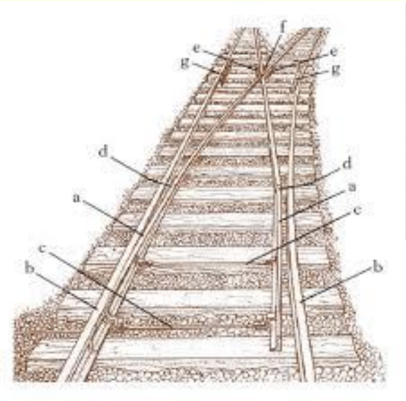


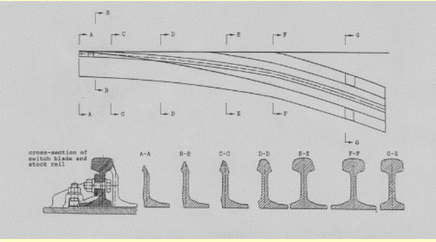
Intersection

Switch-Intersection (English switch)

Simple switch parts and layout







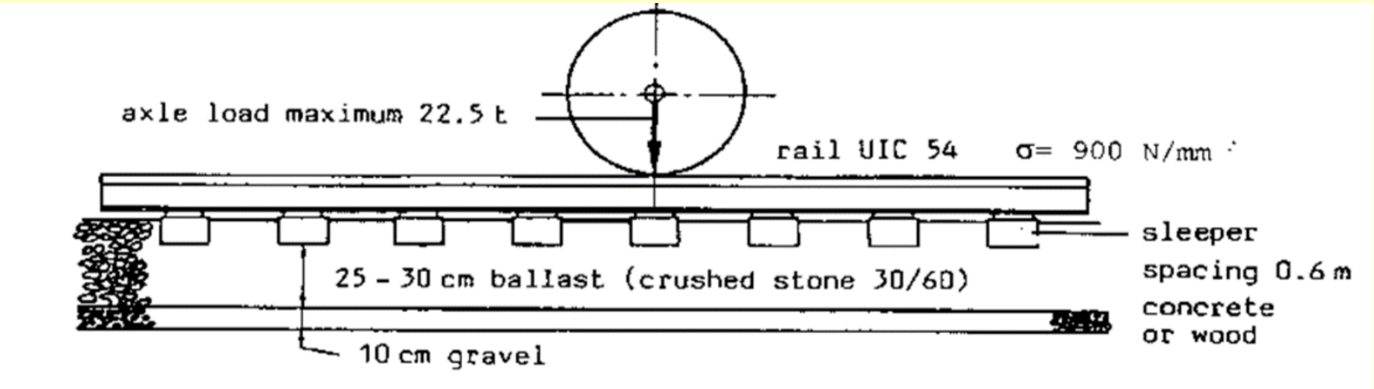
Load limits

<u>Axle load</u>

Maximum weight (tare + payload) laying on rails on train's standstill

=

Maximum solicitation tolerated <u>by track equipment</u> (12.0-25.0 t)



<u>Linear load</u>

Maximum weight (tare + payload) of a vehicle / Vehicle length measured between extremity of buffers

=

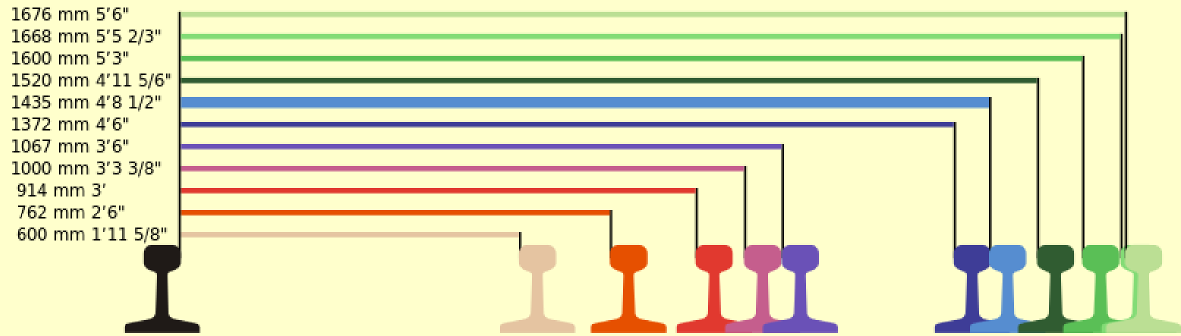
Maximum solicitation tolerated <u>by foundations and structures</u> (4.8-8.0 t)

Performance parameters for passengers and freight traffic (TSI)

Performance parameters for passenger traffic				
Traffic Code	Gauge	Axle load [t]	Line Speed [km/h]	Usable legth of platform [m]
P1	GC	17.0	250-350	400
P2	GB	20.0	200-250	200-400
P3	DE3	22.5	120-200	200-400
P4	GB	22.5	120-200	200-400
P5	GA	20.0	80-120	50-200
P6	G1	12.0	n.a.	n.a.
P1520	S	22.5	80-160	35-400
P1600	IRL1	22.5	80-160	75-240
Performance parameters for freight traffic				
Traffic Code	Gauge	Axle load [t]	Line Speed [km/h]	Train length [m]
F1	GC	22.5	100-120	740-1050
F2	GB	22.5	100-120	600-1050
F3	GA	20.0	60-100	500-1050
F4	G1	18.0	n.a.	n.a.
F1520	S	25.0	50-120	1050
F1600	IRL1	22.5	50-100	150-450

Standard for gauge

Gauge variety

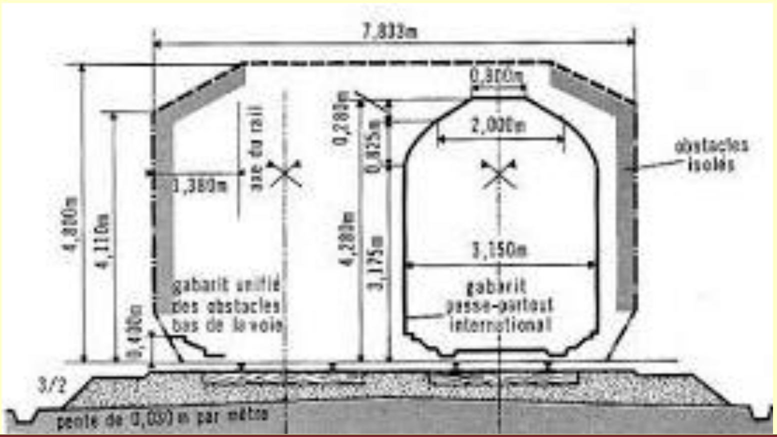


Requirements

Free trackside between vehicles and fixed obstacles

Maximum template (*Gabarit*)

Maximum transversal dimensions (rolling stocks + loads) of vehicles
- Tubular volume containing any item during motion
- Unique for straight and curve sections

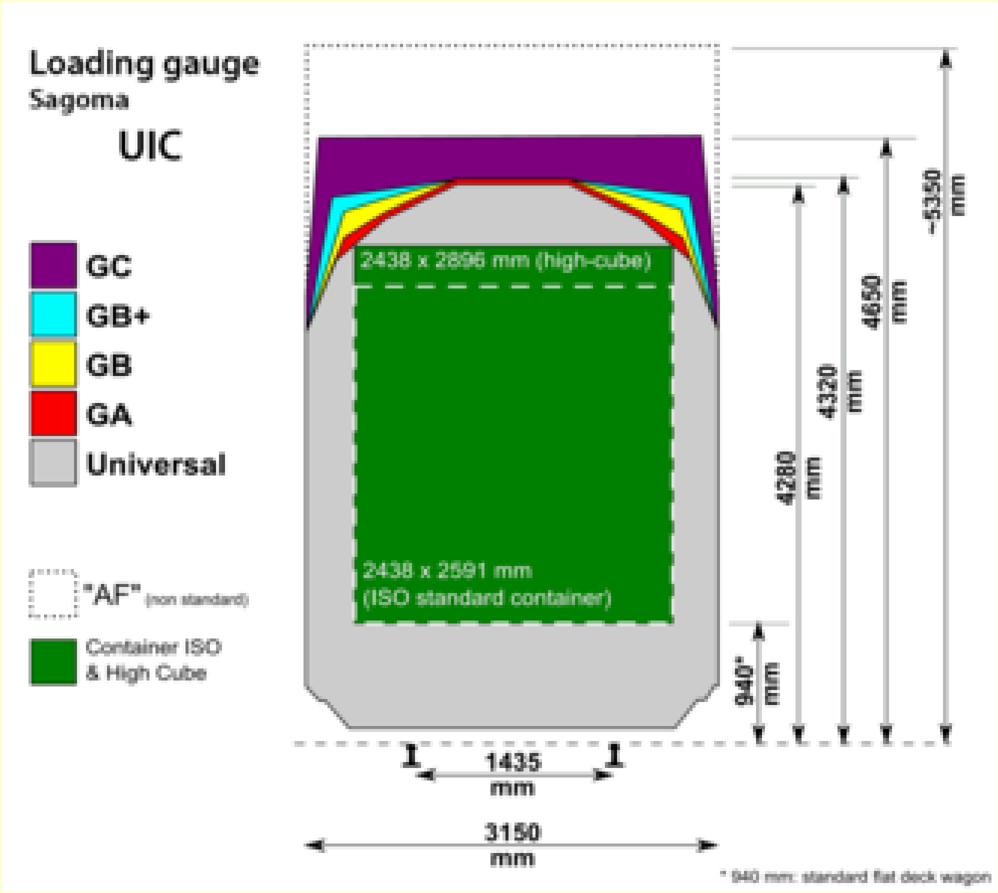


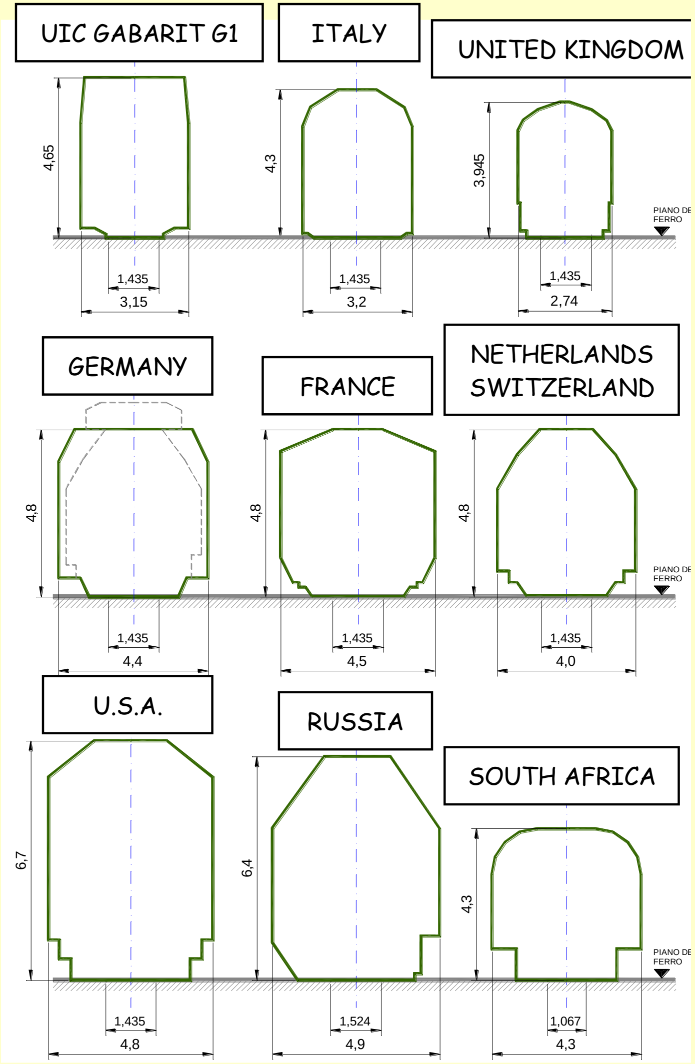
Minimum prescribed track profile

Maximum Gabarit + Free trackside

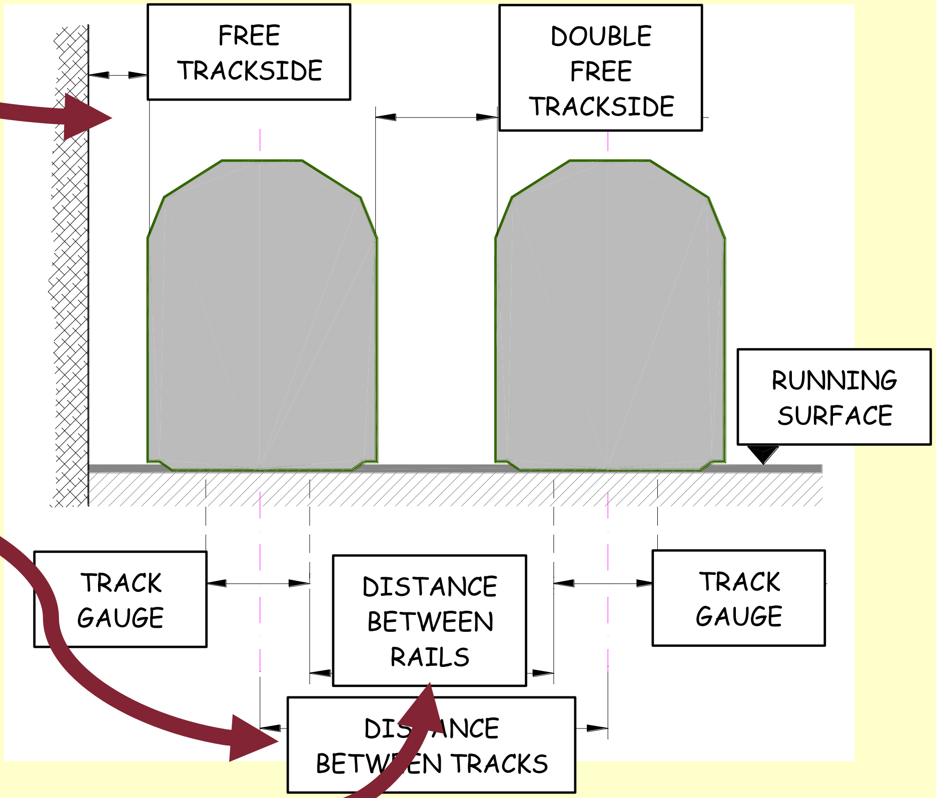
International and national maximum gauge

International Gauges (UIC)





Typical distances



<u>Free trackside, allowing</u>
Swinging due to suspensions
Unbalanced centrifugal force
Vehicle-track gauge differences
Tolerances in vehicle dimensions
Not homogeneous loads repartition

<u>Distance between tracks axis</u>
Depending on the line speed (TSI):
- 3.80 m (160-200 km/h)
- 4.00 m (200-250 km/h)
- 4.20 m (250-300 km/h)
- 4.50 m (> 300 km/h)

<u>Distance between side-by-side internal rails</u>

Maximum speed [km/h]	<100	100-140	140-160	160-180	180-200	>200
Distance [m]	1.65	1.75	1.80	1.90	2.00	2.40

Additional space for walking path (RFI): 0.50 m (line), 0.25 m (station)

IN2
Timetable definition and train composition

<u>References</u>

- **European Commission – *Commission implementing regulation (EU) 2019/773 of 16 May 2019 on the technical specification for interoperability relating to the operation and traffic management subsystem of the rail system within the European Union and repealing Decision 2012/757/EU* - 2019**
- **Pachl J. - *Railway timetable & traffic. Timetable design principles* – Railway Timetabling & Operations, Eurail Press, Hamburg, 2008 (ISBN 3-777-10462-1)**
- **Ivina D., Palmqvist C.W. - *Railway maintenance windows. Discrepancies between planning and practice in Sweden* - Transportation Research Interdisciplinary Perspectives, 22, 100927, 2023 (doi: 10.1016/j.trip.2023.100927)**

Limits to train's speed

<u>Line</u>
Lay-out geometry
Superstructure
Infrastructure
Other constraints

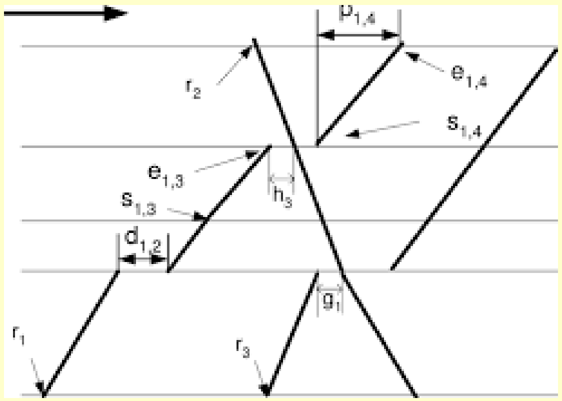
<u>Vehicles</u>
Traction Power
- Typology and position of locomotive
- Number and typology of pulled/pushed vehicles
Braking power
- Performances of braking systems

<u>Criteria to consider limits due to line and vehicles</u>
Classification of lines
Standard performances of trains on lines

Single train timetable planning process

1) <u>Fix departure and arrival times from/to first and last stations</u>

2) <u>Fix train speed on sections of the line</u>
Locomotive
Train mass
Planned speed, including buffer to recover possible delays
 - Normally at least 10% speed reduction



3) <u>Fix intermediate stations to be called</u>
Additional times for acceleration and deceleration

4) <u>Derive running times between stations</u>
Estimation according to standard performances
Precise calculation according to line and rolling stock (next step)

Reference values according to standard performances

Maximum pulled mass (tare + payload) [t]
(Electric locomotive E656 on various line sections)

Speed categories [km/h]	*120*	*110*	*100*	*90*	*80*	*70*	*65*	*55*
Roma Termini – Campoleone	1150	1330	1330	1330	1330	1330	1330	1330
Campoleone – Priverno F.	1580	1600	1600	1600	1600	1600	1600	1600
Priverno F. – Culmine galleria M. Orso	920	1040	1210	1210	1210	1210	1210	1210
Culmine galleria M. Orso – Fondi	1580	1600	1600	1600	1600	1600	1600	1600
Fondi – Itri	680	760	920	1160	1210	1210	1210	1210
Itri – Formia	1600	1600	1600	1600	1600	1600	1600	1600

Additional times for acceleration and deceleration [min]
(Electric powered trains)

Additional time	*Station category*	*Line average speed [km/h]*				
		>110	*100*	*90*	*70÷80*	*55÷65*
Acceleration	A	2,5	2,0	1,5	1,0	0,5
	B	3,0	2,5	2,0	1,5	1,0
	C	3,5	3,0	2,5	2,0	1,0
	D	4,0	3,5	3,0	2,5	1,5
Deceleration	All	0,8	0,5	0,5	0,5	0,5

Inputs for pulled/pushed mass

Conventional loads for some vehicles

Vehicle typology	*Conventional load [t]*
First class coach	4
Second class coach	5
Second class coach with more than 80 seats	6
Bar, restaurant coaches	2
Double level coaches	12
Sleeping coaches	2
Luggage coaches	5
Double level wagons with cars	2
Freight wagons with animals or large parcels	3
Freight wagons with big animals	6÷8
Service wagons for maintenance works	10

Maximum efforts tolerated by coupling gears of first pulled vehicle

Design standard for breaking stress: 850-950 kN
(tensioners, coupling hooks and draw bars)
Reduced conventional stress: 650 kN (presence of old wagons)
Maximum prudential force: 260 kN (safety coefficient: 2.5)

Maximum load reduction due to slope

Horizontal sections: 2000 t
35‰ slopes: 530 t (progressive higher risk of rips and skids upwards)

Braking power

Conventional effective % braking effort
Effective braked mass / Total mass to brake
(calculated by braking performance and load on each braking axis)

Values for vehicles equipped with continuous braking systems

Vehicle	*Mass to be braked [t]*	*Braked mass [t]*
Steam locomotive 940	87	52 (60%)
Diesel locomotive D 445	72-76	60-64 (83%)
Electric locomotive E 444	78-80	72 (90%)
Electric locomotive E 656	120	100 (83%)
Railcar ALn 668	32-37	38-42 (113%)
Railcar ALe 804	54	44 (81%)
Electro-train ETR 450	41-46	67 (146%)

Braking effort requirements along descending slopes
1) Immobilization of rolling stock at standstill
2) Calculation of braking distance according to braked mass
3) Calculation of maximum speed depending on braked mass

Information for train driving

<u>Sequence of stations and singular points</u>
Progressive distances

<u>Required traction and braking performances</u>
Standard values according to slopes

<u>Features of signalling systems</u>
Information provided and actions required

<u>Speed by sections</u>
Planned (according to timetable) and maximum values

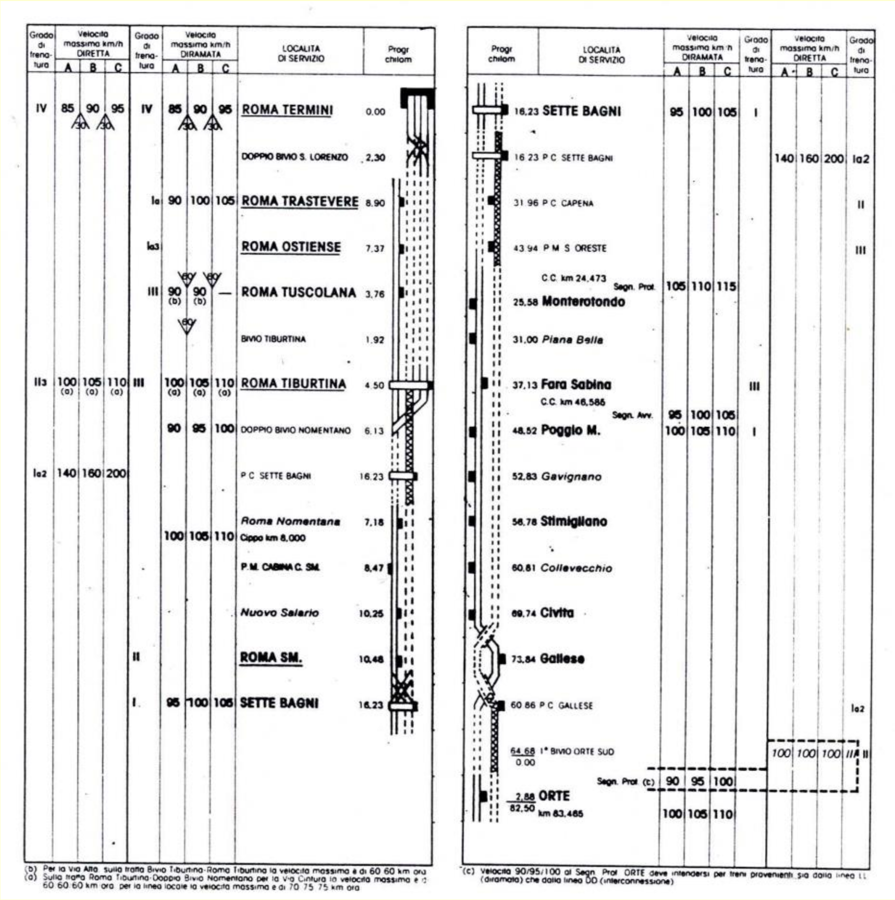
<u>Permanent and temporary speed restrictions</u>
Lay-out, signalling, maintenance

<u>Run time per each line section</u>
Planned timetable

Additional information available to the driver

Example for a line section

Roma Termini - Orte

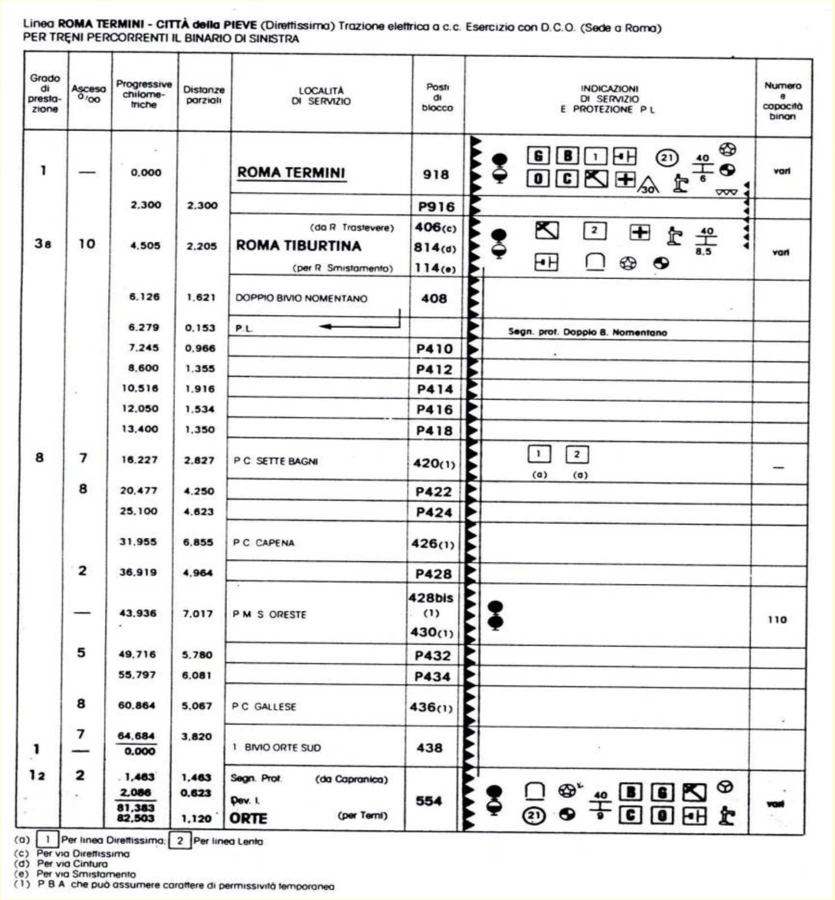


Grado di frenatura	Velocità massima km/h DIRETTA A	B	C	Grado di frenatura	Velocità massima km/h DIRAMATA A	B	C	LOCALITÀ DI SERVIZIO	Progr chilom
IV	85	90	95	IV	85	90	95	ROMA TERMINI	0.00
								DOPPIO BIVIO S. LORENZO	2,30
				Ia	90	100	105	ROMA TRASTEVERE	8.90
				Ia3				ROMA OSTIENSE	7.37
				III	90 (b)	90 (b)	—	ROMA TUSCOLANA	3.76
								BIVIO TIBURTINA	1.92
IIa	100 (a)	105 (a)	110 (a)	III	100 (a)	105 (a)	110 (a)	ROMA TIBURTINA	4.50
					90	95	100	DOPPIO BIVIO NOMENTANO	6.13
Ia2	140	160	200					P C SETTE BAGNI	16.23
					100	105	110	*Roma Nomentana* Cippo km 8,000	7,18
								P.M. CABINA C. SM.	8,47
								Nuovo Salario	10,25
				II				ROMA SM.	10,48
				I	95	100	105	SETTE BAGNI	16,23

(b) Per la Via Alta, sulla tratta Bivio Tiburtina-Roma Tiburtina la velocità massima è di 60 60 km ora
(a) Sulla tratta Roma Tiburtina-Doppio Bivio Nomentano per la Via Cintura la velocità massima è di 60 60 60 km ora, per la linea locale la velocità massima è di 70 75 75 km ora

Progr chilom	LOCALITÀ DI SERVIZIO	Velocità massima km/h DIRAMATA A	B	C	Grado di frenatura	Velocità massima km/h DIRETTA A	B	C	Grado di frenatura
16,23	SETTE BAGNI	95	100	105	I				
16 23	P C SETTE BAGNI					140	160	200	Ia2
31 96	P C CAPENA								II
43 94	P M S ORESTE								III
	C.C. km 24,473 Segn. Prot.	105	110	115					
25,58	**Monterotondo**								
31,00	*Piana Bella*								
37,13	**Fara Sabina** C.C. km 46,586				III				
	Segn. Avv.	95	100	105					
48,52	**Poggio M.**	100	105	110	I				
52,83	*Gavignano*								
56,78	**Stimigliano**								
60,81	*Collevecchio*								
69,74	**Civita**								
73,84	**Gallese**								
60 86	P C GALLESE								Ia2
64,68 / 0.00	1° BIVIO ORTE SUD					100	100	100	IIA II
	Segn. Prot. (c)	90	95	100					
2,88 / 82,50	ORTE km 83,465	100	105	110					

(c) Velocità 90/95/100 al Segn. Prot. ORTE deve intendersi per treni provenienti sia dalla linea LL (diramata) che dalla linea DD (interconnessione)



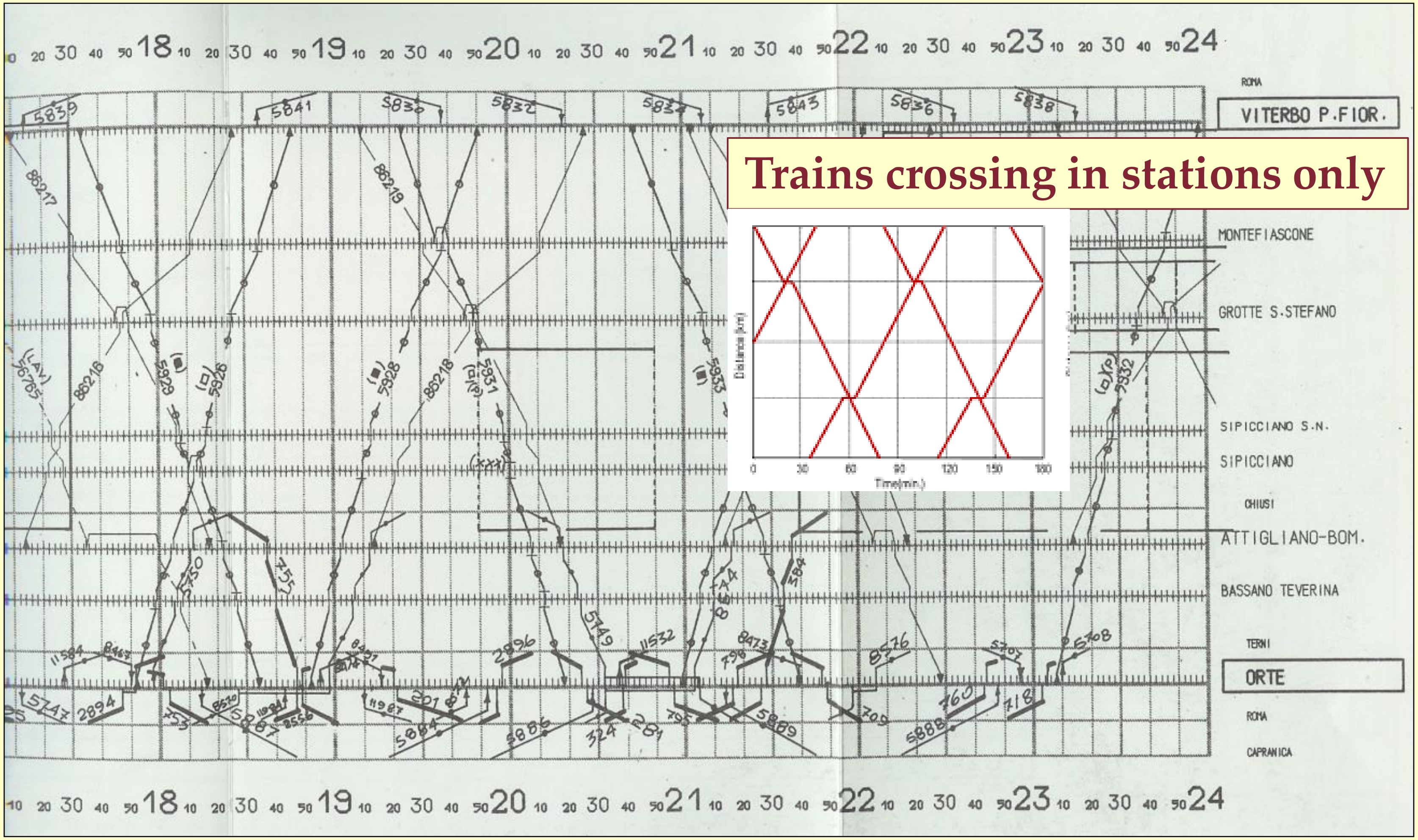
Linea ROMA TERMINI - CITTÀ della PIEVE (Direttissima) Trazione elettrica a c.c. Esercizio con D.C.O. (Sede a Roma)
PER TRENI PERCORRENTI IL BINARIO DI SINISTRA

Grado di presta-zione	Ascesa ‰	Progressive chilometriche	Distanze parziali	LOCALITÀ DI SERVIZIO	Posti di blocco	INDICAZIONI DI SERVIZIO E PROTEZIONE P.L.	Numero e capacità binari
1	—	0,000		ROMA TERMINI	918	G B 1 (21) 40 6 0 C 30	vari
		2,300	2,300		P916		
38	10	4,505	2,205	(da R. Trastevere) ROMA TIBURTINA (per R. Smistamento)	406(c) 814(d) 114(e)	2 40 8.5	vari
		6,126	1,621	DOPPIO BIVIO NOMENTANO	408		
		6,279	0,153	P.L.		Segn. prot. Doppio B. Nomentano	
		7,245	0,966		P410		
		8,600	1,355		P412		
		10,516	1,916		P414		
		12,050	1,534		P416		
		13,400	1,350		P418		
8	7	16,227	2,827	P C SETTE BAGNI	420(1)	1 (a) 2 (a)	—
	8	20,477	4,250		P422		
		25,100	4,623		P424		
		31,955	6,855	P C CAPENA	426(1)		
	2	36,919	4,964		P428		
	—	43,936	7,017	P M S ORESTE	428bis (1) 430(1)		110
	5	49,716	5,780		P432		
		55,797	6,081		P434		
	8	60,864	5,067	P C GALLESE	436(1)		
1	7 —	64,684 / 0,000	3,820	1 BIVIO ORTE SUD	438		
12	2	1,463 / 2,086 / 81,383 / 82,503	1,463 / 0,623 / 1,120	Segn. Prot. (da Capranica) / Dev. I. / ORTE (per Terni)	554	40 B G (21) 9 C 0	vari

(a) [1] Per linea Direttissima; [2] Per linea Lenta
(c) Per via Direttissima
(d) Per via Cintura
(e) Per via Smistamento
(1) P.B.A. che può assumere carattere di permissività temporanea

Graphic timetable on a single-track line

Example for a line section   Viterbo – Orte

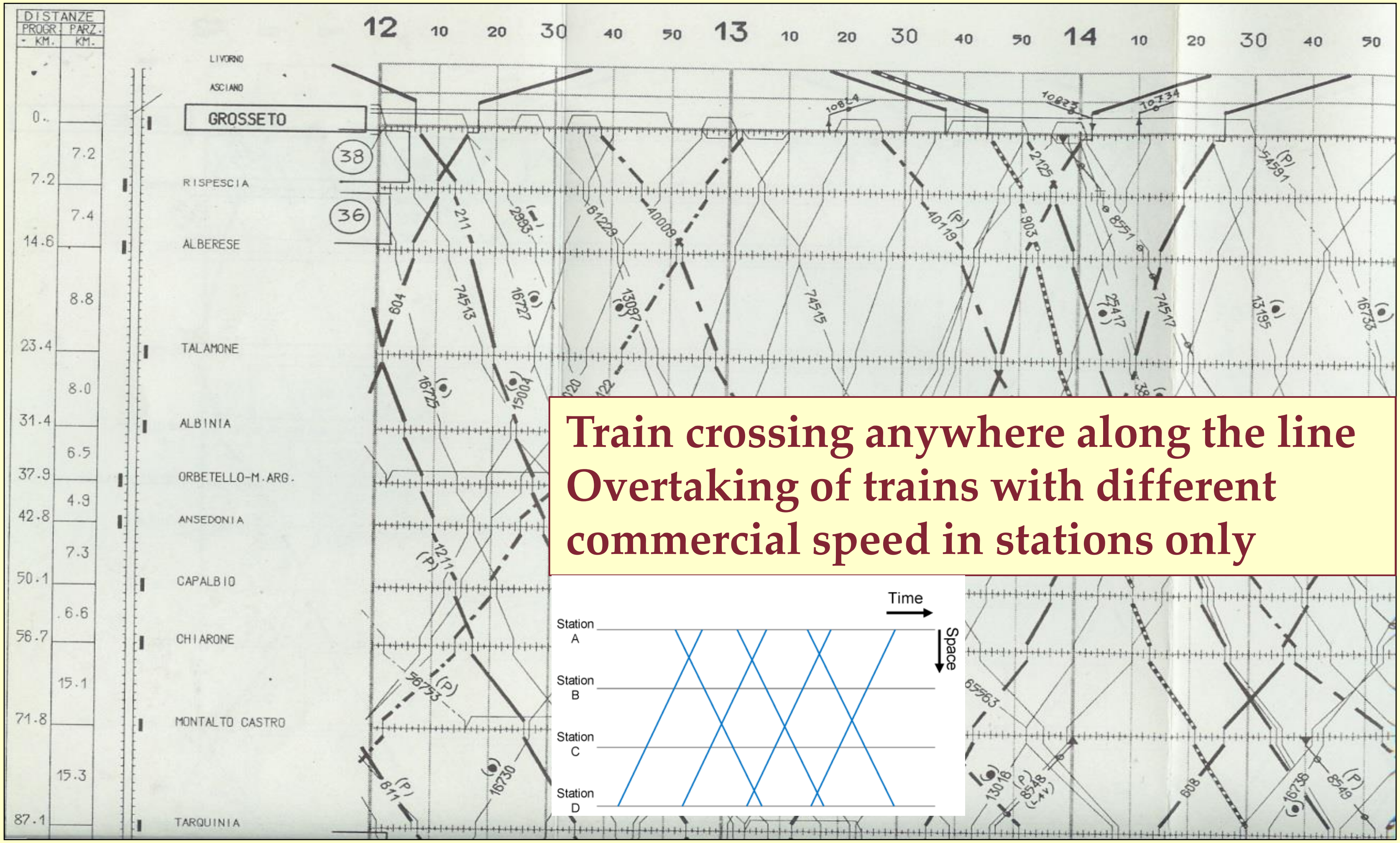


Trains crossing in stations only

Graphic timetable on a double-track line

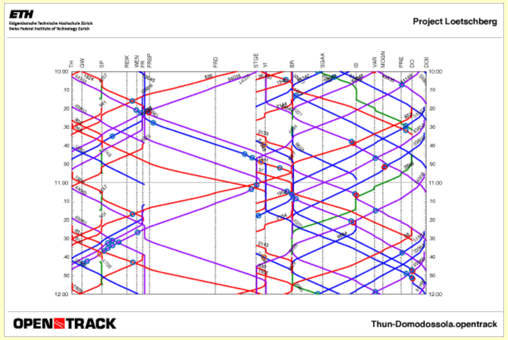
Example for a line section

Tarquinia - Grosseto



Train crossing anywhere along the line
Overtaking of trains with different commercial speed in stations only

Double-track line operation



<u>Specialised tracks</u>
Normal operation

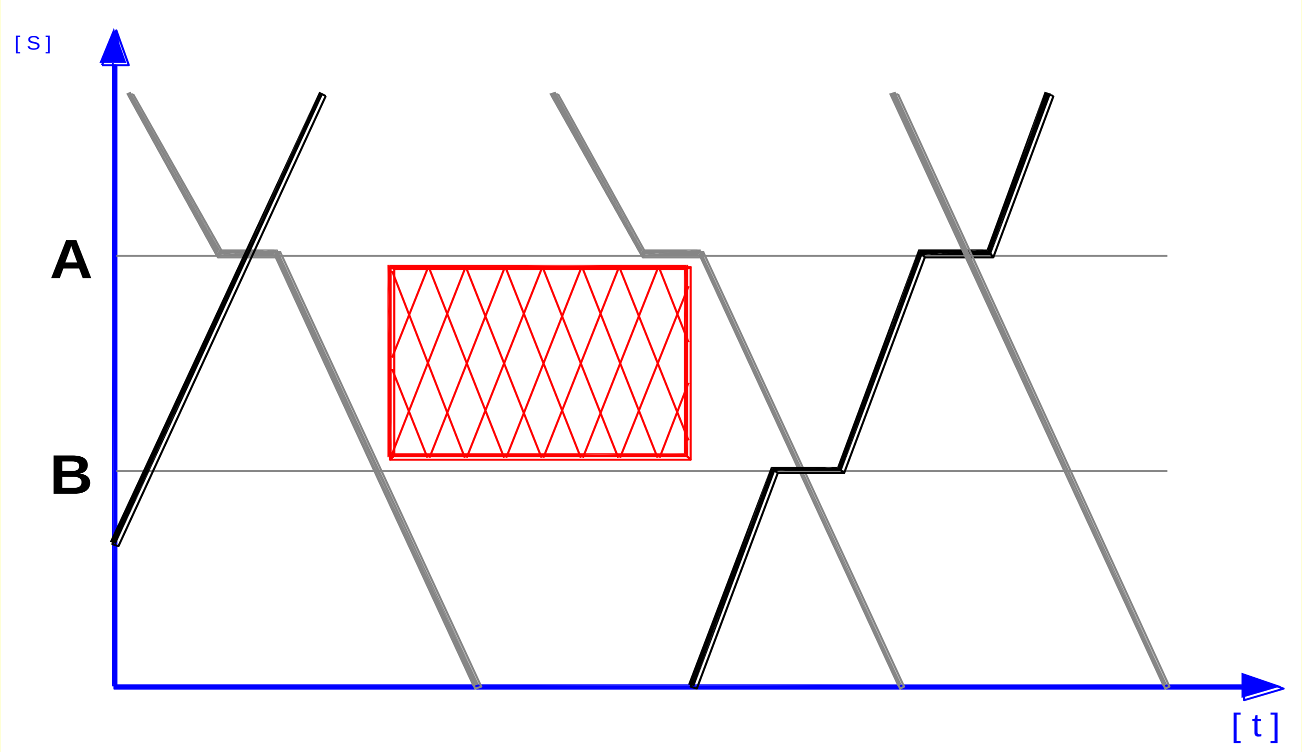
<u>Temporary single track bi-directional operation</u>
Traffic management between extreme stations/junctions

<u>Temporary mono-directional operation of both tracks</u>
Parallel traffic on high density traffic lines
Required line reversibility (*Banalisation*)
Signalling designed to allow this operational mode

<u>Signalling banalisation</u>
Reducing negative effects on traffic due to exclusion of a track
Dynamic parallel overtaking avoiding to stop the overtaken train
Parallel operation for dense mono-directional traffic (peak periods)

Effects of maintenance interval on single-track line

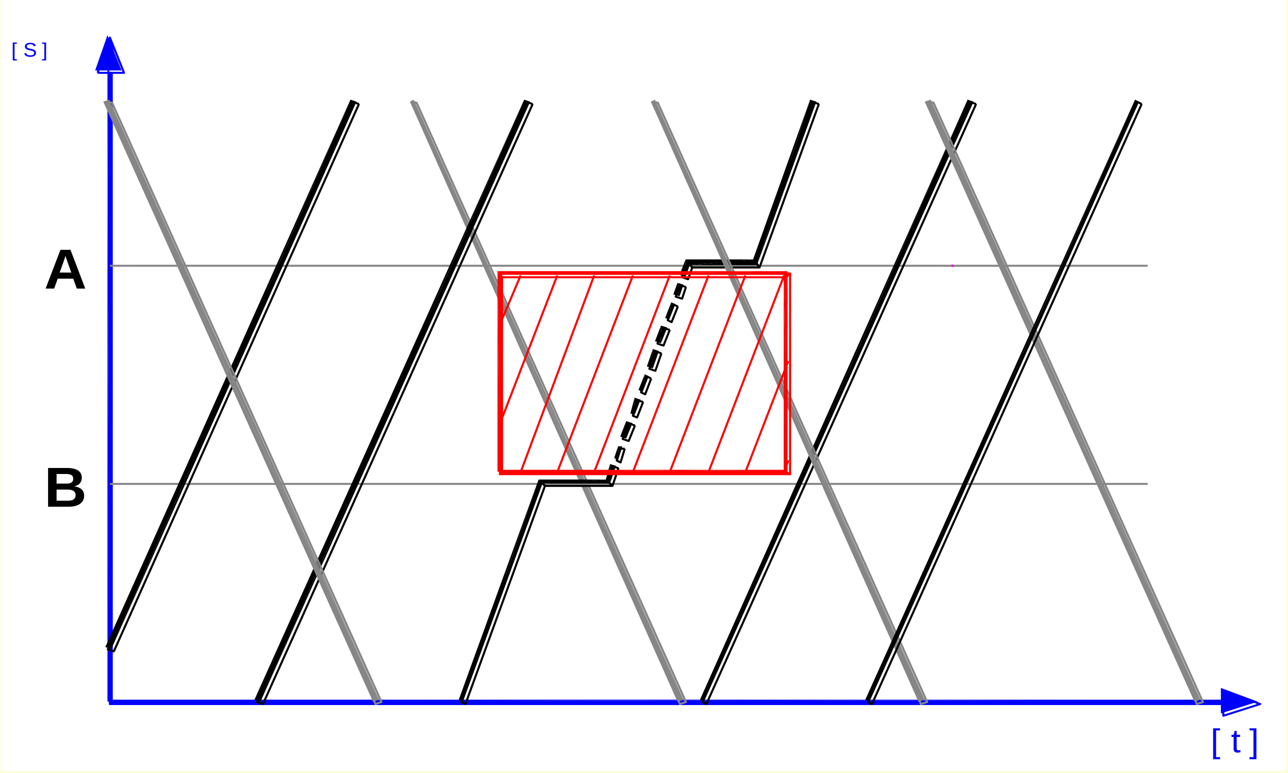
<u>Interruption requiring total suspension of services</u>
Planned maintenance intervals during low traffic periods
Exceptionally, substitutions with alternative services (buses)



Effects of maintenance interval on double-track line

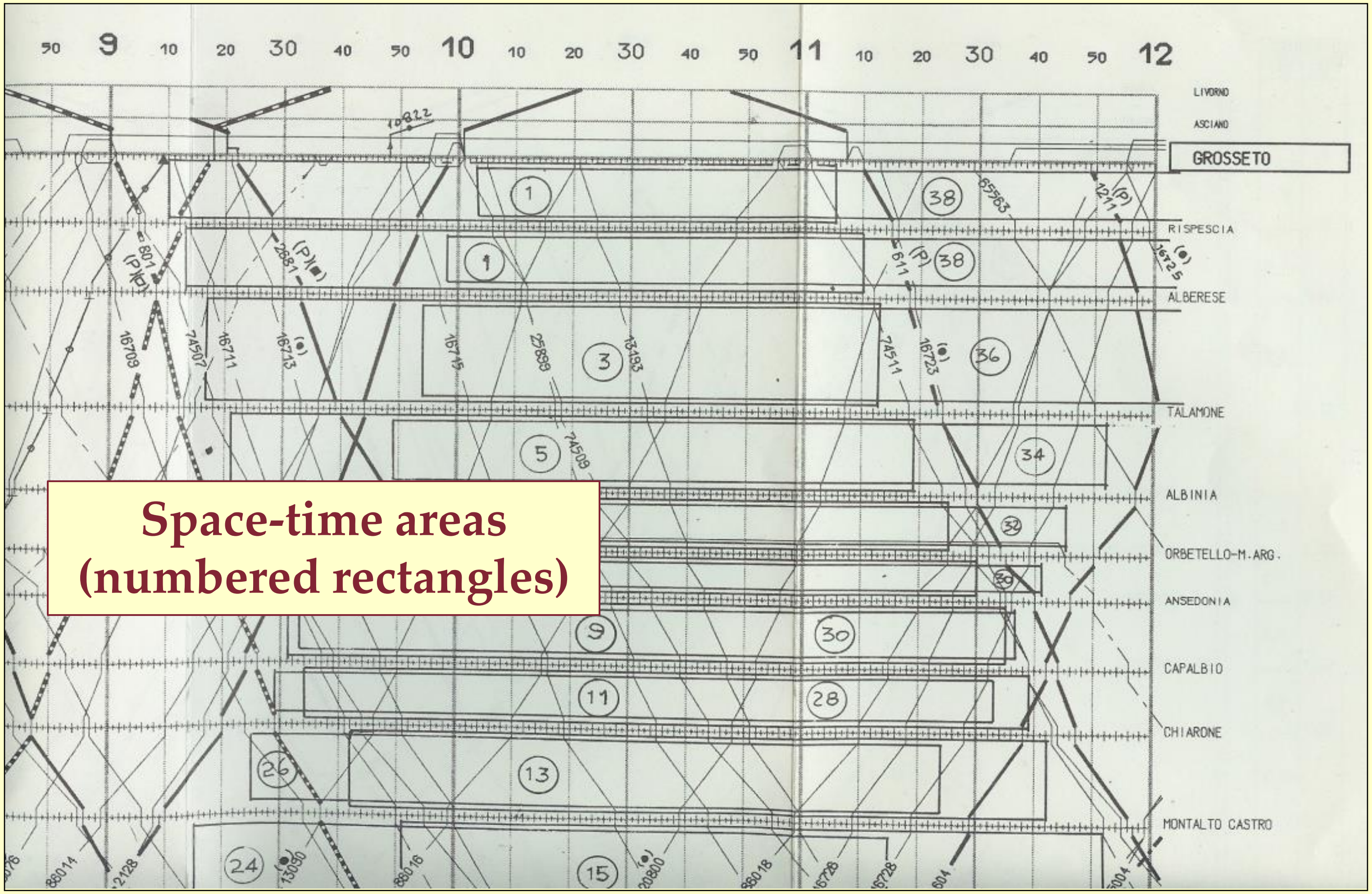
Temporary single-track operation between extreme stations of interrupted sections

Planned maintenance intervals during low traffic periods



Planning of maintenance interval on double-track line

Example **Tarquinia-Grosseto**



Space-time areas (numbered rectangles)

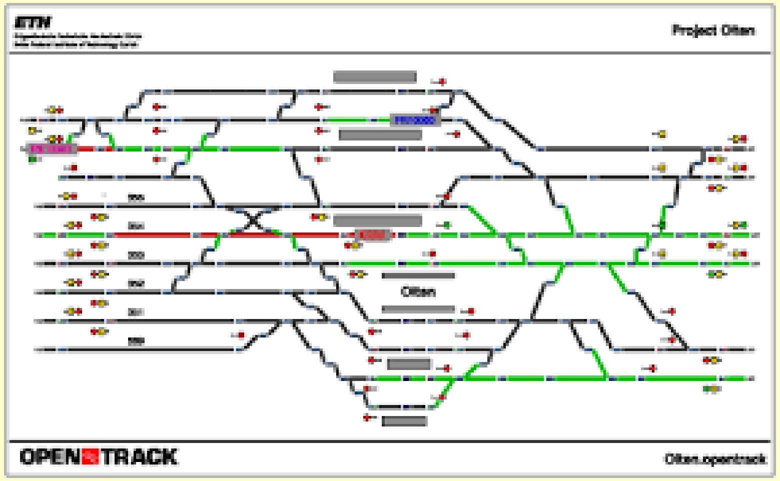
Station timetabling

<u>Relevant constraints on railway operation planning</u>
Transit with speed restrictions
Loading/unloading of passengers and goods
Crossings and overtaking of trains
Composition of trains

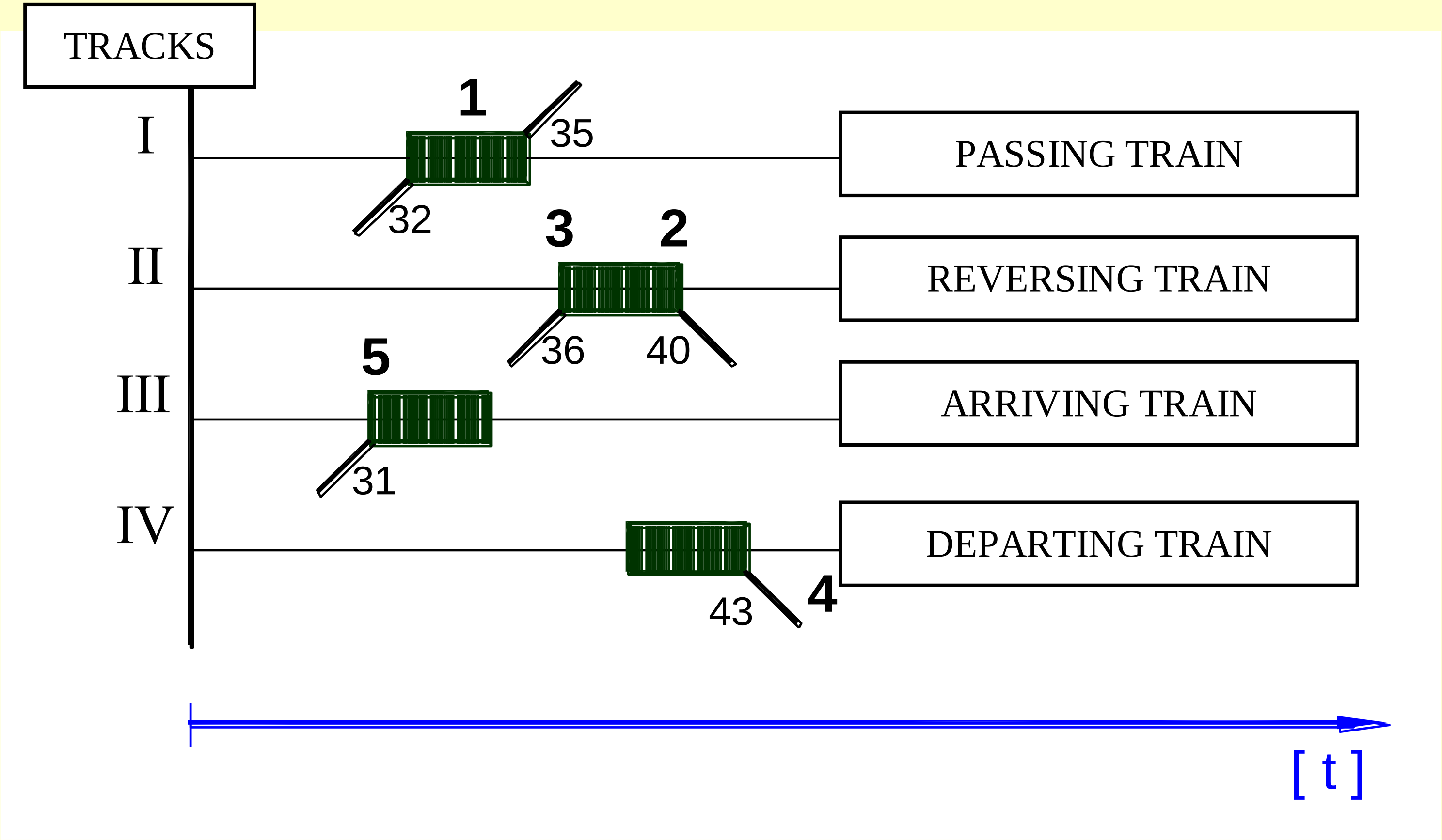
<u>Effects on dynamic capacity (movements of trains)</u>
Incompatible movements generate interdiction times (route preparation + train running)

<u>Effect on static capacity (stays of trains)</u>
Stop times on tracks

<u>Length and equipment of platform</u>
Crossing / overtaking of trains
Boarding / alighting of passengers
Loading / unloading of goods



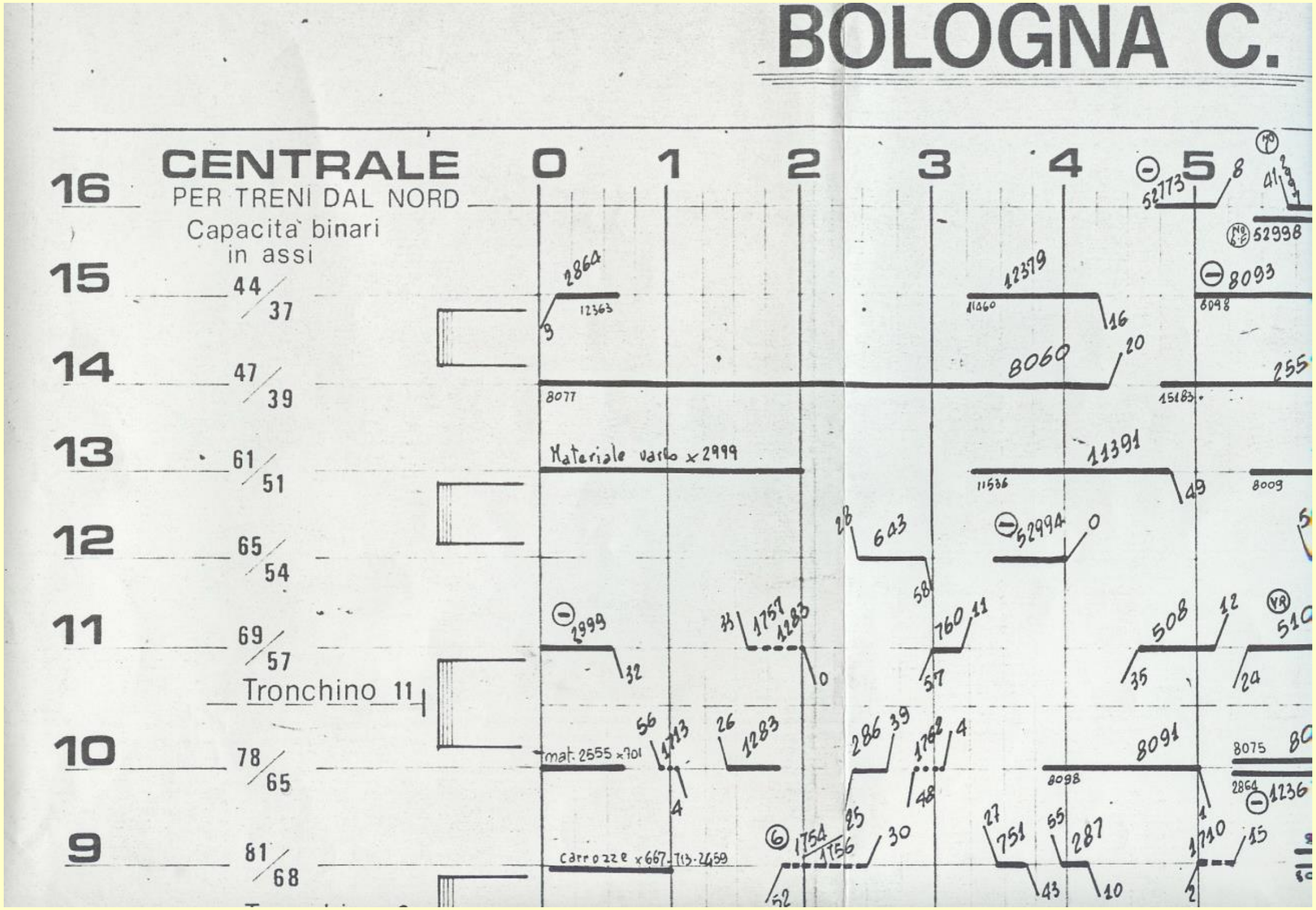
Typologies of station tracks occupation



Occupation of station tracks

Example for a station

Bologna Centrale



IN3
Signalling functions and typologies

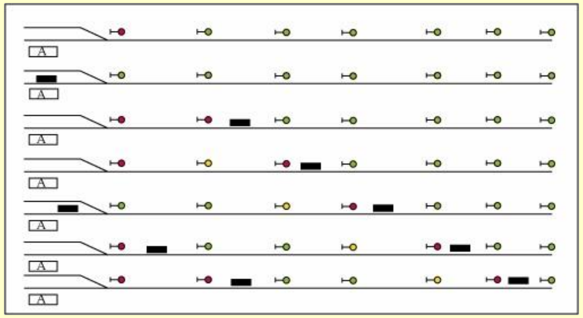
References

- **European Commission –** ***Commission implementing regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919*** **- 2023**
- **European Railway Agency -** ***ERTMS/ETCS Functional Requirements Specification FRS v. 5.0*** **- 2007**
- **Pachl J. -** ***Railway Signalling Principles. Edition 1.1*** **– Braunschweig, 2020**

Traffic regimes and block systems

<u>Space based traffic regimes</u>
Line is divided into Block Sections (BS) ≥ braking distance
Any BS can be occupied by one train only
Entering in BS is not allowed until release by previous occupying train

<u>*Consensus* regime</u>
BS is considered *normally occupied*
Freedom check is required before authorization
The authorization requires a double willingness
(Request + Concession of movement authorization)



<u>*Arrived* regime</u>
BS is considered *normally free*
Freedom is ensured by *complete arrival* of train in next BS

Systems under *Consensus* regime

<u>Phone Block</u>

Single BS between 2 stations

Signals normally showing *restrictive aspect*

Switch of signals to *permissive aspect* after receiving authorization

Authorization by standard recorded phone communications

Use on low traffic lines or on degraded conditions

Progressively substituted by automatic systems

<u>Manual Electric Block</u>

Single BS between 2 stations

Electric equipment linking block sections

Switch of signals to *permissive aspect* after receiving electric authorization

Equipment ensuring the use of authorization by *one train only*

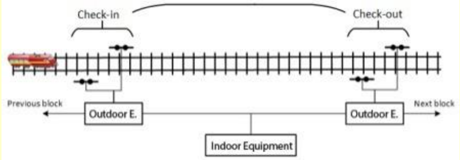
Self-protected by occupation detectors (track circuit, axle counters, etc.)

Use on low-medium traffic lines

Progressively substituted by automatic systems

Systems under *Arrived* regime

<u>Automatic Block based on track circuits</u>
Single or multiple BS between 2 stations
Reduction of times for authorization and release
Line equipped with energized track circuits
Signals showing permanently *permissive aspect*
Restrictive aspect only to protect stations, junctions and level crossings
Signals changing aspects according to BS occupation/release
Codified Current in rail transmitting information on-board
Signals repetition making train driving independent upon visibility
Use on all typologies of lines: the most diffused in European countries



<u>Automatic Block based on axle counters</u>
Single BS between 2 stations
Device counting and comparing numbers of exiting and entering axles
Automatic transmission of detected freedom/occupation of BS
Low cost remote control management
Use on medium-low traffic lines, mainly on single track

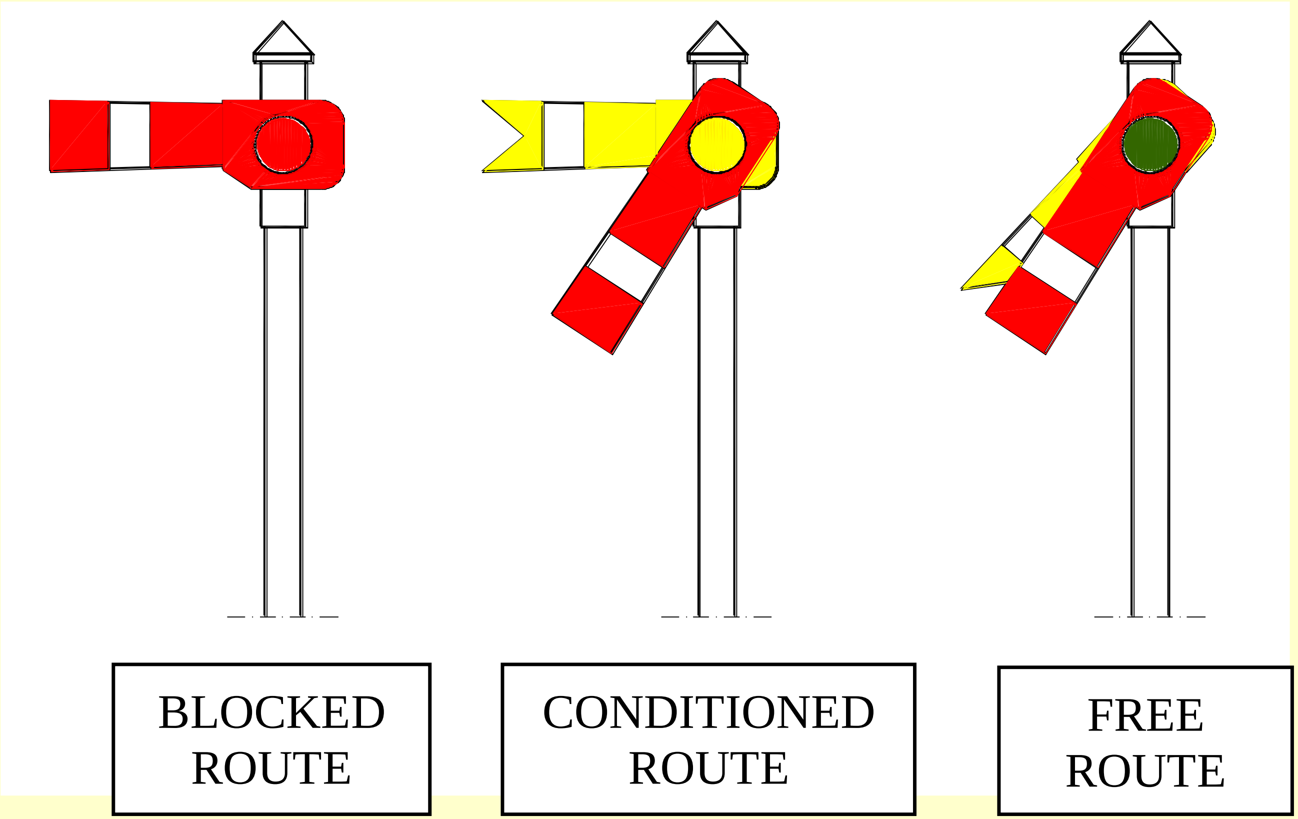
Origin of signalling systems

<u>Indications for safe driving</u>
Signals positioned along line in clear, unique and prompt mode

<u>Historical equipment</u>
Optical indication: signals by flags in daylight, beacons during night
Fixed signals in specific locations along lines
Semaphores with wings hanging from vertical supporting structure

<u>*Semaphores* features</u>
Various positions under action of tyrants
More information with better visibility
Operating under adverse meteo conditions (small surfaces)
Differentiated day / night information: position of wings / color of lights
Accidental block of mechanisms due to frictions or external causes
Problematic implementation with limited Gabarit (e.g. tunnels)

Example of *semaphores*

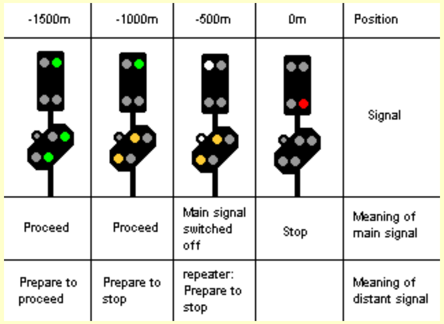


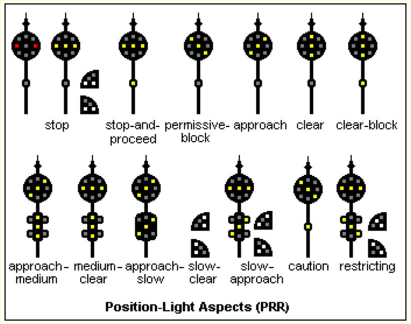
Light signals

<u>Colors / Position</u>

Colors / Grouping of lights to reproduce formal indications

Binary / Ternary combinations of colours + flashing





<u>Structure</u>

Mobile screens with colored glasses

Fixed to supporting structures and rotating under relay action

<u>Main Signals (MS)</u>

Located before protected points: stations, junctions, level crossings

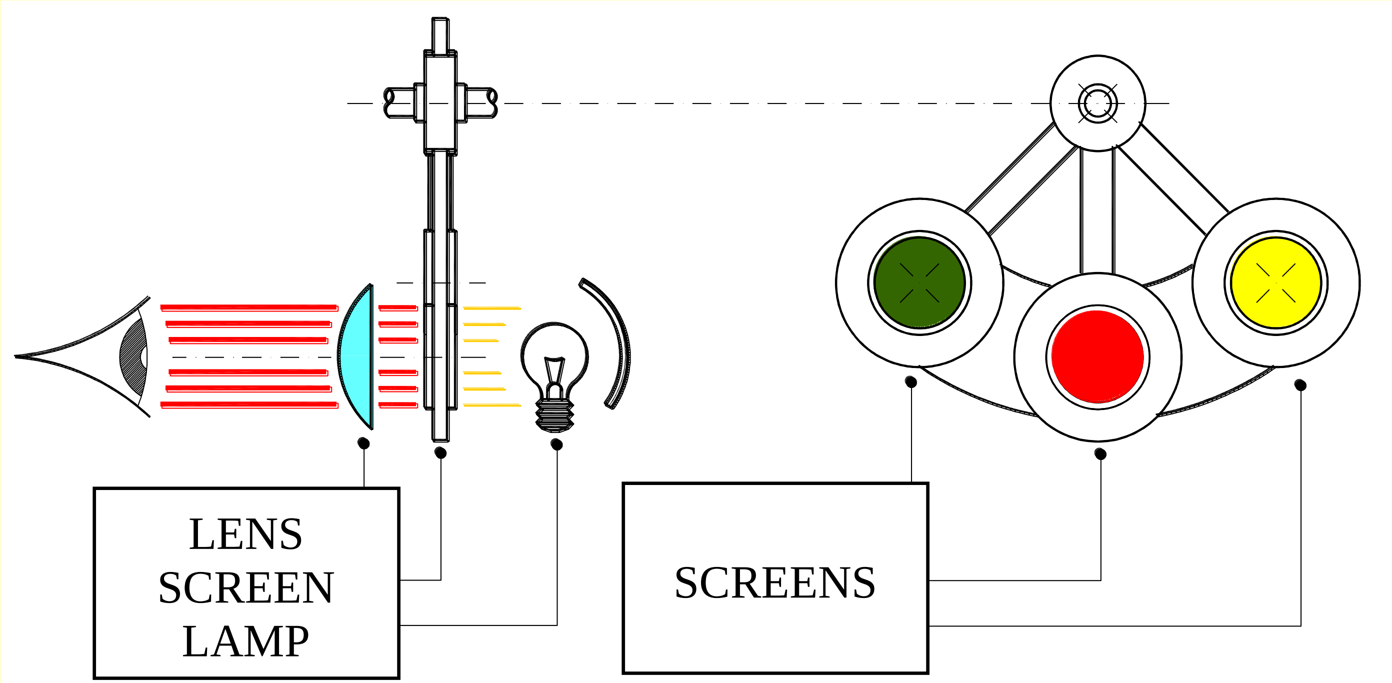
No over-passable when showing *restrictive aspects* (exception with on-sight running for automatic block on lines without protected points)

<u>Advance Signals (AS)</u>

Located *in advance* to main signals

Information to drivers on behaviour to adopt for not overpassing MS

Light signals with mobile screens

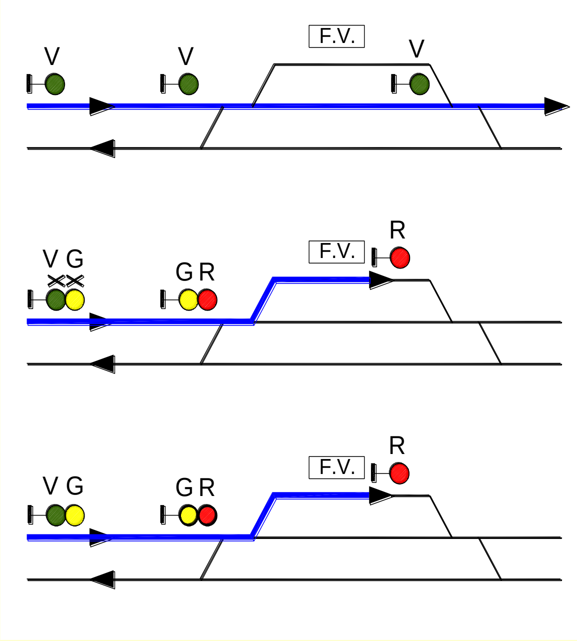


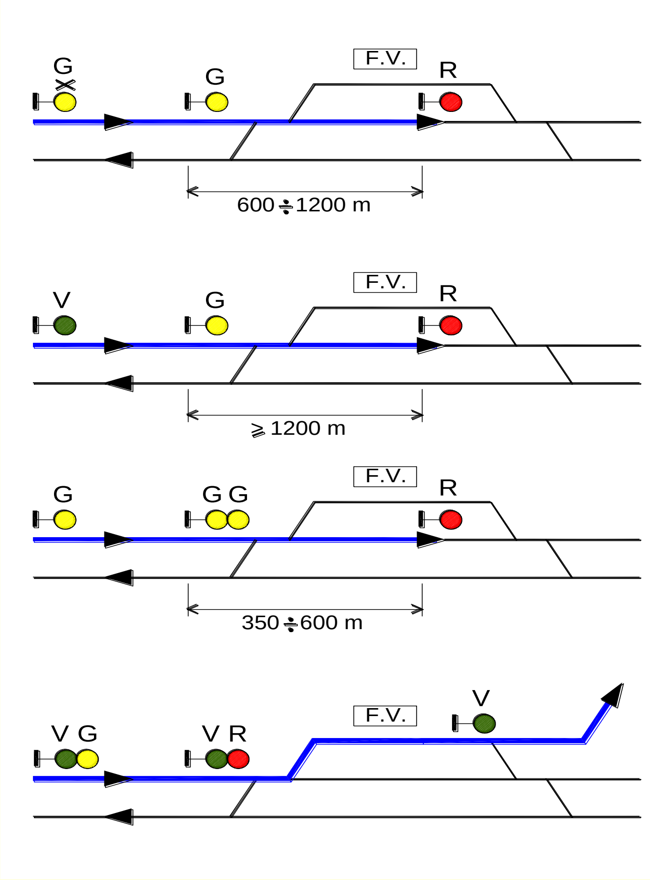
Speed signalling

<u>Information on allowed speeds</u>

Need of more fine tuned indications for train driving

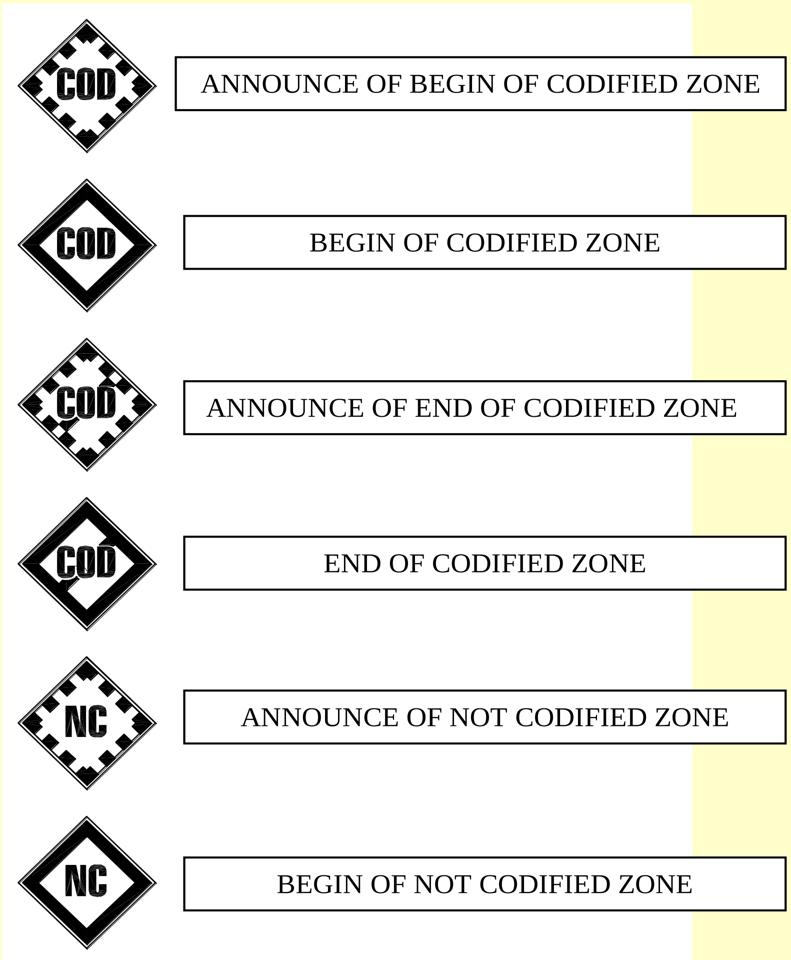
Increase of aspects of signals (e.g. double light with flashing)



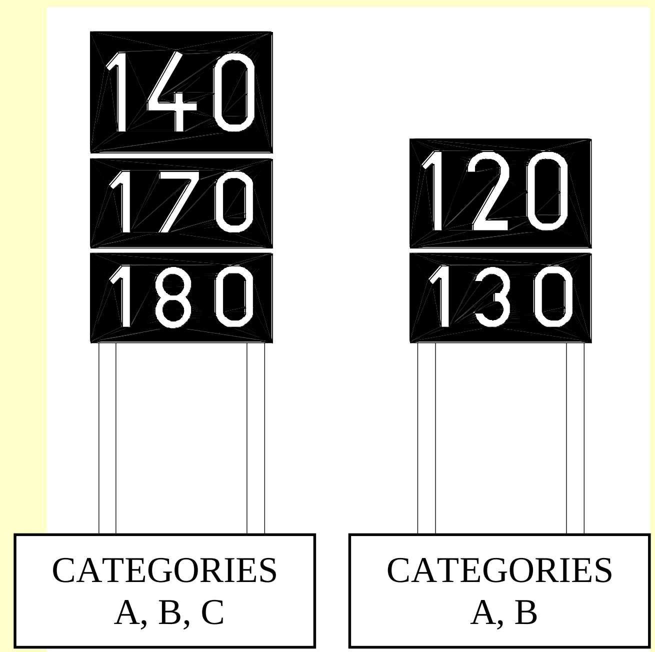


Additional signals (1)

Tables defining codified current BS

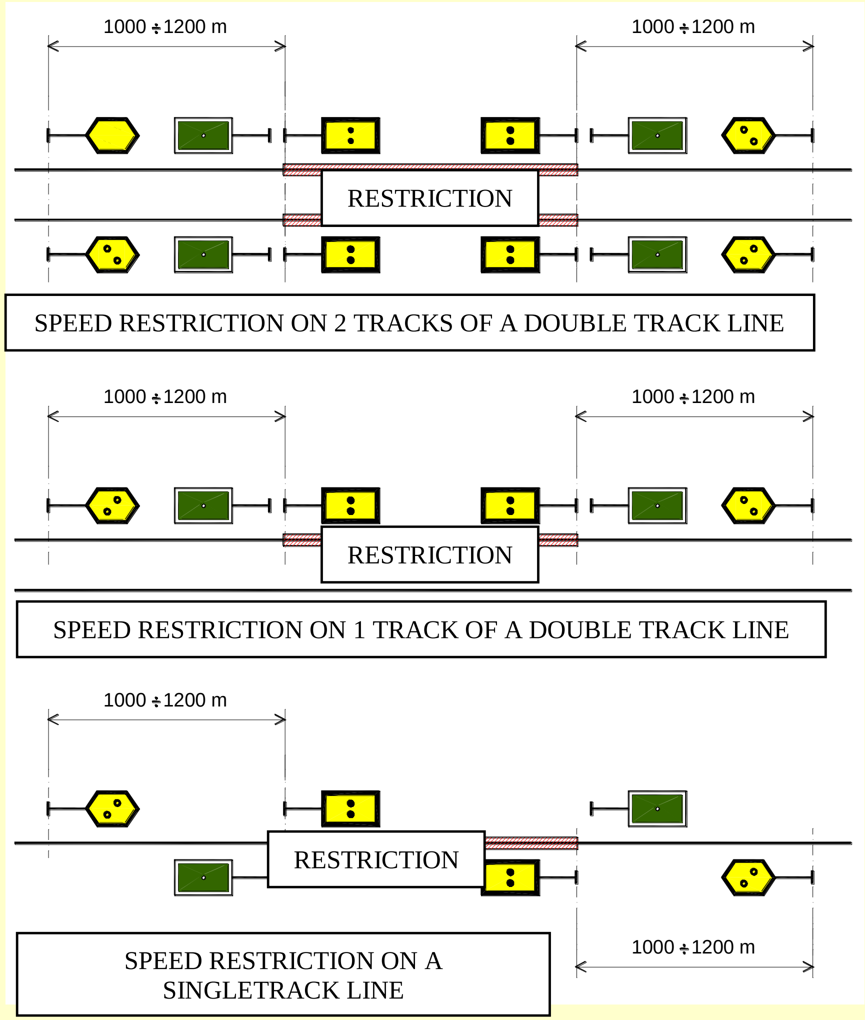


Maximum speed variation tables

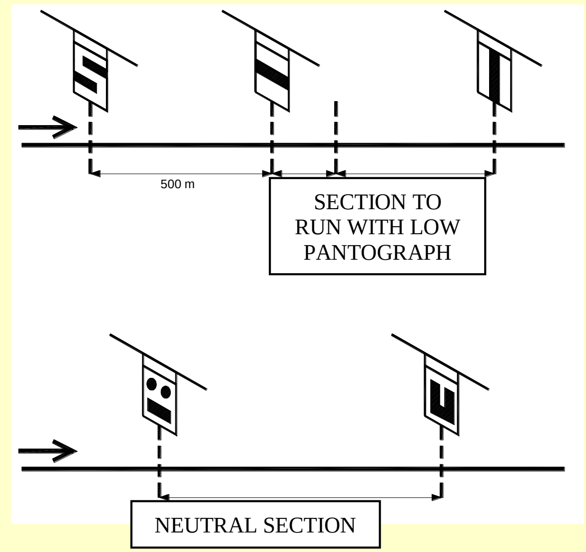


Additional signals (2)

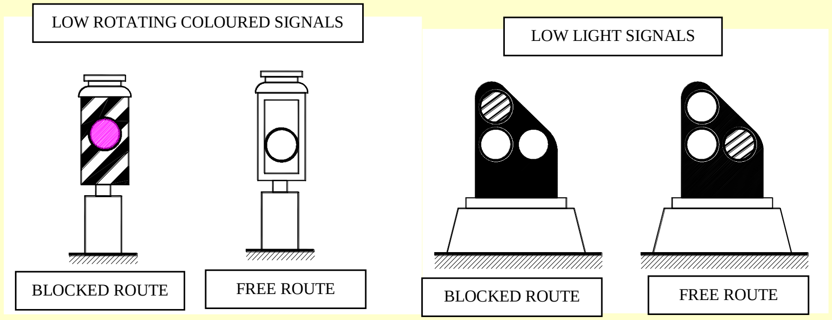
Speed restriction tables



Pantograph movements' tables



Manoeuvres signals



Position of signals

<u>Fixed signals located nearby the concerned track</u>

Exceptions with specific indications

- Local constraints: visibility or obstacles
- Double track lines with temporary bidirectional operation

<u>MS</u>

Located at minimum distance from protected points (e.g. 100 m)

- Points of switches encountered from points
- Fouling limit of intersection/switch encountered from heel
- Extreme limit reachable by manoeuvring or standing trains at stations
- Level crossing area

<u>AS</u>

Located in position allowing respect of indications before reaching MS

- Depending upon line characteristics (max. speed and slope)
- Normal distance AS-MS or MS-MS: 800-1200 m
- Short distance MS-MS: 600-1000 m
- Very short distance AS-MS: 350-600 m (specific warning signals)

Signals repetition onboard and speed control

<u>High trains' speed and/or high traffic density</u>

Need of devices to help drivers respecting signals indications

- Optical/acoustic alarms by approaching more restrictive signals
- Required acknowledgement after alarms
- Automatic control systems for vehicle-infrastructure info exchange

<u>Cab signalling</u>

Merely informative warning alarm

Speed control: automatic braking for Signals Passing At Danger (SPAD)

Permanent/Local vehicle-infrastructure info exchange

Detection of free track circuits between two trains

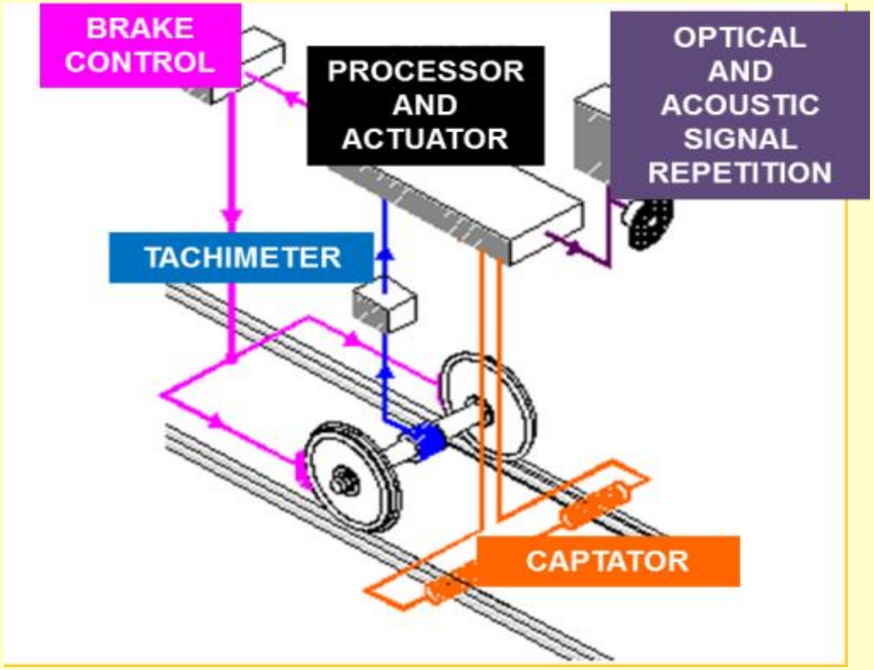
Frequency of current impulses depending on freedom/occupation

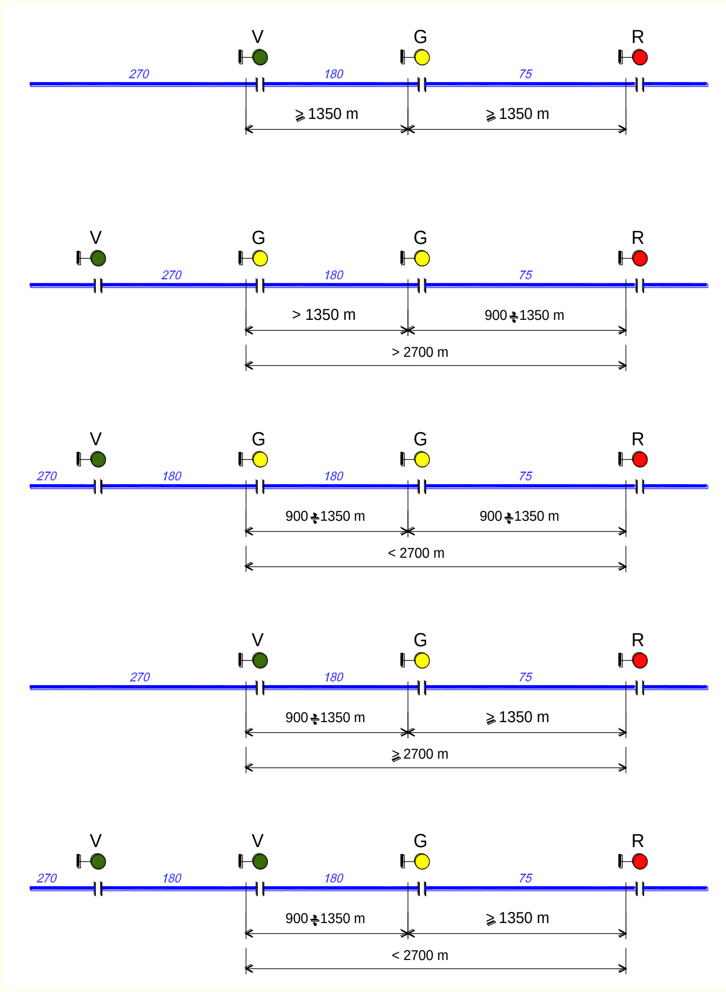
Allowing higher speed than with AS-MS sequence only

Cab signalling repetition systems

Example of codified current electric block use

Functional scheme





Speed control systems

Check of congruence between speed and limits imposed by signalling

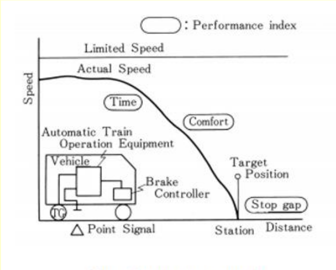
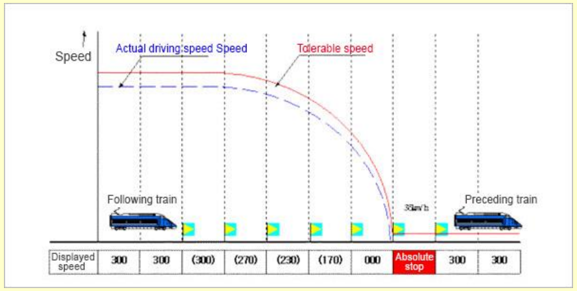


Fig. 1 Train automatic control



Continuous control

Continuous check of speed compatibility

Emergency braking forcing train to respect indication of next signal

Safety curve including initial points of braking curve to prevent SPAD

Semi-continuous control

Cyclic check of actual and target speed

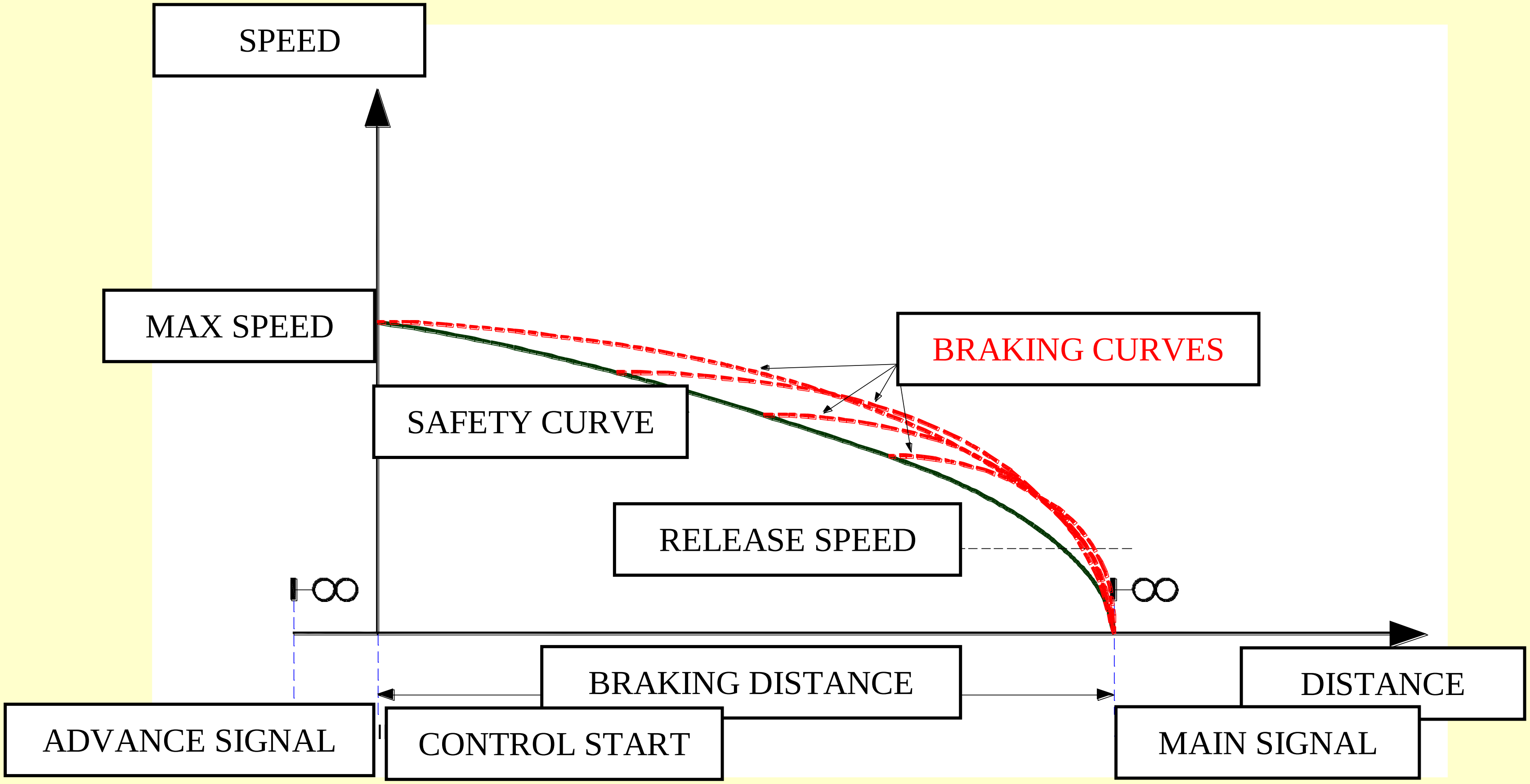
Information provided by short loops circuits (length << BS)

Stepwise control

Local exchange of speed information by electromagnetic devices (*Balise*)

Locations suitable to ensure SPAD prevention

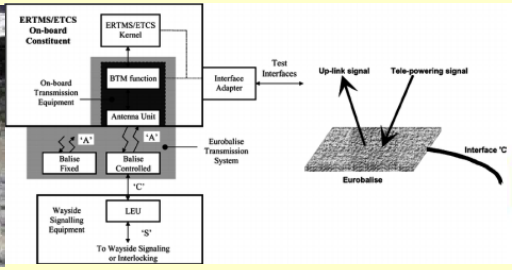
Safety curve for a speed control system

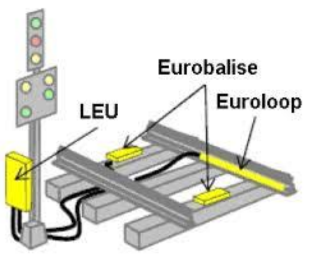


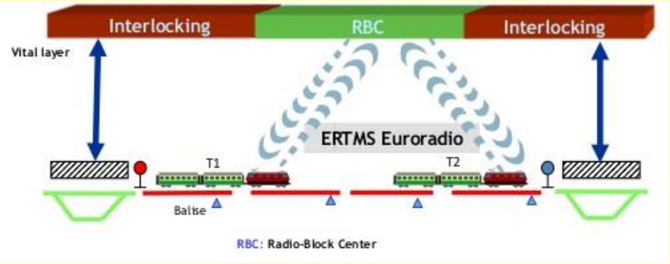
ERTMS aims and components

<u>Unified European Systems implemente in EU</u>
ETCS (European Train Control System) as a part of ERTMS (European Rail Traffic Management System)
- Progressive replacement of national systems
- Full interoperability: rolling stock and personnel interchange

<u>Principle: land based and on-board components exchanging info</u>
Discontinuous Exchange (DE)
- EUROBALISE, devices located in particular locations along the line
Semi-Continuous Exchange (SCE)
- EUROLOOP, cable based system integrating discontinuous info
Continuous Exchange (CE)
- EURORADIO, radio based (GSM-R) safe info transmission







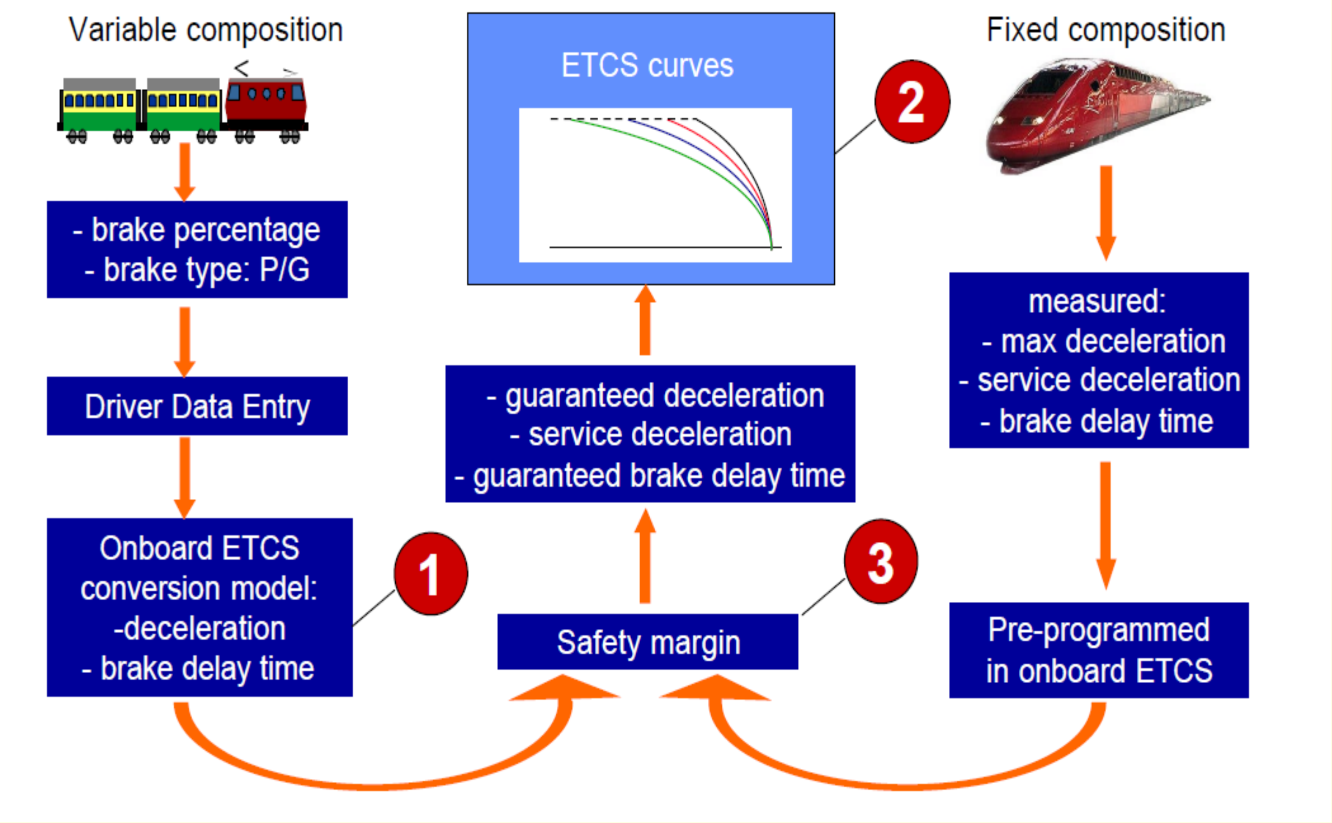
Train protection by ERTMS

<u>Information required for train protection</u>

Signaling: concession of Movement Authority (MA)

Track layout: allowed speed, slopes, etc.

Rolling stock: maximum allowed speed

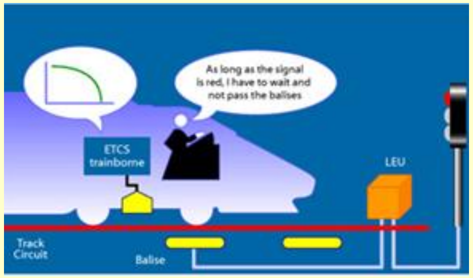


ERTMS implementation levels

Overlap and progressive replacement of existing signalling systems

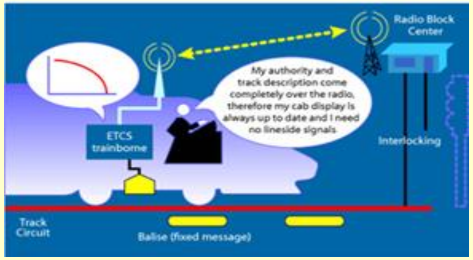
Level 1

Train integrity checked by non-ERTMS systems
DE/SE of info by ERTMS/existing systems
Train spacing based on existing systems
Line signals not eliminated



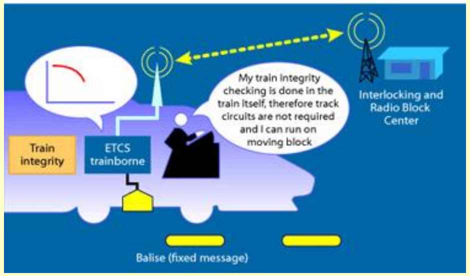
Level 2

Train integrity checked wayside by non-ERTMS systems
CE of info by ERTMS/existing systems
Train spacing based on fixed block managed by RBC
Line signals optionally eliminated

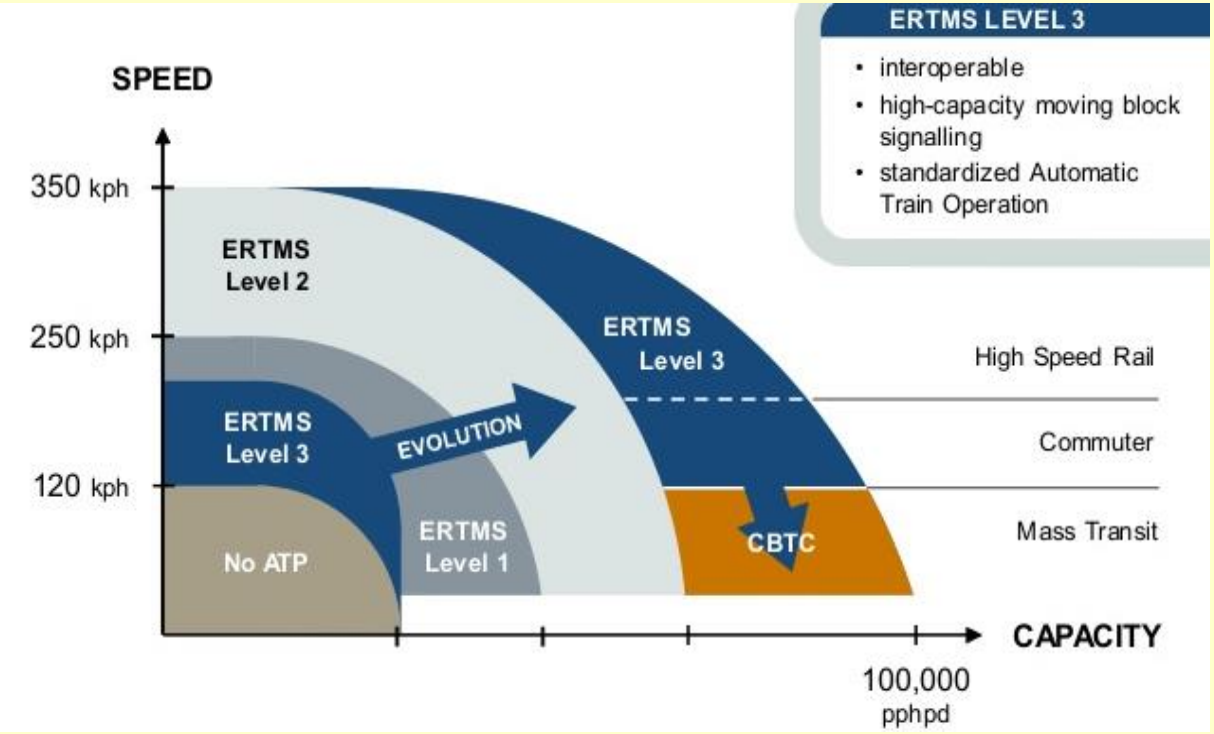


Level 3

Train integrity checked on-board by non-ERTMS systems
Train integrity and location safely communicated to RBC
CE of info by ERTMS systems
Train spacing based on moving block managed by RBC
Line signals eliminated



ERTMS levels speed and capacity performances

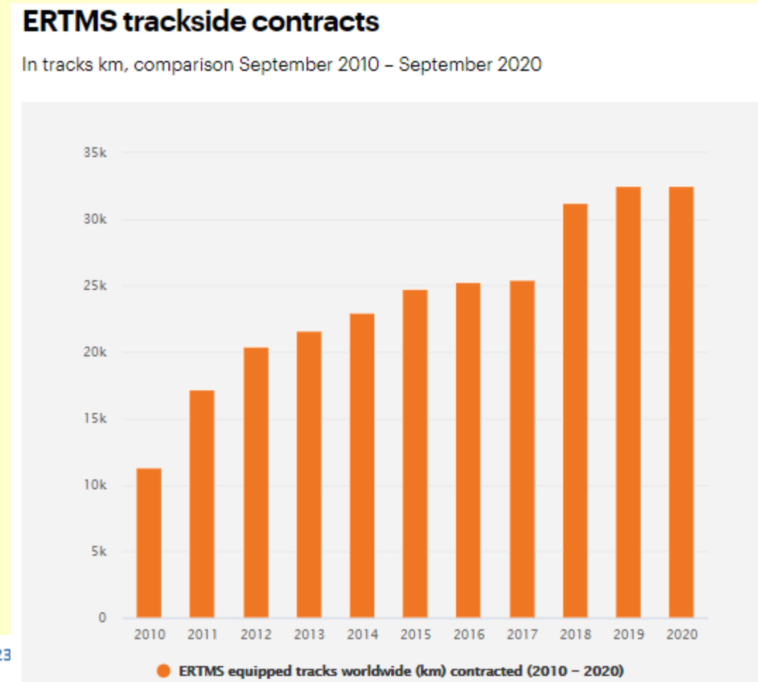


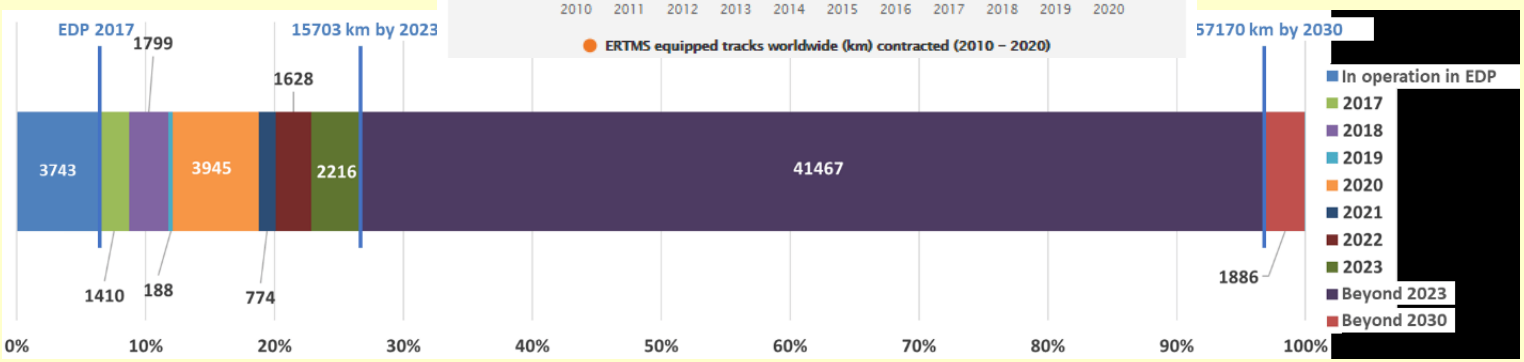
https://www.ferrovie.academy/ferrovie-ertms-etcs-come-funziona/

https://www.youtube.com/watch?v=yZNcJ1OZI8I

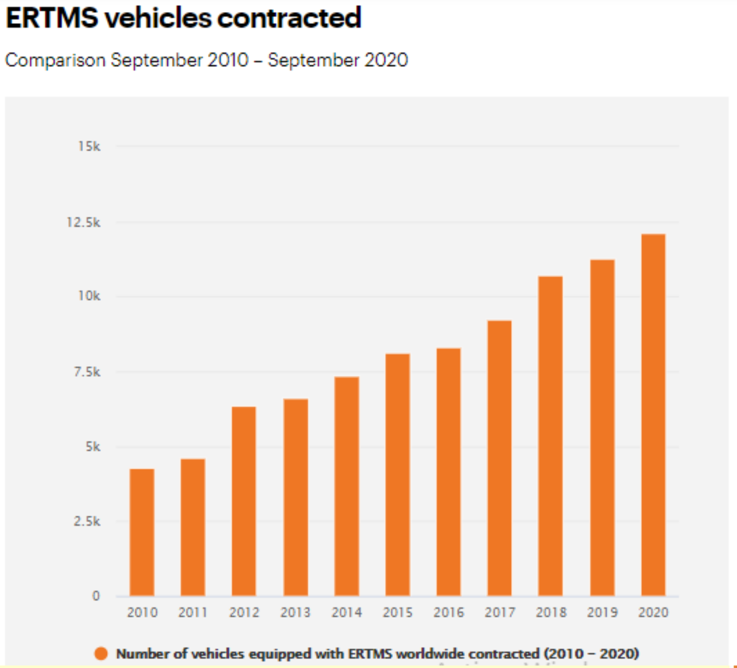
https://www.youtube.com/watch?v=cD4tmkPtDoc

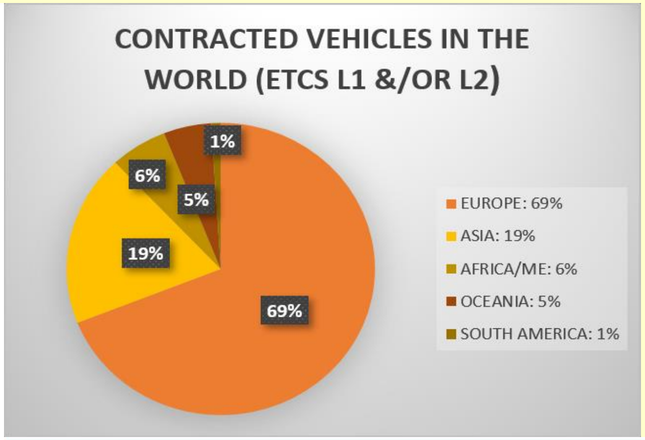
ERTMS trackside equipment diffusion [km]

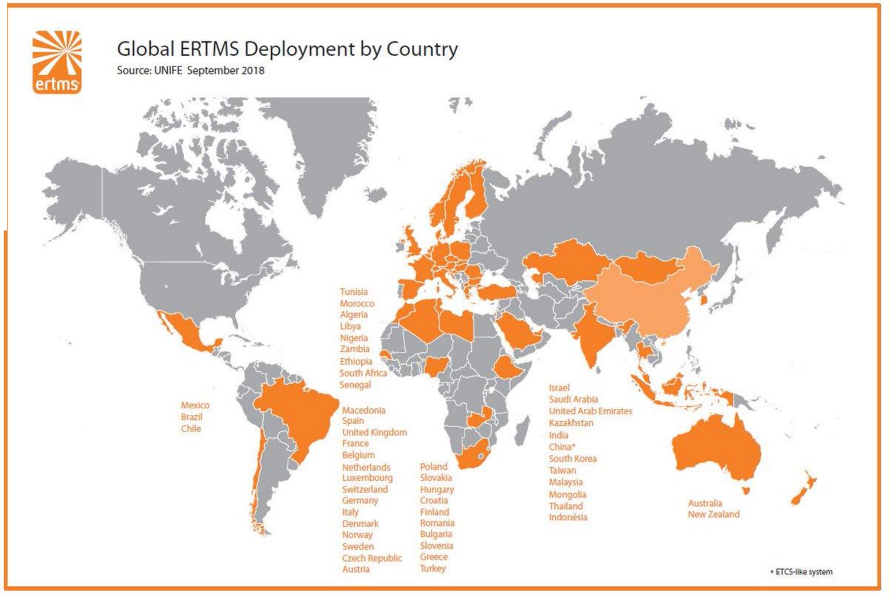




ERTMS equipped fleet diffusion [vehicles]







IN4
Train integrity equipment and level crossing protection

References

- **Network Rail -** ***Enhancing Level Crossing Safety 2019-2029*** **- 2019**
- **European Commission -** ***European Road Safety Observatory. Road Safety Thematic Report Railway level crossings*** **- 2021**

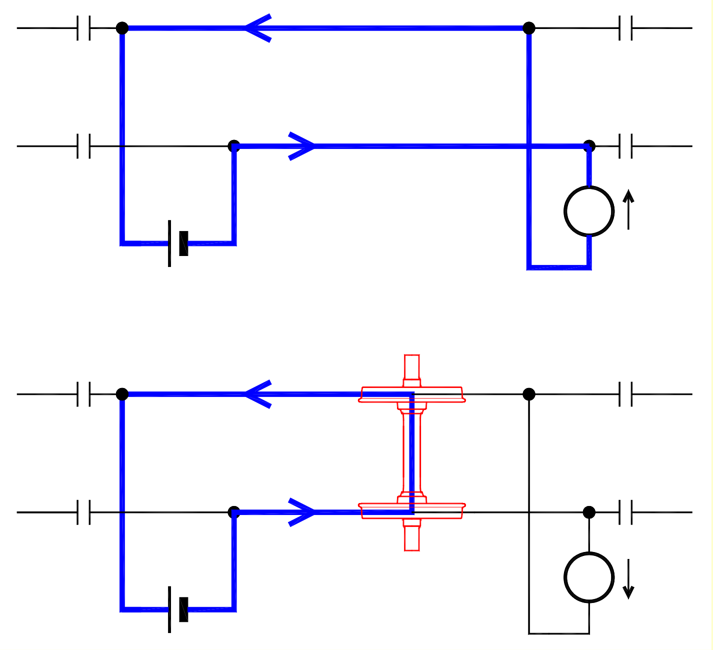
Route freedom check

<u>Freedom of the line to be run</u>
Key action to allow train running

<u>Automatic check</u>
1) Presence of vehicles on a section
2) Transit of vehicles in fixed point along line

<u>Equipment</u>
- Track circuits
- Pedal
- Axle-counters

Track circuit



Able to inform about presence of vehicles
Supplied by accumulator
Supplying a relay at the opposite extreme

Current passing through rails

Insulating couplings between sections
Interrupting electric continuity
Allowing mechanic continuity

Ability of current to reach relay
YES: no axles on the track sections
NO: axle allowing shortcut by preventing energizing relay

Pedal

<u>Mechanical pedal (Treadle)</u>
Local detection of vehicle in to check release of rear section
Location on rail
Moving parts activated by wheel flange shutting electric circuit

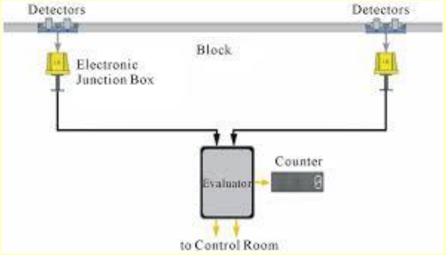
<u>Electro-mechanic pedal</u>
Amplification of induced oscillations between sleepers at vehicle transit
Missing integrity check of running train
Need of additional checks (full train passed) to derive section freedom

Axle-counters

<u>Ability to ensure single axles passages in specific locations</u>
<u>Derived check of rear section release</u>
Comparing number of axles entering section

<u>Double axel-counters (2 transmitting coils + 2 receiving coils)</u>
Two rail-head high frequency supplied coils
(transmitting + receiving)
Continuous signal to check system activity
(damages or dismantling = main signal restrictive aspect)
Sequential impulse at passage of each wheel detecting train direction
(increased electro-magnetic coupling due to wheel mass)

<u>Comparison of data detected by 2 devices at section extremity</u>
Block release message in case of counting parity



Level Crossings (LC) safety issues

<u>**Intersection between railway and road networks at same level**</u>

Potentially dangerous point

Procedures to grant interruption of road traffic before train arrival
- Road traffic interrupted proportionally to railway traffic density
- Traffic incidence indicator: *Traffic Moment* = $\Phi_{road} \cdot \Phi_{railway}$

<u>**Expensive solutions**</u>
New railways without level crossings
Progressive substitution with pass-over/under infrastructures

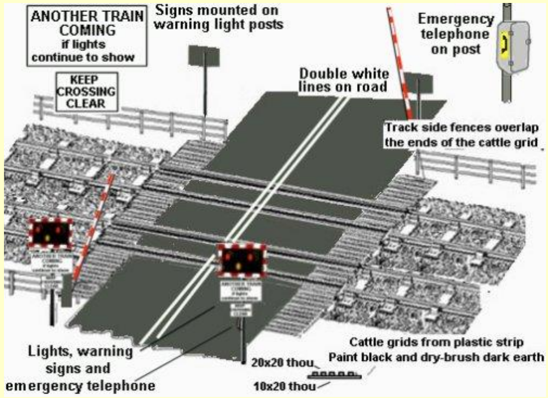
Relevant problem in all railway networks (about 4000 LC in Italy)

LC layout

<u>Layout capable to allow safe and regular transit of both vehicles flows</u>

Guard rails reducing interruption of road and let wheel flange running

Limited super-elevation on curves (speed restrictions)



<u>Road-side protection by signalisation required by road codes</u>

by railway infrastructure manager on intersection itself

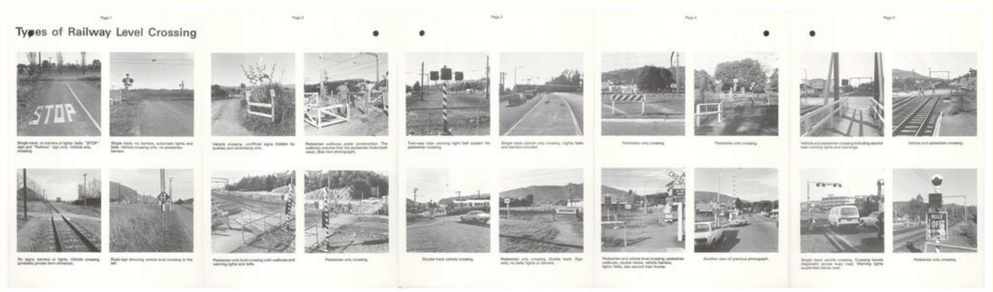
by road administration along carriageway

<u>Railway-side protection by Main Signal</u>

Level crossings indicated on drivers' documents

Acoustic alert emitted by approaching LC in dense urbanised areas

LC classification



Road traffic typology

Walking / Open to vehicles

Position along railway

Station / Line

Closure regime

Open and unattended / Private assigned to users / Open upon request / Closed by time / Closed according to trains traffic / Closed automatically

Closure devices equipment

Signal integrated by alert pinwheel (walking crossings only) / Gates / Barriers / Semi-barriers / Double semi-barriers

Closure manoeuvres

On site / Remote / Automatic

Permissive aspect of protection MS conditioned by closure of barriers

https://www.unece.org/trans/roadsafe/lx_film.html

https://www.youtube.com/watch?v=G7hyIkqyp9k

Closure devices

<u>Closure by barriers with remote control of completion</u>

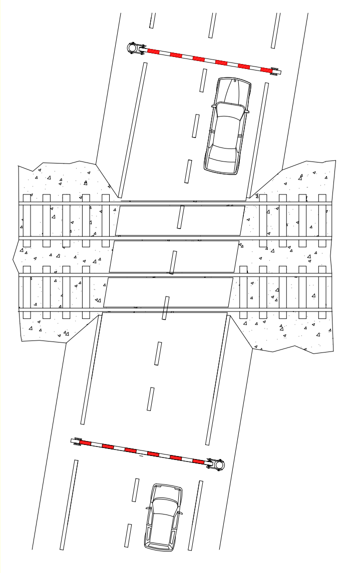
Barriers’ integrity

Freedom of crossing area

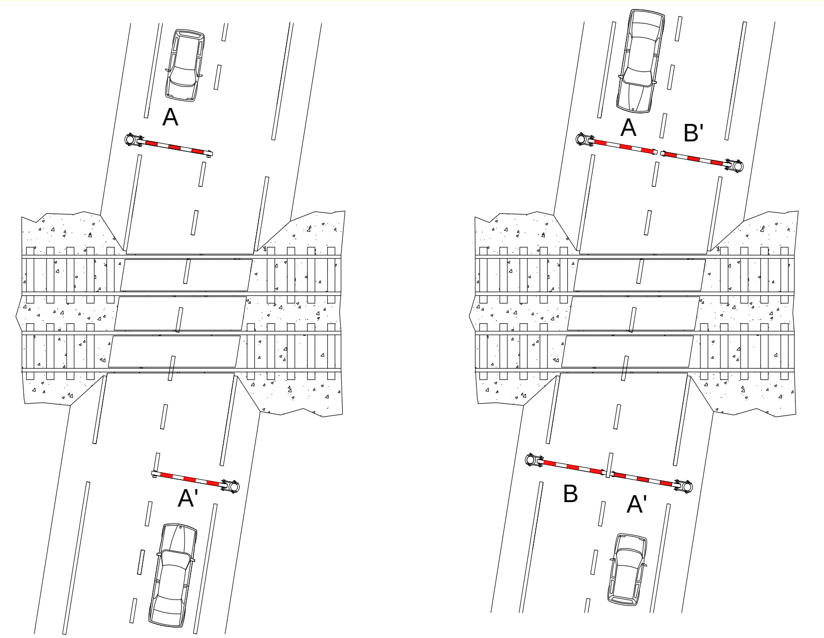
<u>Risk of vehicle remaining blocked between barriers</u>

Mitigations

- Soft barriers
- Recovery areas



Single/double semi-barriers

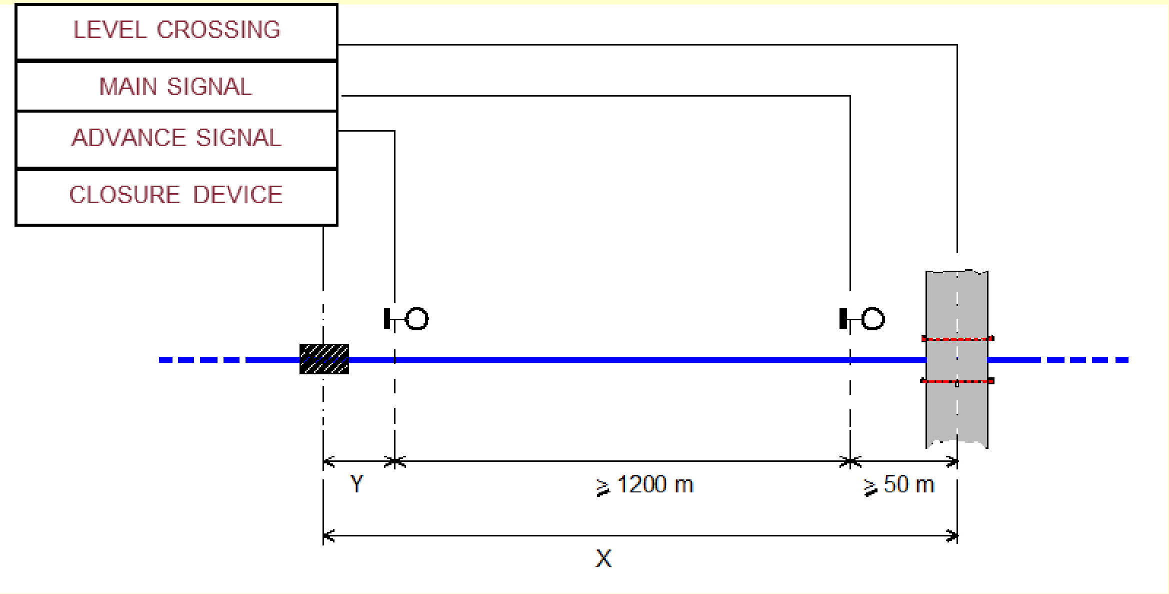


Automatic control of barriers

<u>Closing cycle activated by train transit on device located at distance *X*</u>
(Track Circuit or Pedal)

$$X = 1.1\ T\ V / 3.6\ \ [m]$$

T = minimum time [s] between transit of train on closing device and LC (e.g. 30 s)
V = maximum speed [km/h]
1.1 = coefficient to take into account lack of tachymeter precision



LC signals positioning

Unperturbed run condition

$$Y \geq D + 1.1\ \tau\ V / 3.6$$

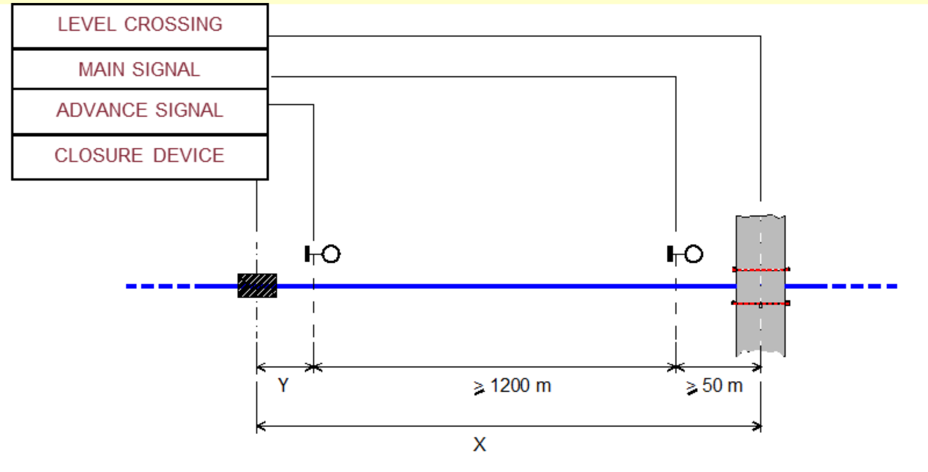
Y = distance between closing device and advance signal
D = visibility distance of advance signal (about 200 m)
τ = time from closure completion to signal permissive shift

Main Signal position

Just before LC (about 50 m)
Minimum distance from other signals (about- 400 m)
Single signal protecting close LC for distance <L (about 1500 m)

Malfunction of protection signal

On sight run with speed restriction (e.g. 4 km/h)



Choice of closure regime and devices

Key decision factors

Flows, speeds and traffic typologies on railway and road
Required safety level and traffic fluidity

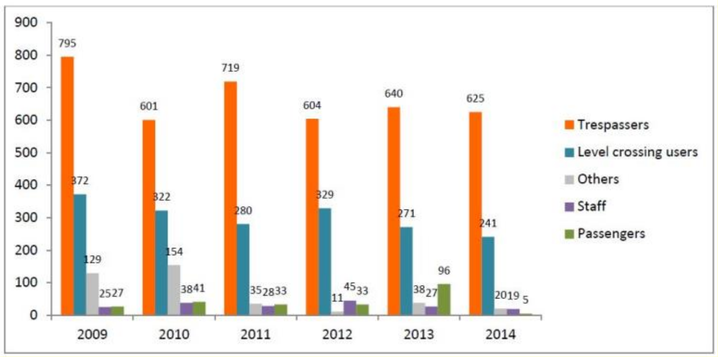
Risk index by closure regime from statistical investigations

$$I = \Sigma_{1,n}\, a \cdot 10^6 \,/\, [\Sigma_{1,n}\, (t \cdot \sqrt{m})]$$

a = number of accidents detected in period t on n level crossings having a traffic moment m

Six years investigation on European railway network

Open and unattended: I = 16.29
Road signal only: I = 8.48
Closed automatically by semi-barriers: I = 2.3
Remotely manually closed: I = 0.31
Average value: I = 3.63



IN5
Station layouts

References

- **Ministry of Railways (Railway Board). Government of India -** ***Manual for standards and specifications for railway stations*** **– June 2009**
- **UIC - Smart stations in Smart Cities – Paris, 2017**
- **Trafikverket –** ***Railway Stations. Layout Manual*** **- English version 2018-02-20 – Borlänge, 2018 (ISBN: 91-7725-245-0)**
- **Network Rail –** ***Station Capacity Planning. Design Manual. NRGNCIV10003*** **- 2021**

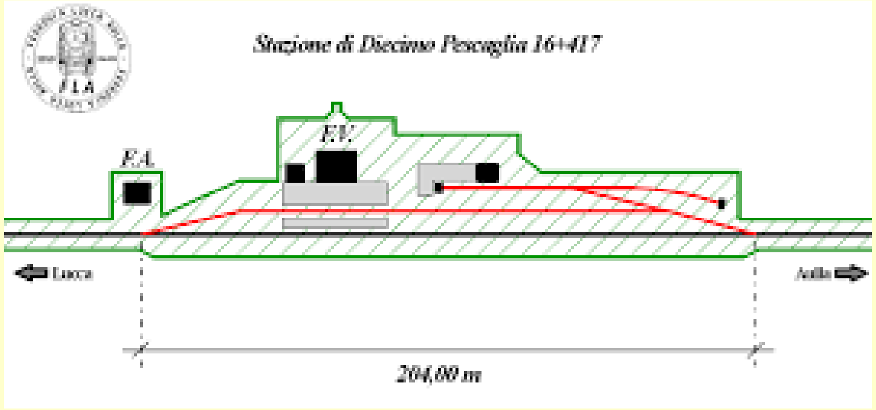
Functions and basic schemes

1) Transit of a train
Main line tracks only, complex layouts not necessary

2) Stop of a train to crossing/overtaking

3) Stop of a train to load/unload passengers and/or goods

4) Stop of a train manoeuvring to couple/uncouple wagons/coaches
Long stay for composition/decomposition of a whole train not included



Increasing complexity of layout

Design criteria

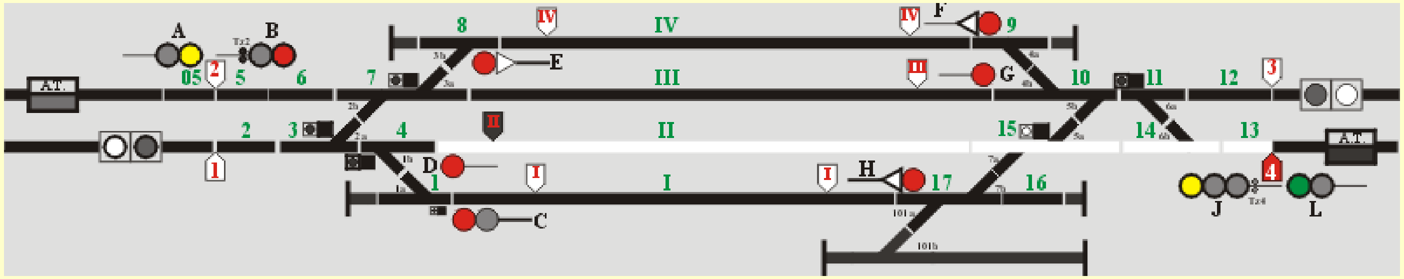
1) Allowance of crossing/overtaking manoeuvers

2) Minimum complexity (lower construction and maintenance cost)

3) Allowance of passengers/freight services

4) Independence of movements (higher capacity)

5) Minimum potentially dangerous conflicts
Train Arrival (A): entry routes
Train Departure (D): exit routes
Converging points with decreasing dangerousness: AA-AD/DA-DD



Müller figure

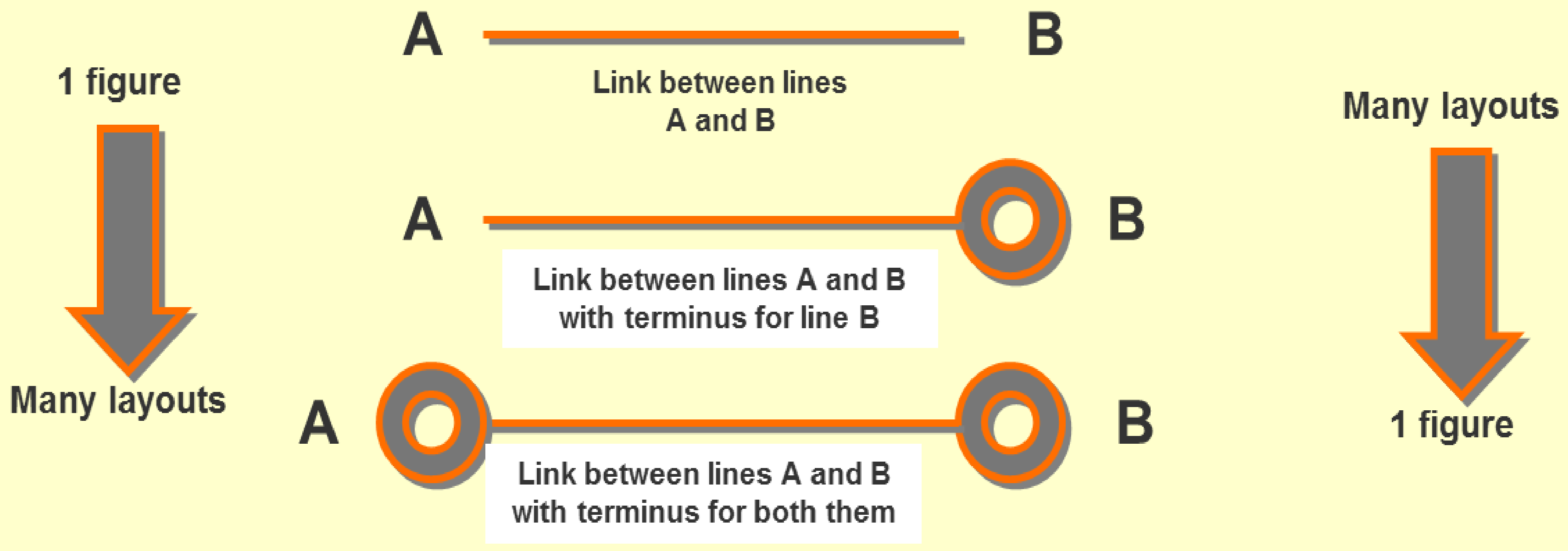
<u>Functional representation tool</u>

Functions linking lines approaching to stations

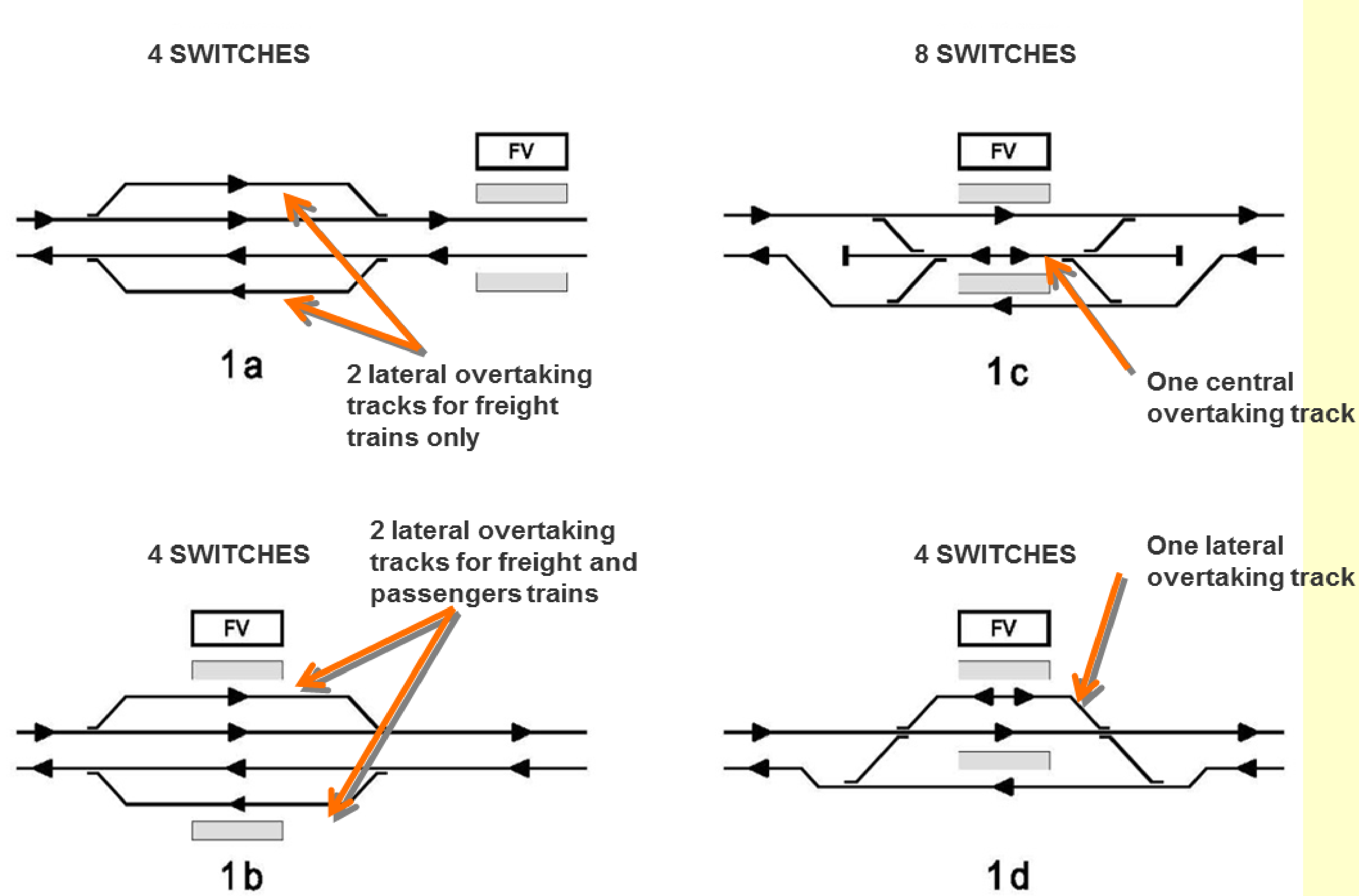
Design use: from functions to layout

Analysis use: from layout to functions

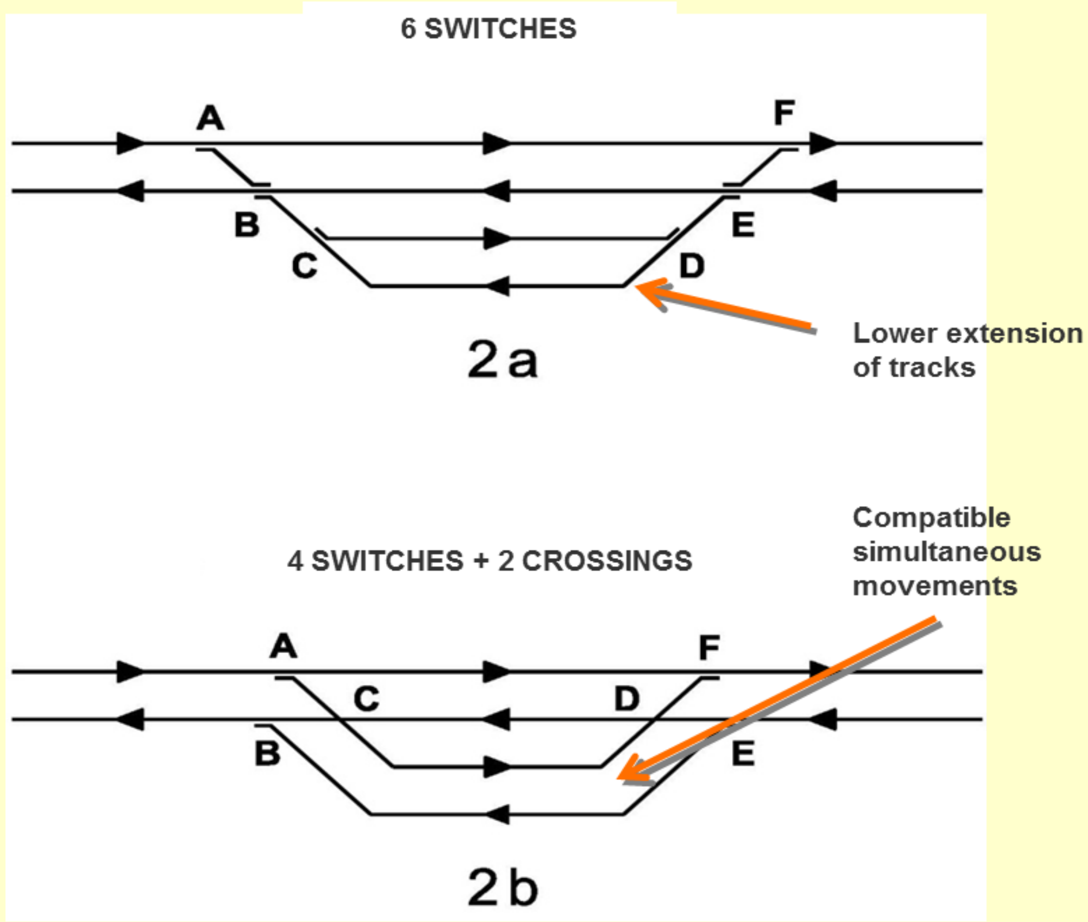
Relevance of links highlighted by lines thickness (bold/dotted lines)



Transit and overtaking stations



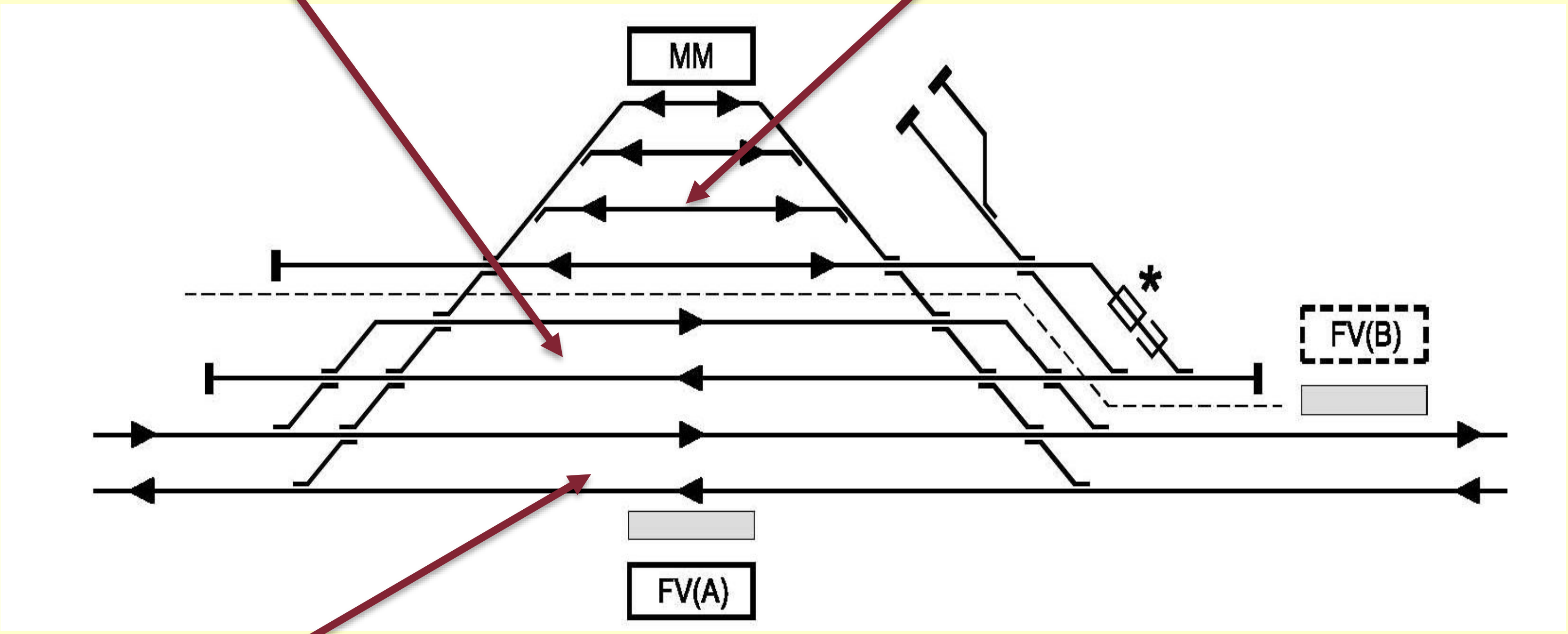
Station layouts with unilateral overtaking tracks



Location of platforms in transit stations

Various tracks dedicated to freight operation

Two unilateral overtaking tracks

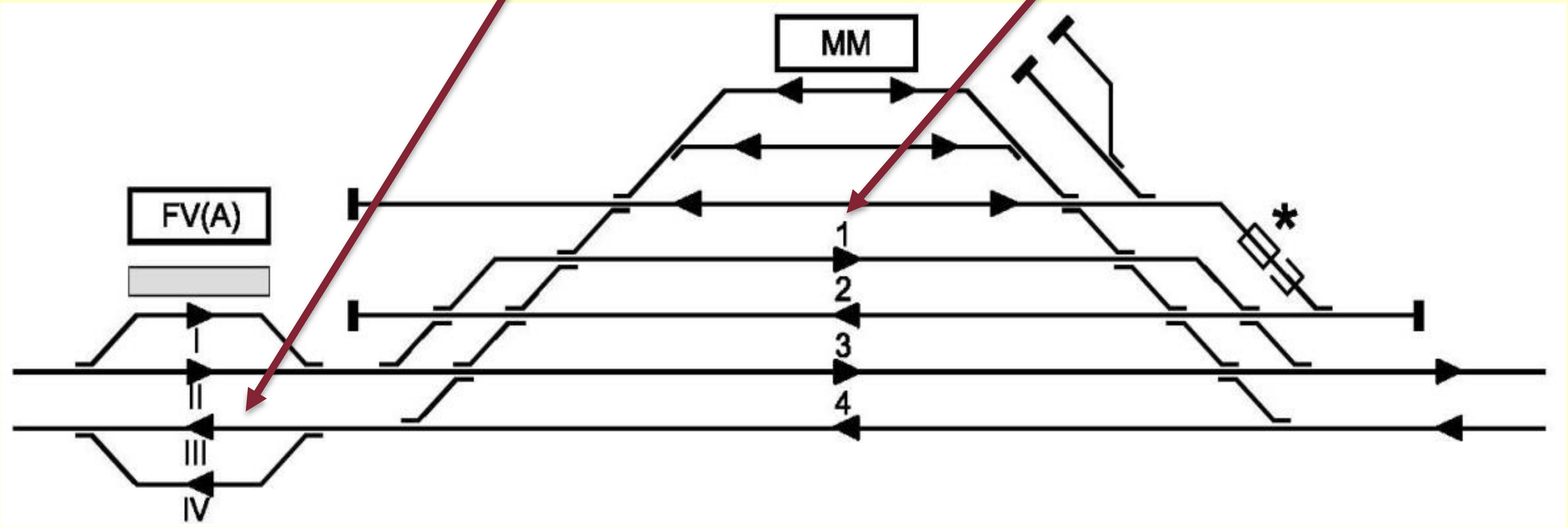


Two main line tracks

Transit station with passengers/freight serial differentiated areas

Passenger services area (4 dedicated tracks)

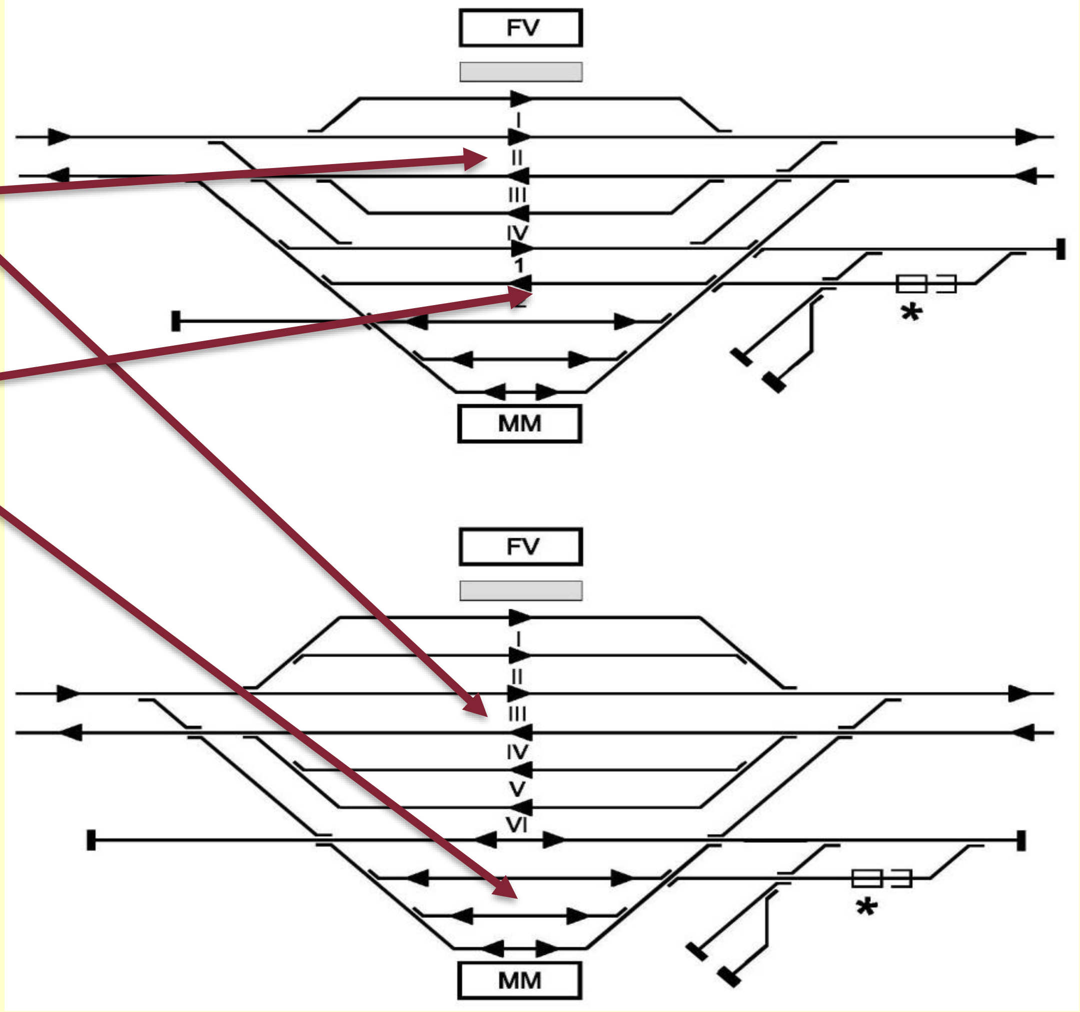
Freight services area



Transit stations with passenger/freight parallel differentiated areas

Passenger services area (4/6 dedicated tracks)

Freight services area



Junction stations

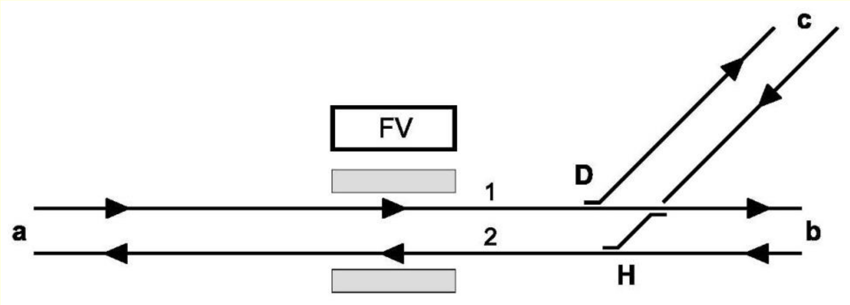
<u>Convergence of at least 2 lines with possibility to exchange trains</u>

Intersections of lines
- Single level (low density traffic)
- Staggered levels (high traffic density)

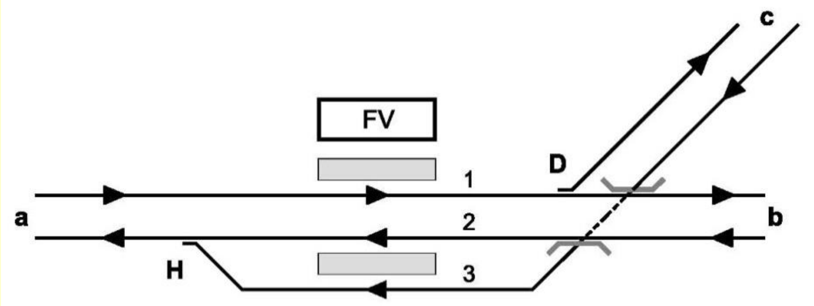
Functions
- Direct / reversing trains
- Starting / ending services

Layout topology
- Transit / Terminus

Single level

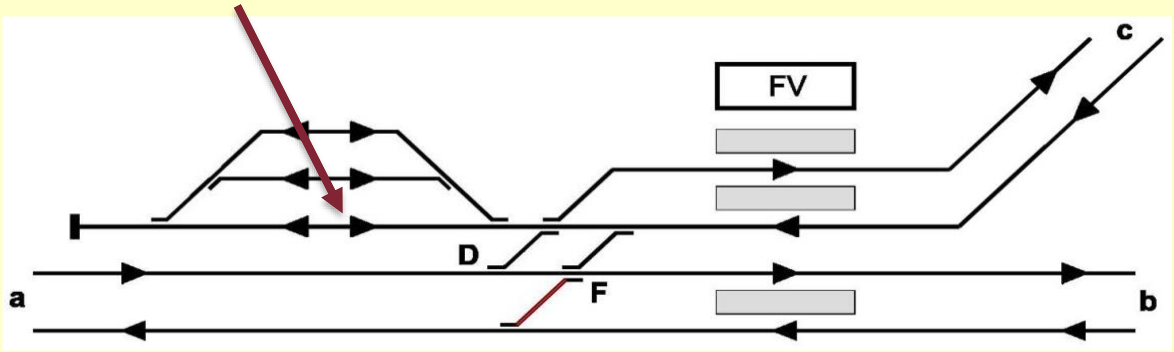


Staggered levels (with underpass)

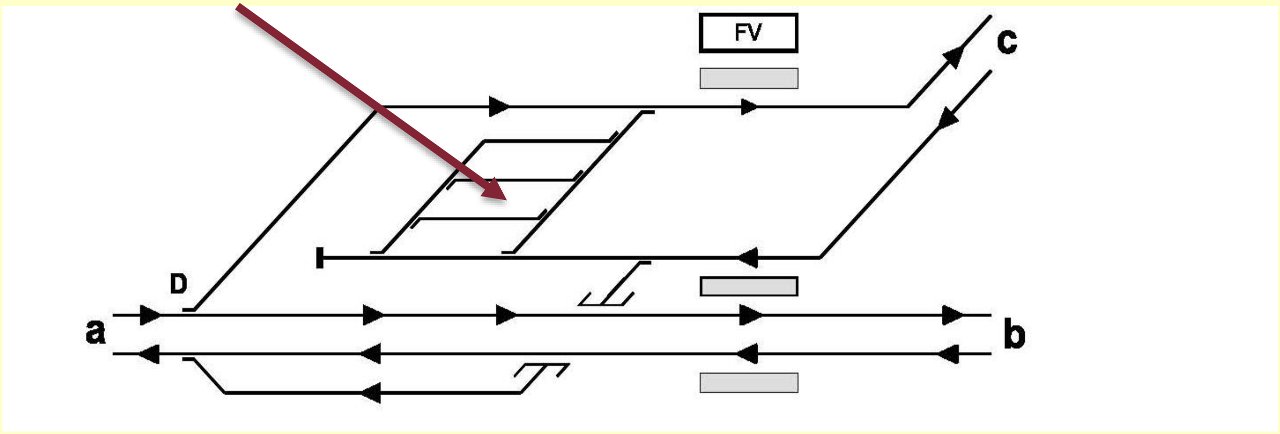


Junction station with terminus for line *c*

External terminus



Internal terminus



Crossing stations: requirements

<u>**Crossing between two lines**</u>

Independence of movements on two lines

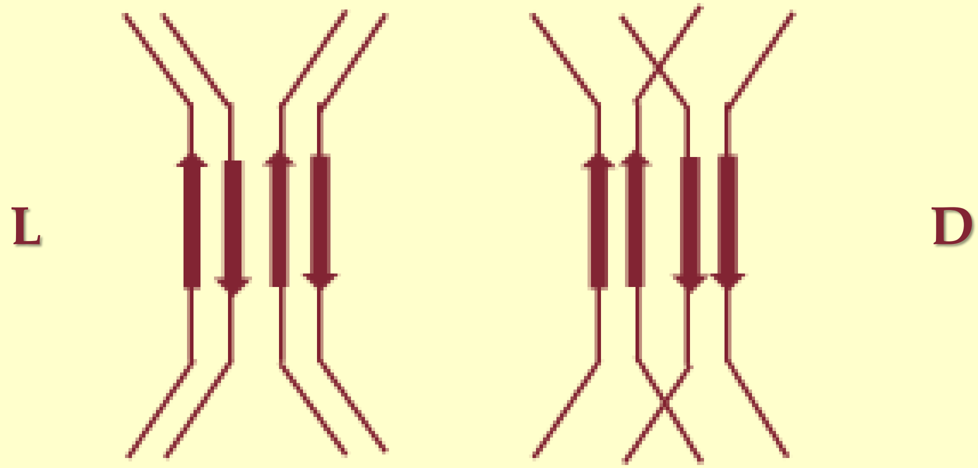
Overtaking track for each main track

Possibility of full exchange among directions

Operational layout

by Lines **(L): aside tracks of the same lines**

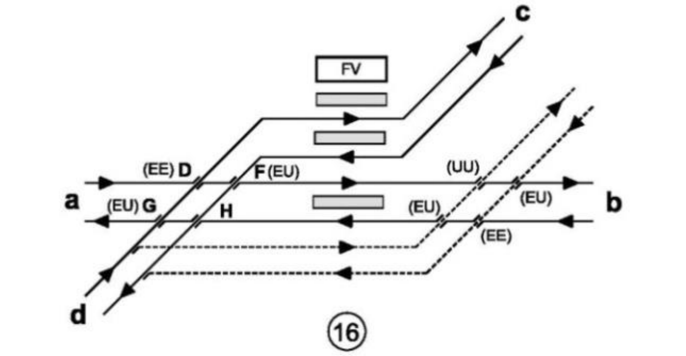
by Directions **(D): aside tracks of the same directions**



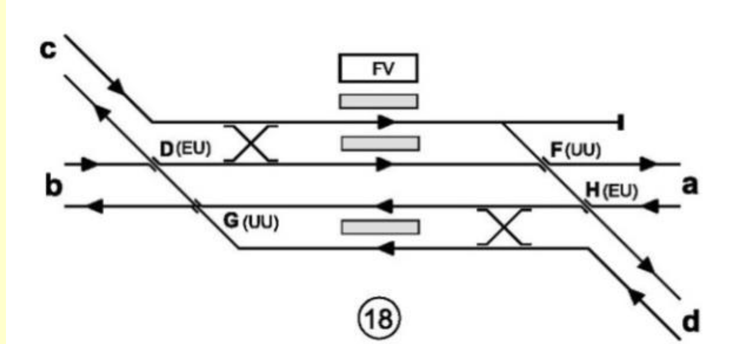
Crossing stations: basic schemes

Operation *by Lines* (L): scheme 16
Operation *by Directions* (D): schemes 17, 18, 19

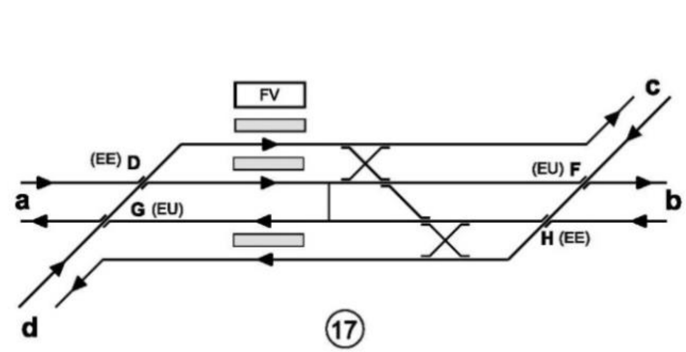
L



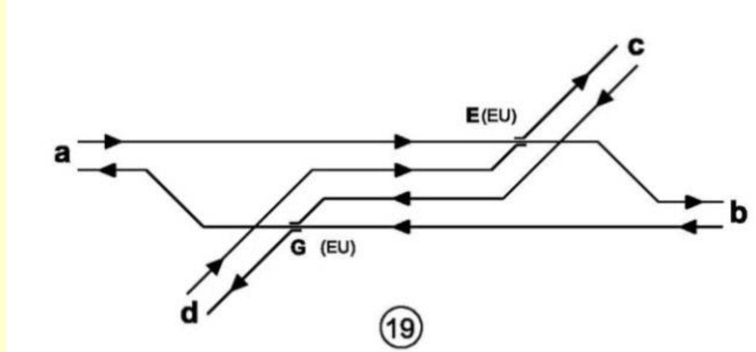
D



D

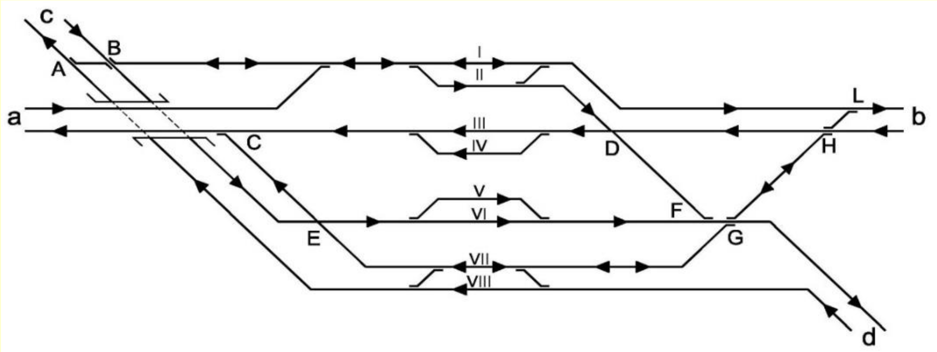


D

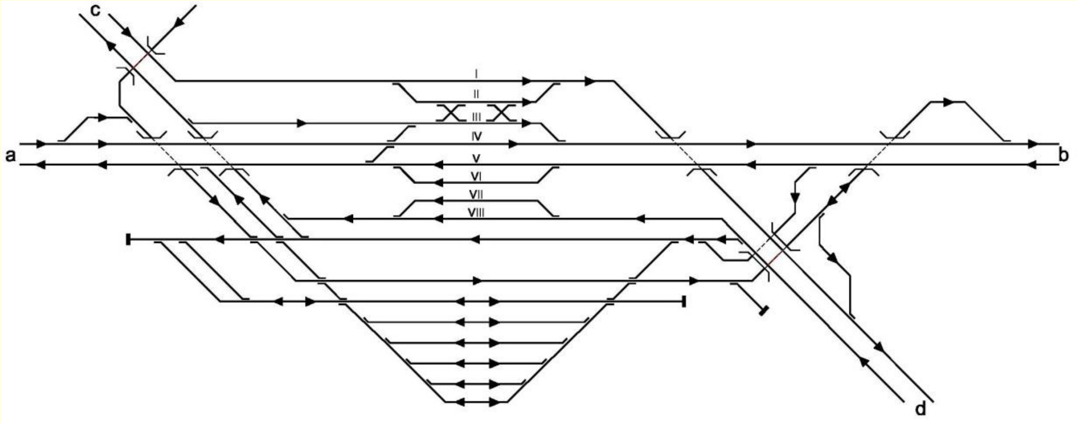


Crossing stations: overtaking tracks + full exchange

Operation *by Lines* (L)

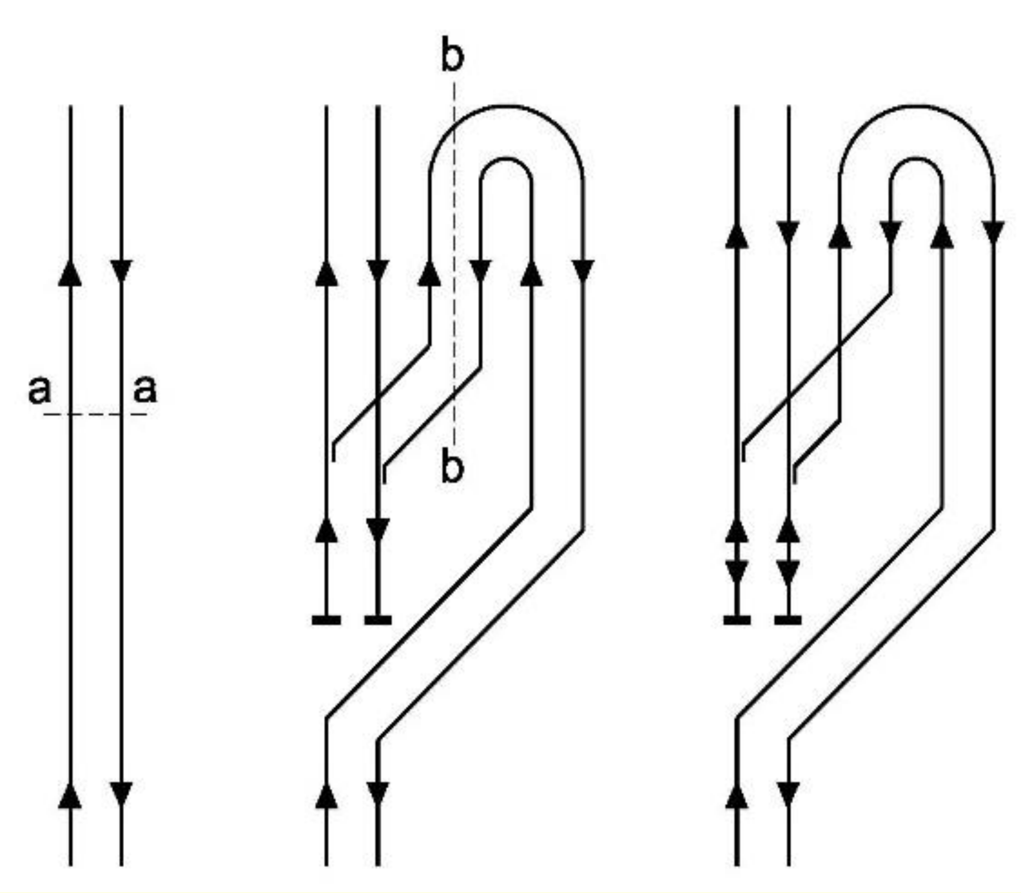


Operation *by Directions* (D)



From transit station to terminus station

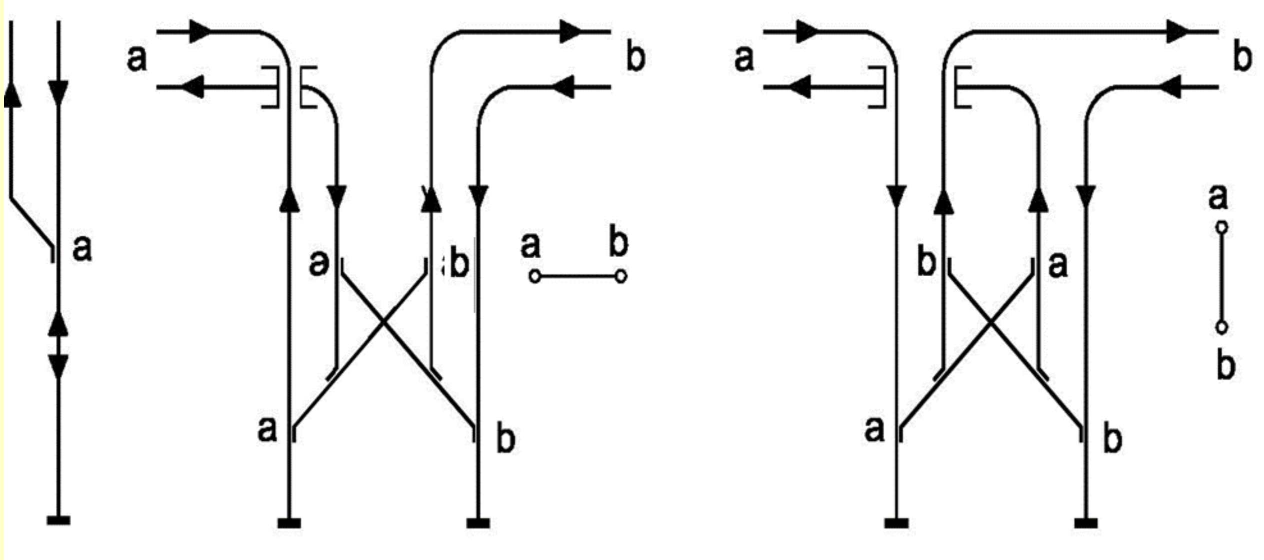
Double 180° sequential rotation around *a-a* and *b-b* axis of lower part of figure



Elementary terminus stations

1) Terminus of line (a)
2) Terminus of lines (a) and line (b): (a-a) and (b-b) tracks aside
3) Transit from line (a) to line (b): (a-b) and (b-a) lines aside

1) 2) 3)



Arrival tracks designed to let trains running on switches in straight position to avoid speed restrictions and station capacity reduction

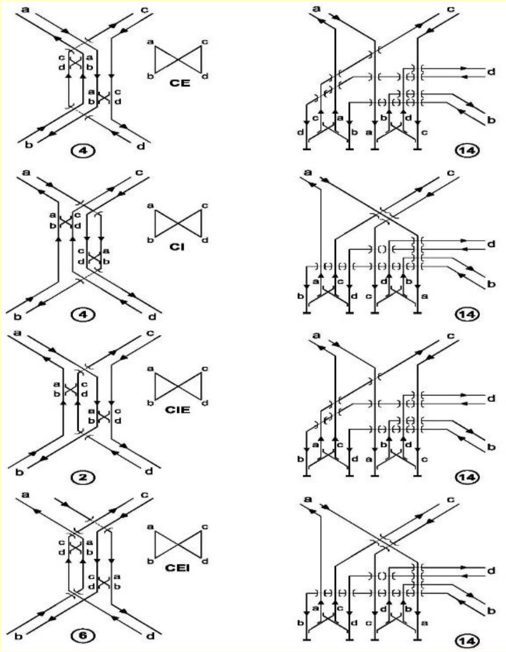
Correspondence transit-terminus stations

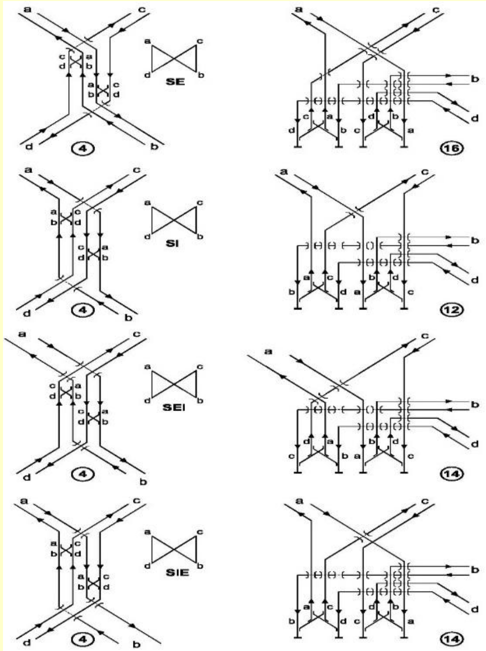
<u>**Invariable Müller figure**</u>

Terminus designed by sequence of letters (e.g.: *abcd*)

<u>**Station typologies**</u>

C) c-d links like *C* letter **S) c-d links like *S* letter**

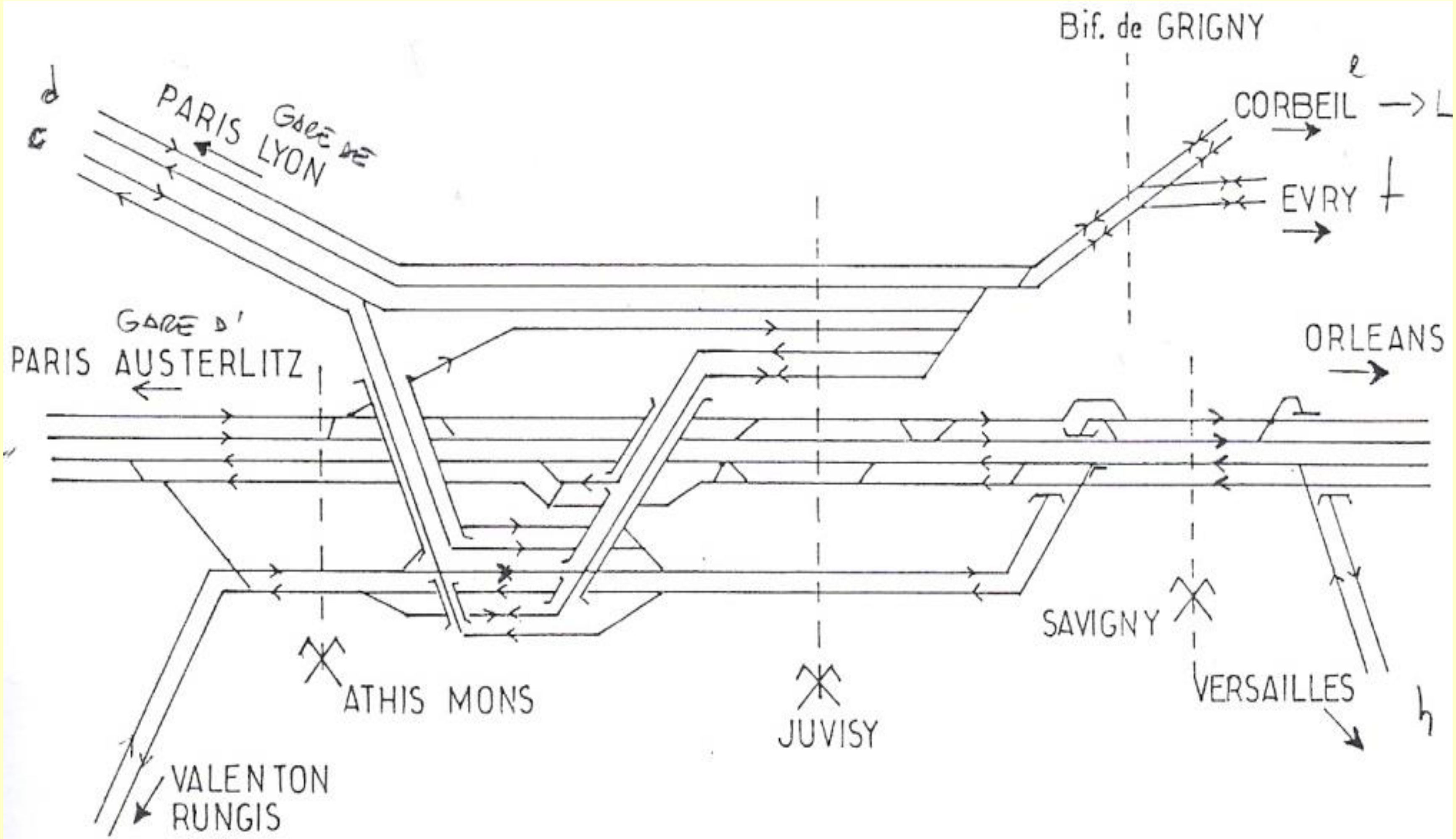




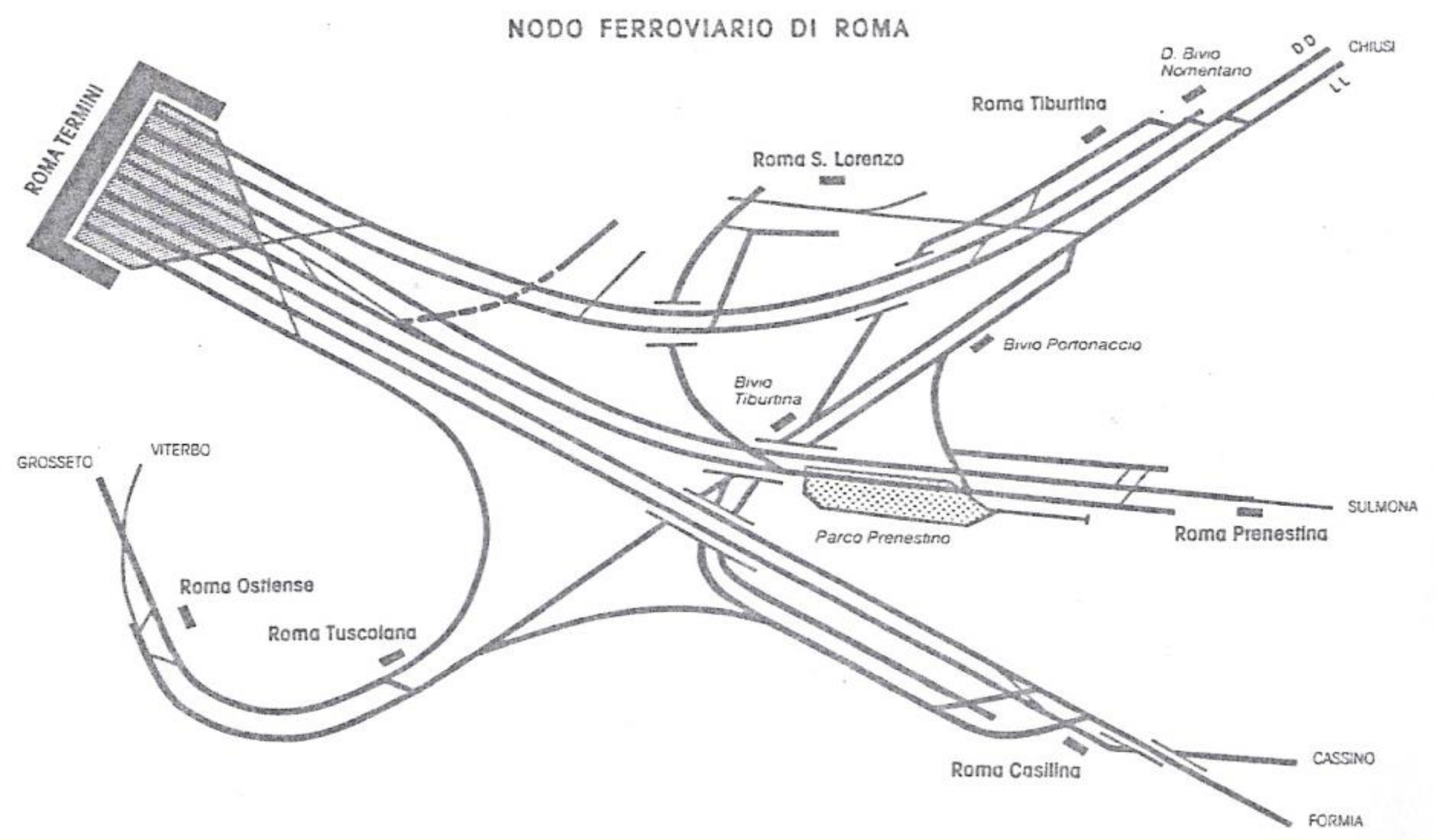
E/I = External/Internal links

(number in circles corresponding to number of tracks intersections)

Example of transit station: Juvisy (France)



Example of terminus station: Roma Termini (Italy)



https://www.youtube.com/watch?v=6Cj_yGVfxMY

IN6
Station interlocking systems

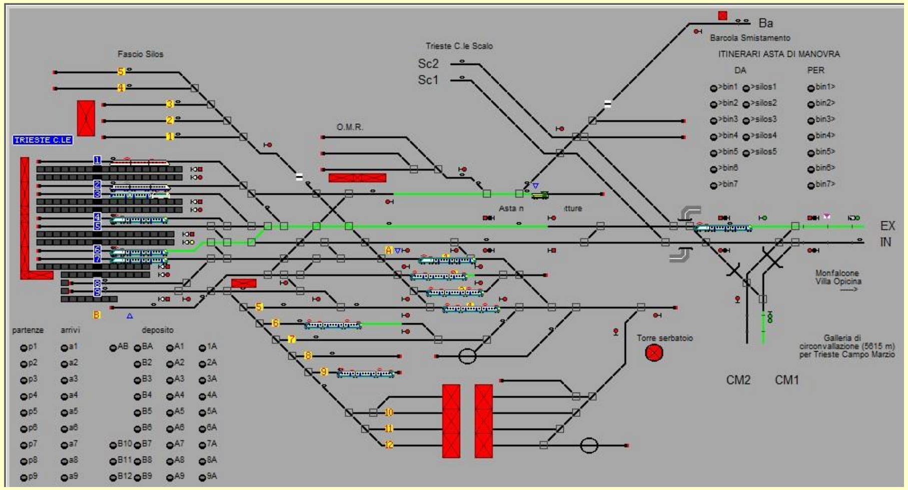
<u>References</u>

- **European Commission –** ***Commission implementing regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919*** **- 2023**
- **Pachl J. -** ***Railway Signalling Principles. Edition 1.1*** **– Braunschweig, 2020**
- **Le Bliguet M., Andersen Kjaer A. -** ***Modelling Interlocking Systems for Railway Stations*** **– Kongens Lyngby, 2008**

Functional analysis

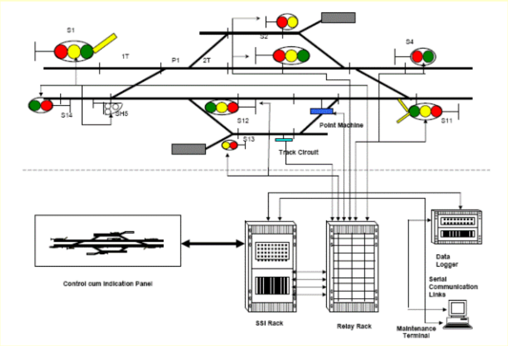
<u>Requirements</u>
Safety: ensuring exclusive use of infrastructure by single trains
Capacity: ensuring shortest sequence of operations

<u>Operational context</u>
Variability of configuration: position of switches



<u>Process</u>
Assignment of routes to trains
- Decision (manual/automatic)
- Setting of the route before train approach (manual/automatic)
- Occupation of the route by the train
- Release of the route by the train

Interlocking steps



<u>Route pre-setting</u>

Decision to prepare route (manual/automatic)

- Number of routes depending on station complexity

Random effects of traffic perturbations

Conflicting elements

- Need of fast decisions to prevent delays to trains
- Careful evaluation of best priorities among possible routes

<u>Route setting</u>

Booking (Recording)

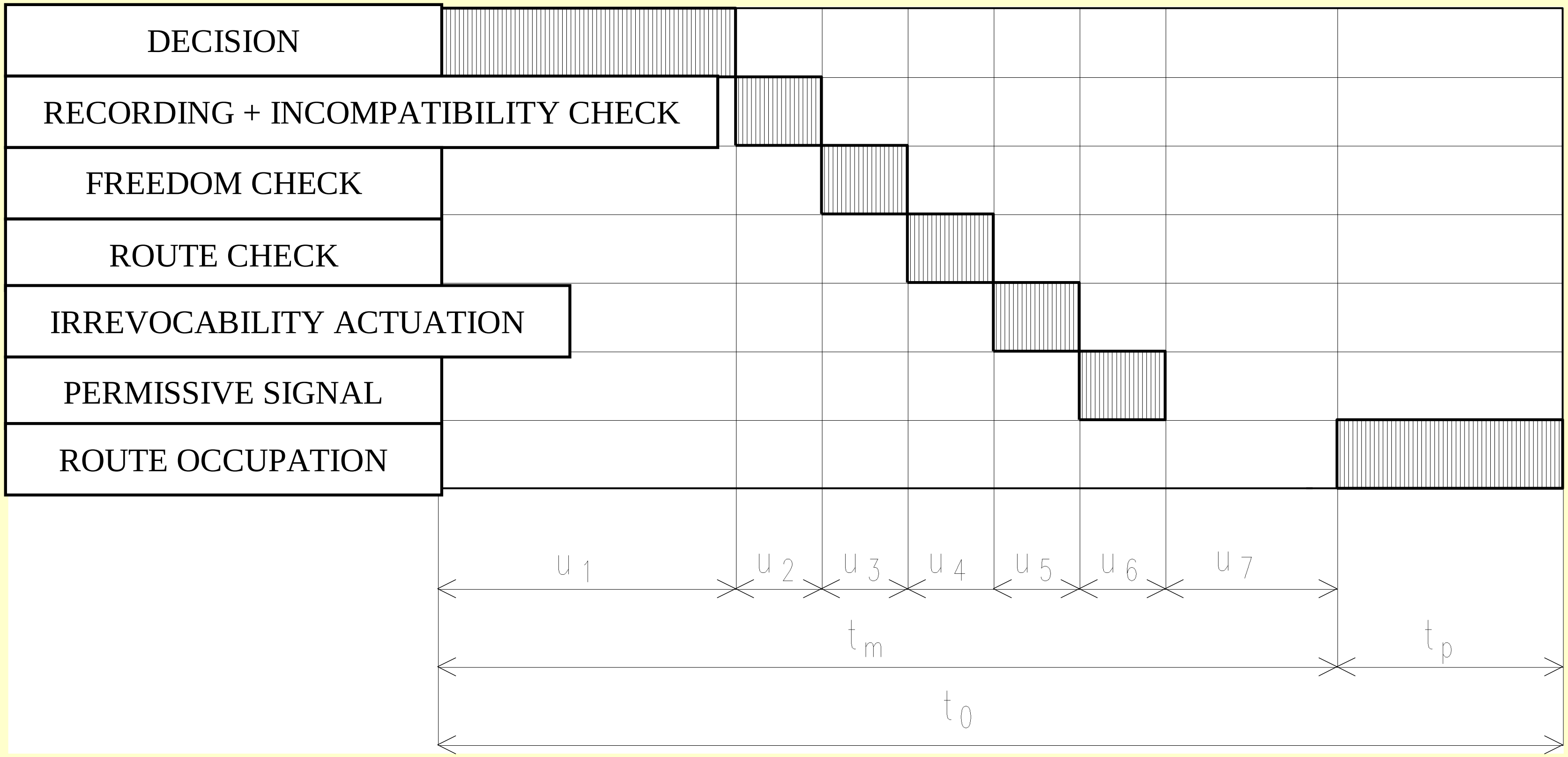
Safety checks by mechanic, electro-mechanic and electronic devices

- *Compatibility*: Route compatible with pre-actuated routes
- *Freedom*: Route not pre-occupied by vehicles
- *Existence*: Switches positioned according to the route
- *Irrevocability*: Booking not modifiable before occupation and release

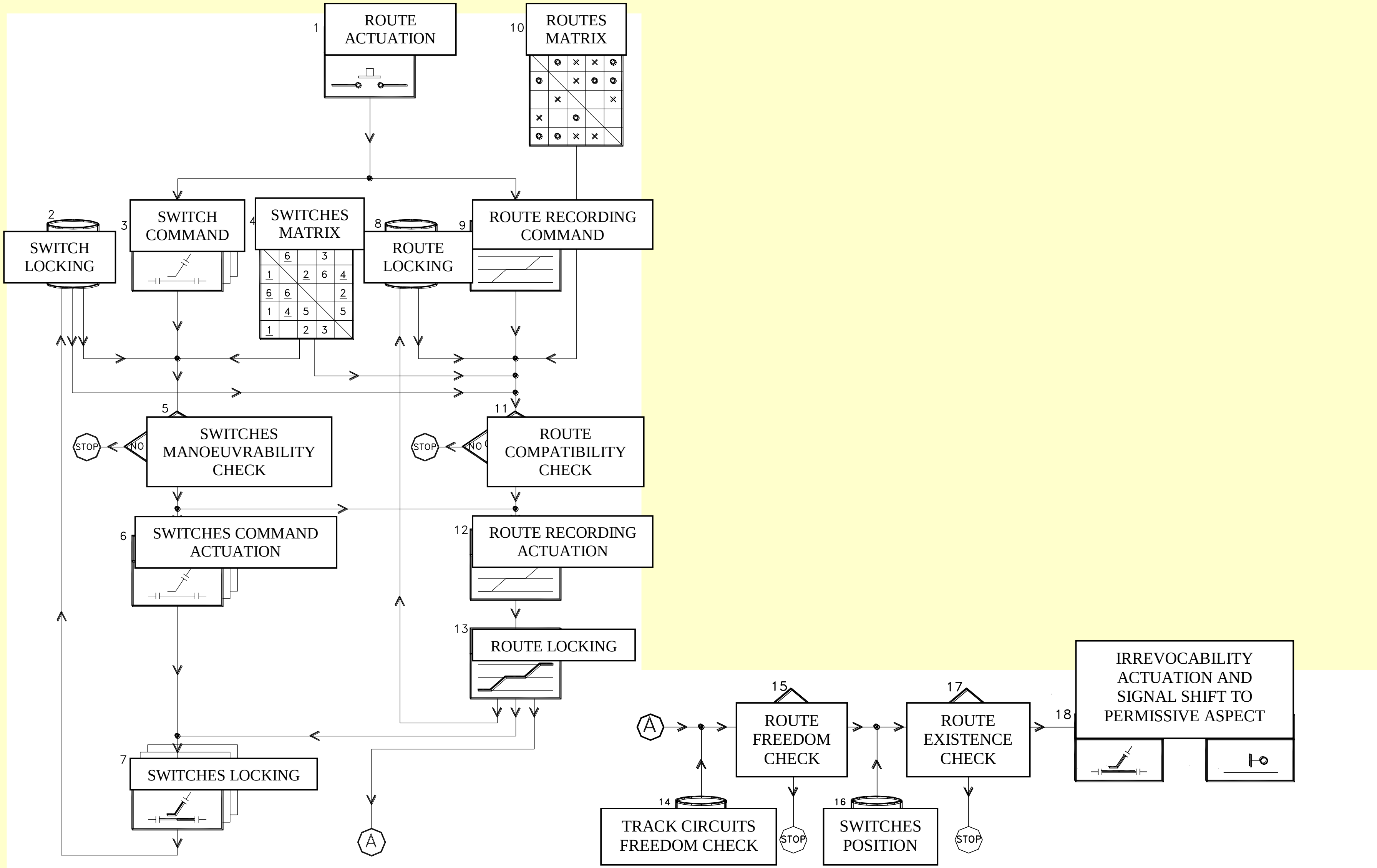
Shift of signal to permissive aspect

Possible delays due to conflicts among routes to be actuated

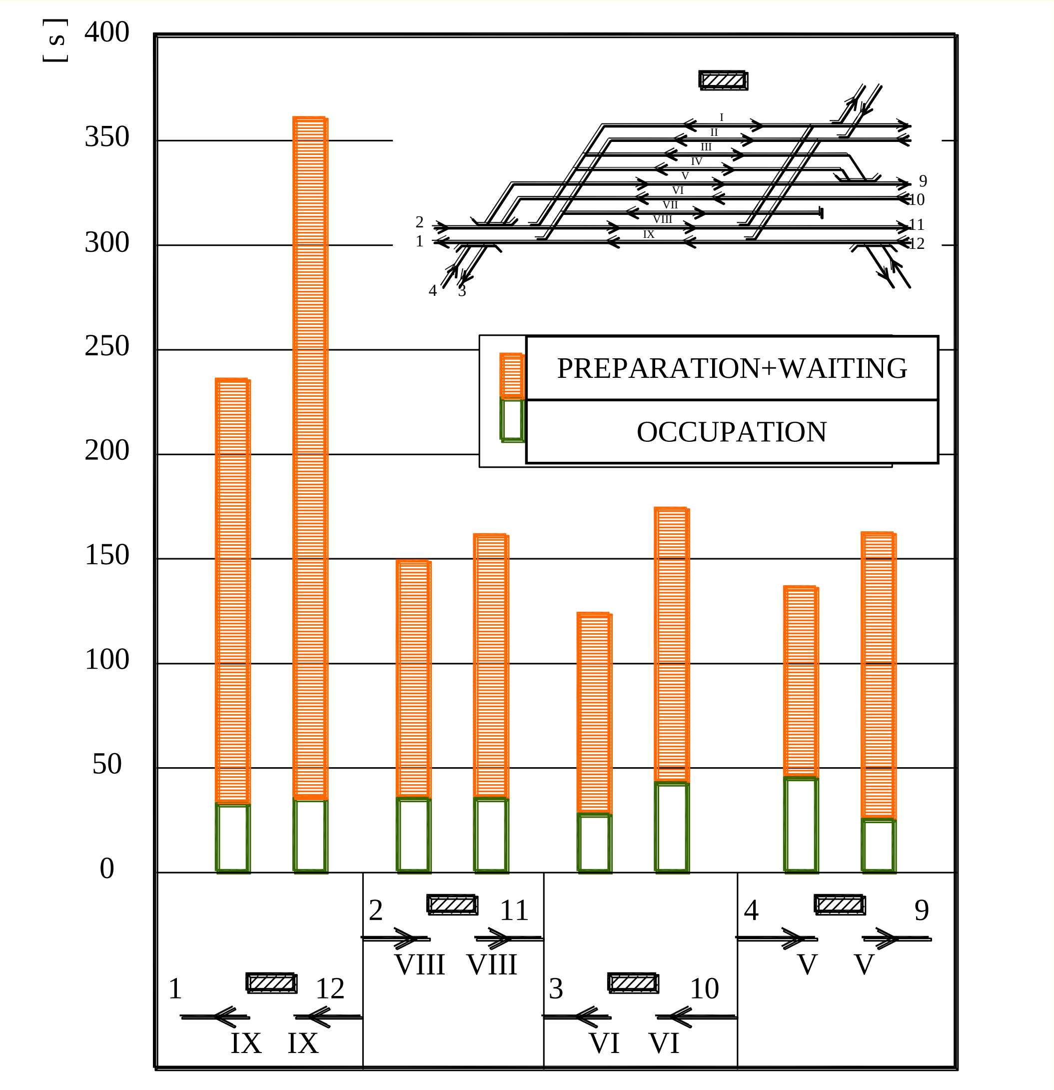
Route management phases



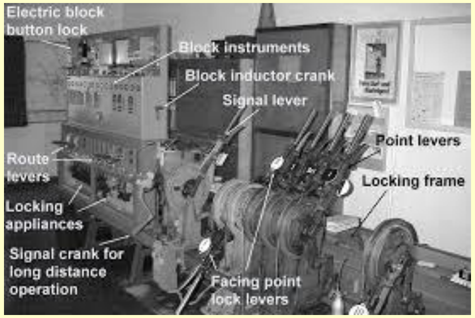
Route actuation: logical steps and tools



Operational times monitored in a medium station



Interlocking systems typologies



<u>Mechanical technology</u>

Mechanical, hydraulic and oleo-dynamic equipment

- Manoeuvre of devices

- Safety checks

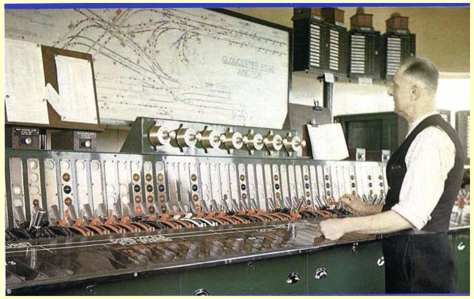
<u>Electro-mechanical technology</u>

Electro-mechanical equipment (electrical engines, electromagnets, etc.)

- Manoeuvre of devices

Electrical circuits: current circulation = physical/logical state of devices

- Safety checks



<u>Electronic technology</u>

Electro-mechanical equipment

- Manoeuvre of devices

Electronic circuits

- Safety checks

Manual vs. automatic operation

Manual process
Routes actuation managed by signalmen operating on switches and signals
Partial automation
Signalmen selecting routes to be actuated
Interlocking systems performing all required checks and actions
Full automation
Routes automatically actuated basing on trains requests
Interlocking systems performing all required checks and actions (independent upon signalmen in regular and perturbed operation)

Interlocking systems components

<u>Visual control panel</u>

Screen reproducing station layout with indications on state of devices

- Aspects of signals, occupation of tracks, position of switches, etc.

<u>Master controller</u>

Interface between signalman and equipment

- Actuation of commands by levers, buttons, lamps, control lights, etc.

<u>Logic unit: relays or computers rack</u>

Electric circuits or elaboration units for safety conditions check

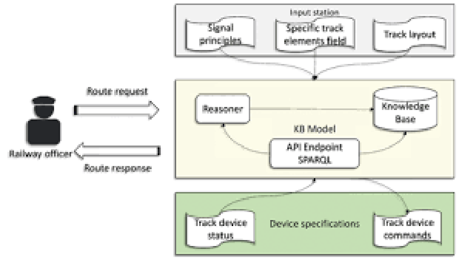
<u>Supply control unit</u>

Electric supply of interlocking system and local devices

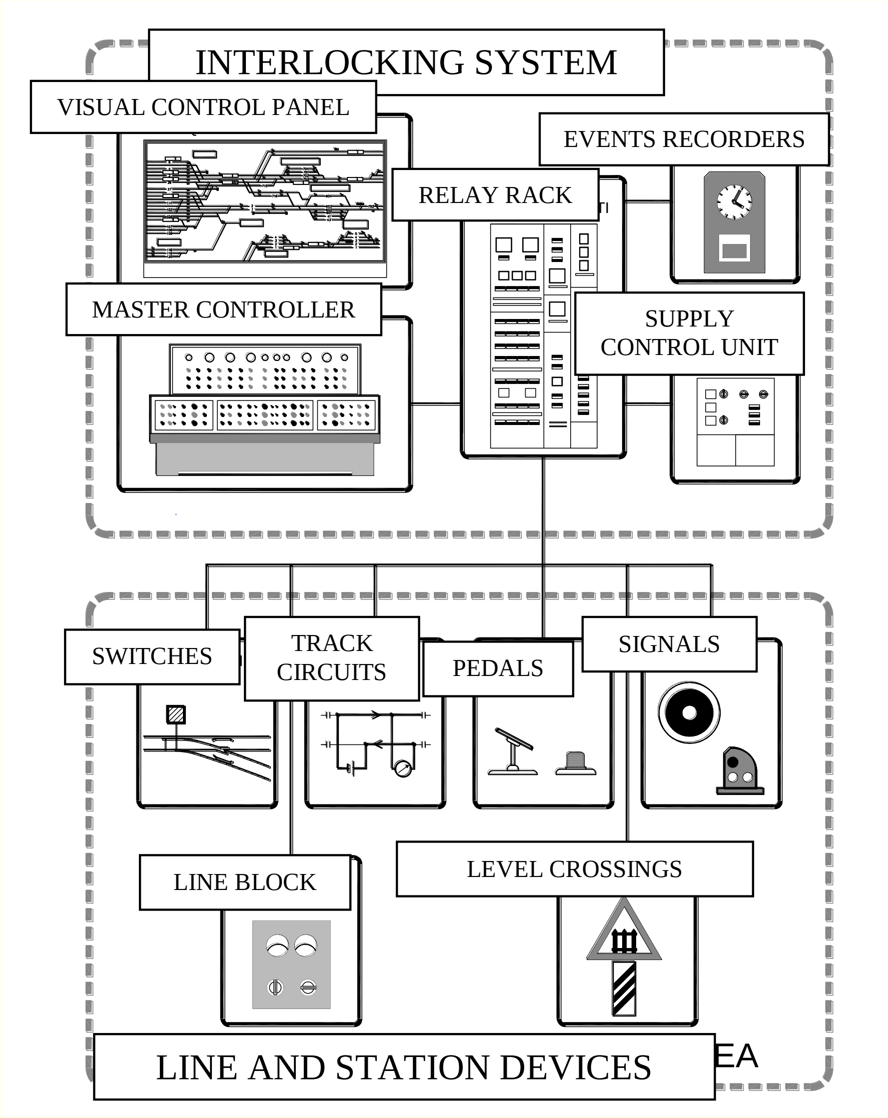
<u>Events Recorders</u>

Continuous recording of manual/automatic performed actions

- On-site devices: signal aspects, track circuits, switches, etc.
- Commands actuators: push-buttons, levers, etc.



Interlocking systems scheme



IN7
Criteria and methods for maintenance

References

- **Esveld C. –** ***Modern Railway Track. Second Edition*** **– www.Esveld.com, Delft, 2014**
- **Indian Railways Institute of Civil Engineering – Handbook for Track Maintenance – Pune, 2016**
- **Metrolink – Track maintenance manual. Final - 2020**
- **Park M.G. –** ***RAMS Management of railway systems. Integration of RAMS management into railway systems engineering*** **– University of Birmingham, 2014**

Definitions and indicators

Reliability

Probability *R* that a component (or a system of components) performs its functions under defined conditions for a fixed duration

- *Mean Time Between Failures* (MTBF): Average time interval between two failures of components (or systems of components)

Maintainability

Probability *M* that a defined unplanned maintenance action (to recover a failure) on a component (or on a system of components) is successfully performed within a fixed time, provided that the planned maintenance is regularly performed (according to the planning)

- *Mean Time To Repair* (MTTR): Average time interval to repair components (or systems of components) = average duration of failure, by including interventions and reactivation time, respectively before and after the reparation itself

Availability

Probability *A* that a component (or a system of components) remains able to perform its functions under defined conditions for a fixed duration

- *Mean Time Of Availability* (MTOA): Average time interval of components (or systems of components) availability

$$MTOA = MTBF - MTTR$$

Reliability of fixed installations and vehicles

Fixed installations and vehicles
Mechanical + Electrical + Electronic components
Exposed to failures during operation

Randomness of failures quantitatively expressed by indicators
Failures generation process well represented by *Poisson* distribution
(extended investigations in various railway networks)
Generic probability to have *n* failures in a defined time *t*

$$p(n,t) = e^{-\frac{t}{T}} \frac{\left(\frac{t}{T}\right)^n}{n!}$$

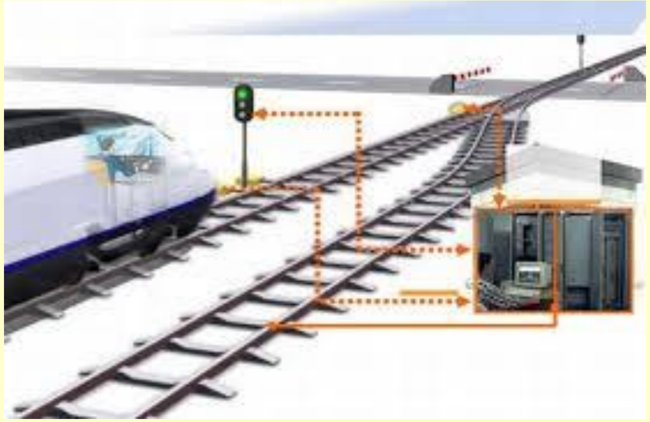
Reliability referred to time *t* expressed by probability to have *n* = 0
(no failures during that period)

$$R = p(0,t) = e^{-\frac{t}{MTBF}}$$

Hypothesis: independence of failures generation process upon mode of use of components/systems (almost continuous use)

Maintenance of signalling systems

<u>Main classes of components to be maintained</u>
Switches mechanisms and blades
Pedals and other occupation/release devices
Track circuits
Block systems
Signals
Telecommunication equipment
Level crossings mechanisms and barriers



<u>Maintenance planning (equipment in continuous operation)</u>
Planning to ensure continuity of traffic safety conditions
Total or partial interruptions of traffic (temporary degraded operation)
Regulated exchange of information *maintenance operators - signalmen*

Maintenance organization and constraints on operation

<u>Frequency of maintenance actions basis</u>

Period of possible unfailing operation

Actual use during this period

<u>Minimisation of traffic interruptions</u>

Simultaneous maintenance of various components

Slots defined according to traffic typology and temporal distribution (mid-mornings and nights)

<u>Maintenance activities</u>

Planned: failures prevention

Unplanned: failures reparation

<u>Factors affecting the frequency of signalling systems failures</u>

Quantity and typology of preventive maintenance

Frequency and mode of use of components

Reliability and teams composition by component

Daily reliability (t = 24 h) of signalling components on a line section

Component	*MTBF [h]*	*Quantity*	*R*
Track circuit	35000	49	0.967
Switch	46000	35	0.982
Signal	58000	33	0.984
Pedal	73000	6	0.998
Manual line block	22000	2	0.999

Average composition of technological maintenance teams

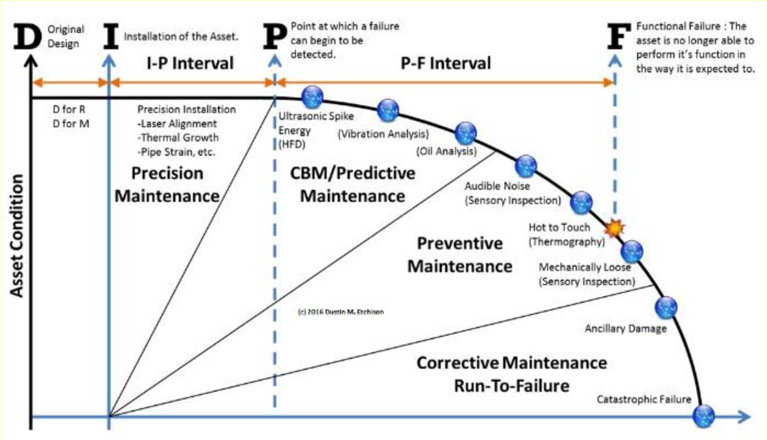
Components and systems	*Number of operators*
Remote control system	3
Remote control centre	3-10
Line block	3-4
Station interlocking	5
Phones	3-4
Cables and tunnels	2-3
Radio	3
Audio diffusion	3

Maintenance of superstructure

<u>Double functions of superstructure: guide and sustenance of vehicles</u>
Limited tolerance in dimensional and mechanical characteristics

<u>Continuous trains' running efforts</u>
Subsidence and wear monitored to plan intervention according to the evolution and the tolerances

<u>Planned maintenance</u>
Fixed deadlines: not depending upon monitoring results
Specific systematic maintenance cycles

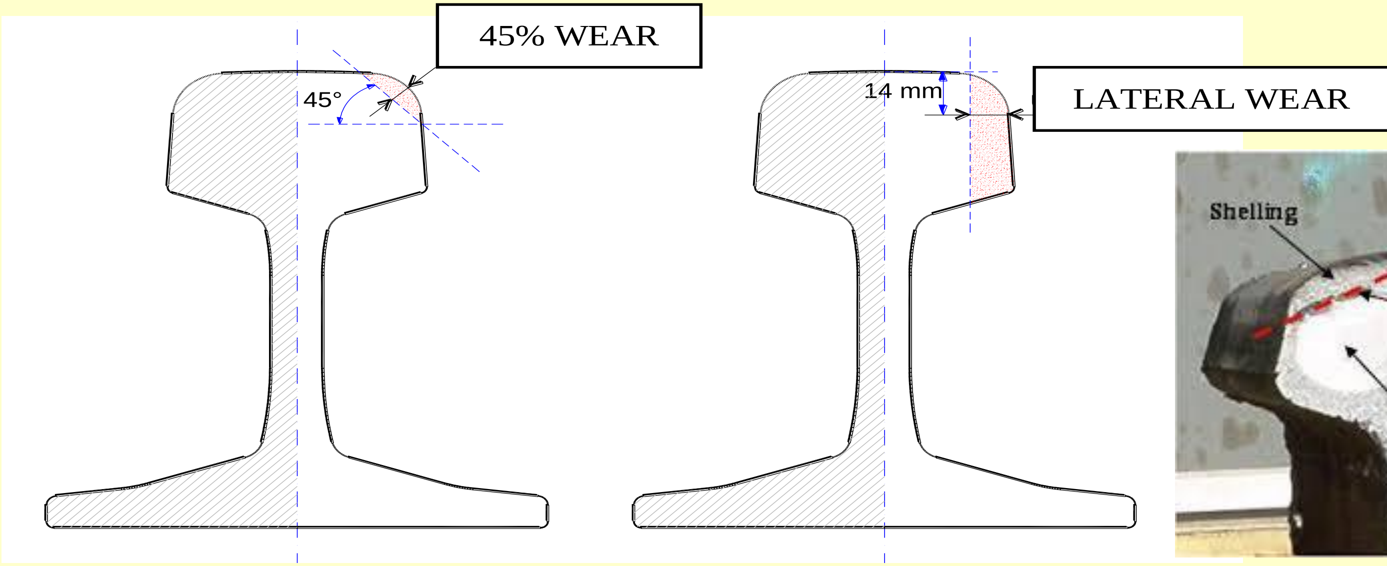


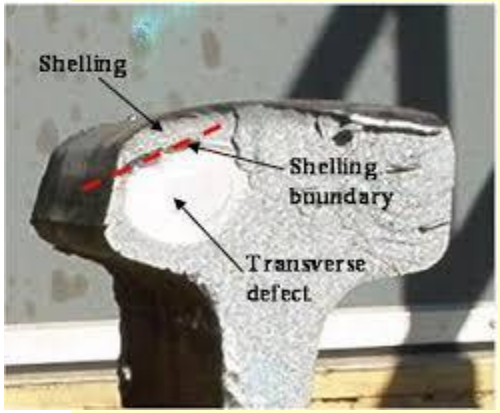
<u>*On condition* maintenance</u>
Unplanned, based on monitoring results or warnings by personnel

Railhead wear

<u>**Homogeneous lack of matter along internal side of railhead**</u>
(in comparison with nominal theoretical rail profile)

45° Wear
- Along 45° inclined top-side line at flank railhead transition
Lateral Wear
- 14 mm under running surface

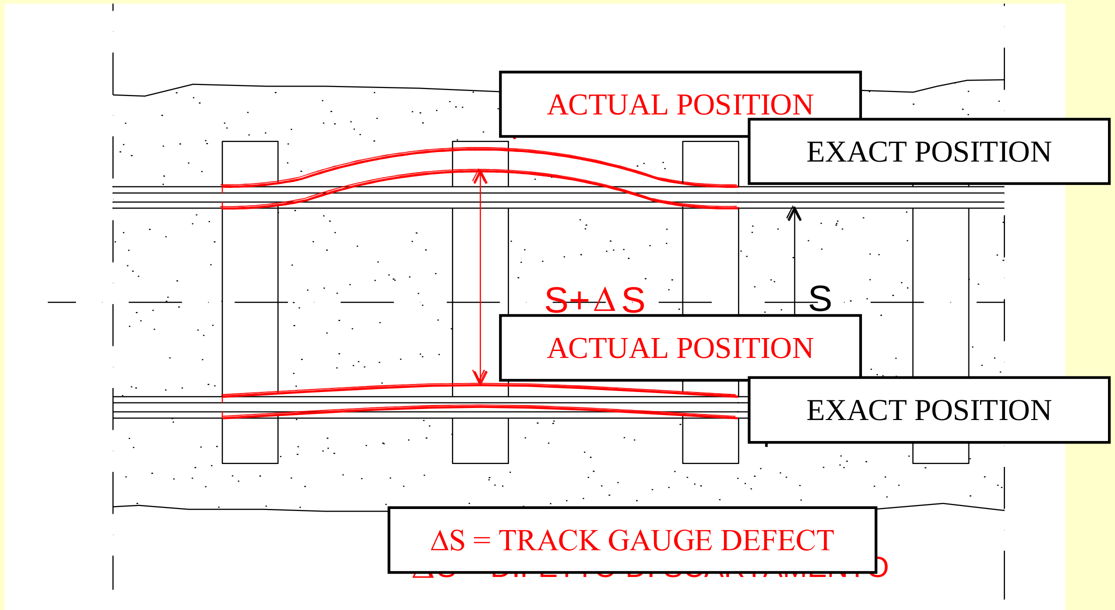




Track gauge defects

<u>Displacement of rail from exact planimetry position</u>

14 mm under running surface between internal sides of railheads

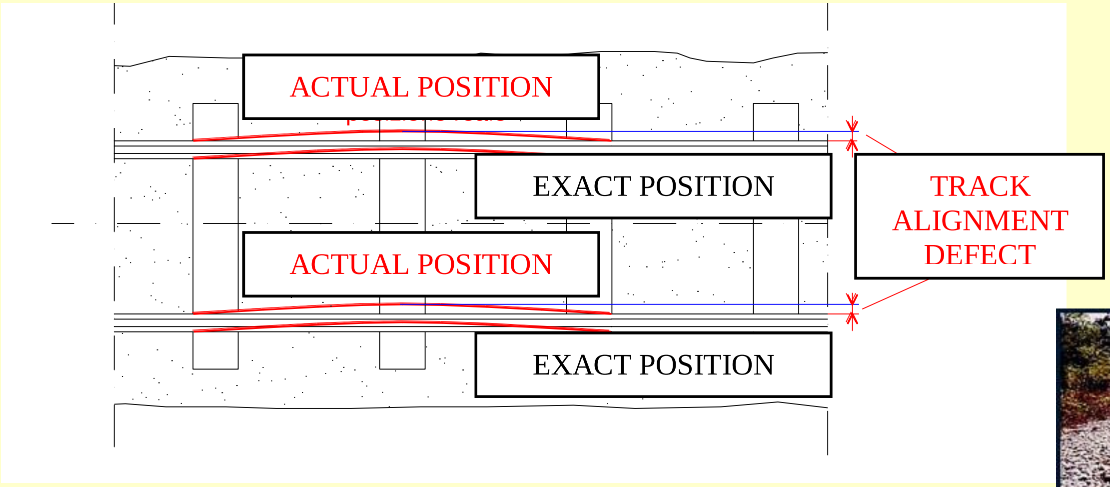


Track alignment defects

<u>Displacement of both rails from exact planimetry position</u>

14 mm under running surface between corresponding sides of railheads

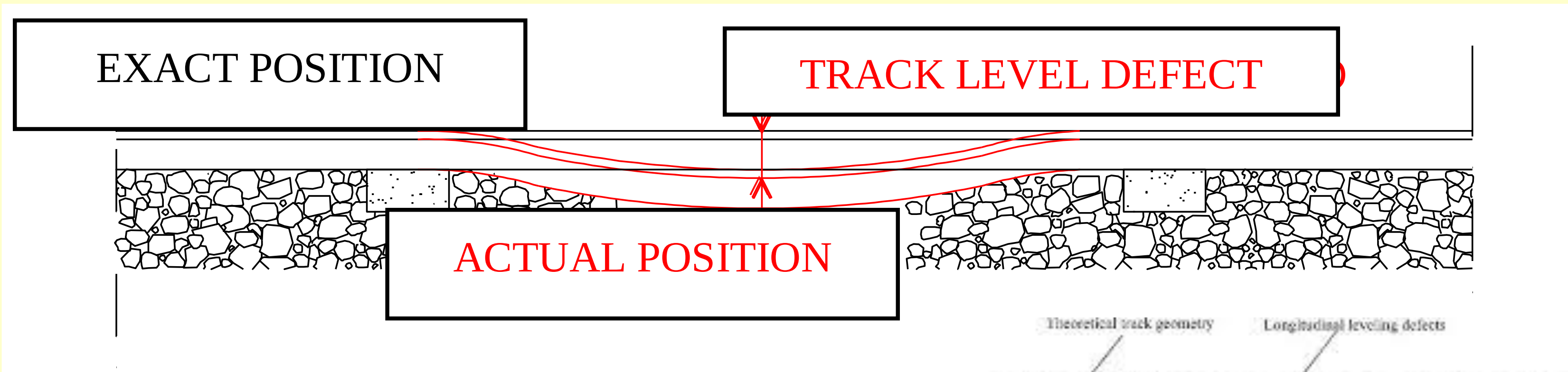
Average deviation of consecutive positions defined by fixed wave length ranges (e.g. 3-25 m and 25-70 m)

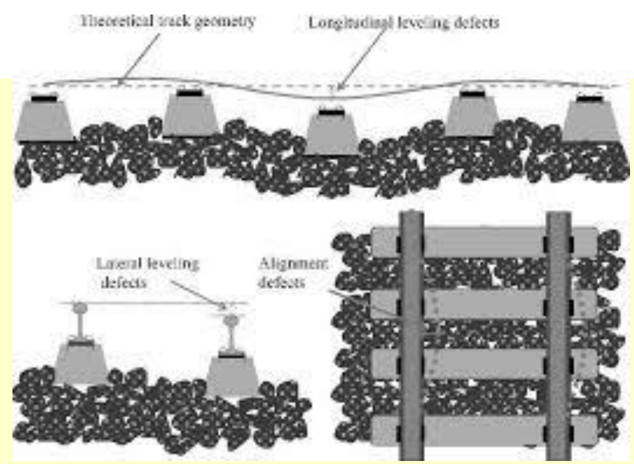


Track level defects

<u>**Displacement of both rails from exact altimetry position**</u>

Distance between average rolling surface level in consecutive positions defined by fixed wave length ranges (e.g. 3-25 m and 25-70 m)

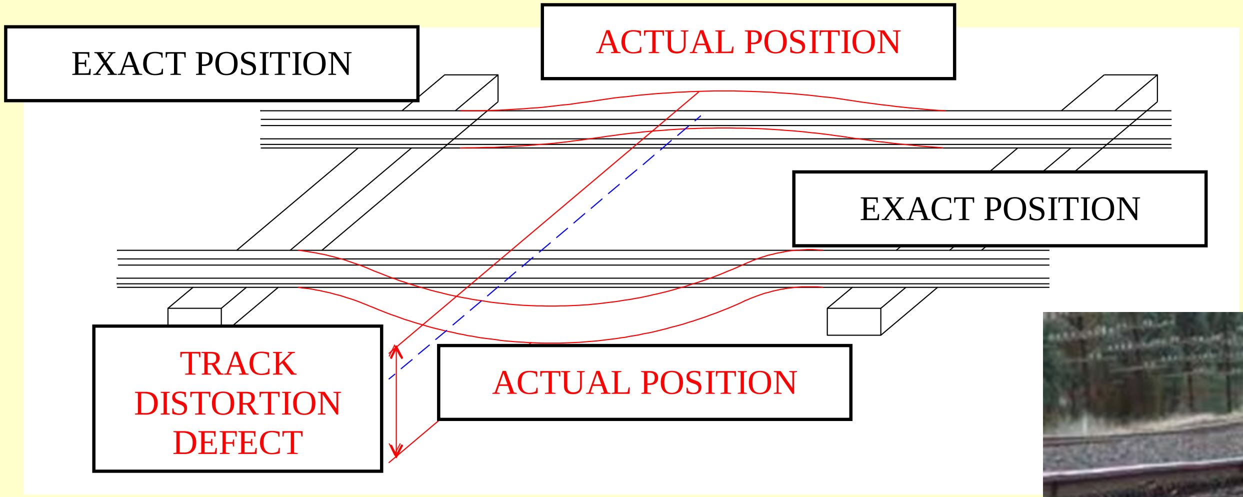




Track distortion

<u>Reciprocal displacement of rails from exact altimetry position</u>
‰ gradient between transversal level in two track sections at fixed distance (distortion measurement basis) and standard level

Potentially dangerous as primary cause of derailments



Other defects

Lack of track stability

Subsidence of sleepers' support and underlying ballast

Lack of track elasticity

Excessive rigidity of sleepers' support and underlying ballast

Un-regulation of track expansion gaps

Extension or reduction of thermic gaps at un-welded joints

Un-regulation of distance between sleepers

Due to frequent accelerations and decelerations

Sleepers degradation

Progressive subsidence: 1) at fastenings, 2) whole body, particularly for wooden sleepers

Loosening of fastenings

Ballast contamination

Progressive modification of dimension of rocks (fragmentation and intrusion of powders)

Maintenance organisation

Short term planned maintenance standard activities

Cyclic standard activities:

1) Measurement of defects
2) Correction of expansion gaps
3) Check of fastenings and track gauge
4) Adjustment of longitudinal and transversal levels
5) Packing of sleepers and track alignment
6) Track uncovering with progressive ballast removing
7) Recovering and side profiling of the ballast
8) Exchange of sleepers

Longer terms activities

Ballast renewal

- Removal and sifting of a defined ballast bed

Track renewal

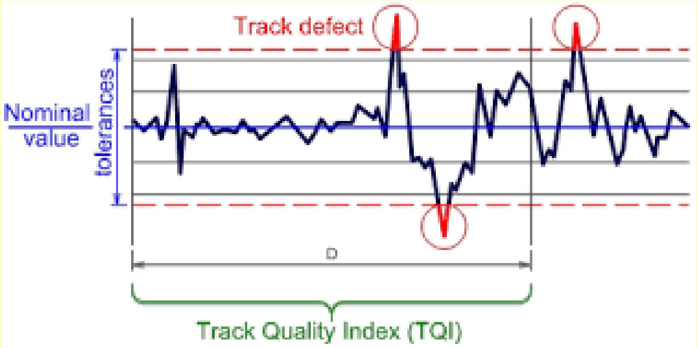
- Substitution of all metallic components of the superstructure

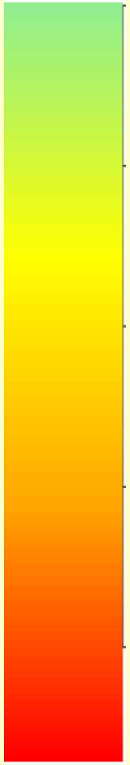
Defects evolution and *on-condition* maintenance

<u>Monitoring activities to identify Alert Levels for critical defects</u>

Maintenance activities required according to detected defect evolution to prevent operational restrictions

<u>https://www.linkedin.com/showcase/assets4rail/</u>





<u>**Geometrical standards**</u>

Target values (after renewal)

- Optimal conditions

First quality level

- Not requiring correcting interventions on superstructure geometry

Second quality level

- Normal operation, investigation on degrades, planned maintenance

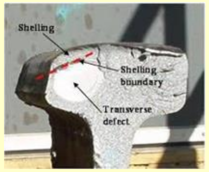
Third quality level

- Operation without restrictions, urgent maintenance required

Alarm level due to relevant degrade

- Operational constraints (speed restriction or traffic interdiction)

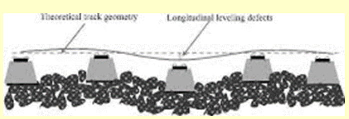
Alarm levels for geometrical standards



45° wear
15 mm

Track distortion
IT: from 6.5‰ (on 3 m basis) to 4.5‰ (on 9 m basis)
FR: 5.4 ‰ for maximum speed of 200 km/h

Alignment
From 7.8 to 23.0 mm



Longitudinal level
IT: from 10.4 to 22.0 mm
FR: from 6.0 to 8.0 mm

Track gauge
From +15 to -24 mm

IN8
Operation regularity

References

- **Hansen I. (editor) – *Timetabling Planning and Information Quality* – WIT Press, Southampton, 2010**
- **Hansen I., Pachl J. – *Railway timetable & traffic. Analysis – Modelling - Simulation* – Eurail press, Hamburg, 2008**
- **Pachl J. – *Railway Operation and Control (Fourth Edition)* – VTD Rail Publishing, Mountlake Terrace, 2002**
- **Joborn M., Ranjbar Z. – *Journal of Rail Transport Planning and Management Understanding causes of unpunctual trains: Delay contribution and critical disturbances* - 23, September 2022, 100339**

Concepts and definitions

<u>**Regularity = Punctuality**</u>
Probability to operate a transport service on defined infrastructure using assigned vehicle typology in compliance with an assigned timetable

<u>**Tolerance**</u>
Maximum allowed deviation from timetable

Relevant affecting factors
- Demand (duties/leisure passengers, ordinary/perishable goods)
- Integration with other public transport services (correspondences)
- Common use of infrastructures (services sharing lines and stations)
- Personnel and vehicles rosters (inter-linked *coverage* of trains)

Regularity indicators

Regularity on section *L*

$K_{Lr} = NU_{Lr} / NE_{Lr}$

NU_{Lr} = **trains operating service *S* exiting section *L* with delay ≤ *r***

NE_{Lr} = **trains operating service *S* entering section *L* with delay ≤ *r***

Example (tolerance = 5 minutes)

- 20 trains entering in section L with delay ≤ tolerance

- 18 trains exiting from section L with delay ≤ tolerance

$K_{L5} = 18/20 = 0.90$

Regularity on all sections until *L*

$I_{Lr} = NU_{Lr} / NT_L$

NU_{Lr} = **trains operating service *S* exiting section *L* with delay ≤ *r***

NT_L = **trains operating service *S* on section *L***

Example (tolerance = 5 minutes)

- 24 trains running on section L

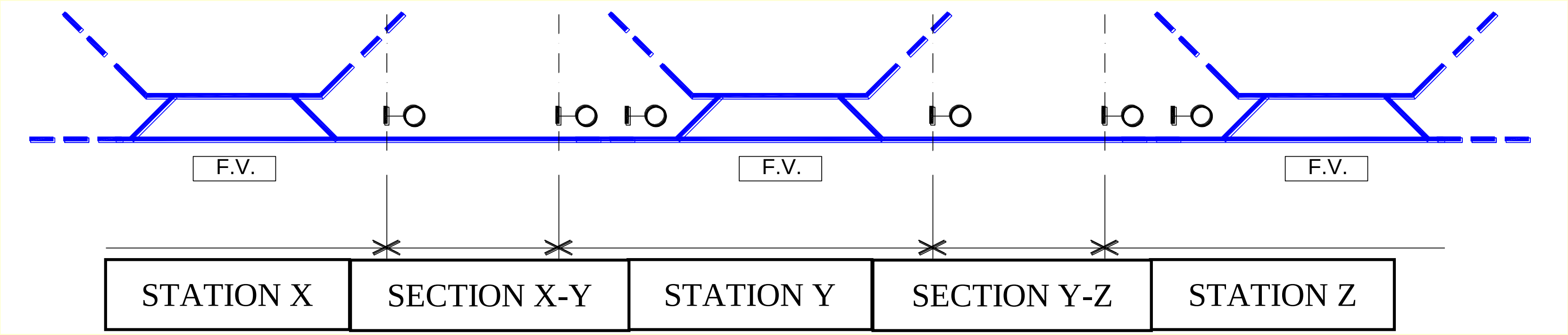
- 18 trains exiting from section L with delay ≤ tolerance

$K_{L5} = 18/24 = 0.75$

Calculation of indicators

Generic service *S* between stations *X* and *Z*

$$K_{XZr} = K_{Xr} \cdot K_{XYr} \cdot K_{Yr} \cdot K_{YZr} \cdot K_{Zr}$$

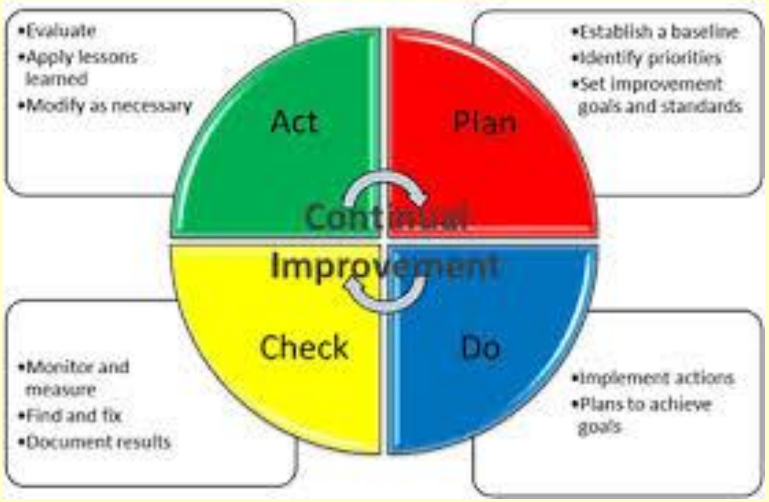


<u>Ex-post (*after*) calculation</u>
Result of operational monitoring

<u>Ex-ante (*before*) calculation</u>
Forecast basing on analytical methods or simulation models

Monitoring of traffic regularity

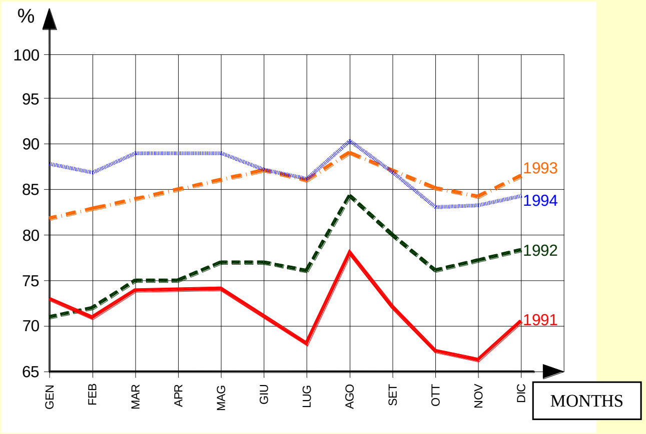
1) Sampling of trains' set to be monitored
2) Daily collection of trains' traffic data
3) Short-medium term (weekly/monthly) statistical analysis
4) Identification of relevant systematic delays
5) Search of delays' causes
6) Identification of actions to reduce or eliminate delays
7) Actuation of identified actions and check of achieved results
8) Iteration of monitoring activity as in a typical *Deming* cycle



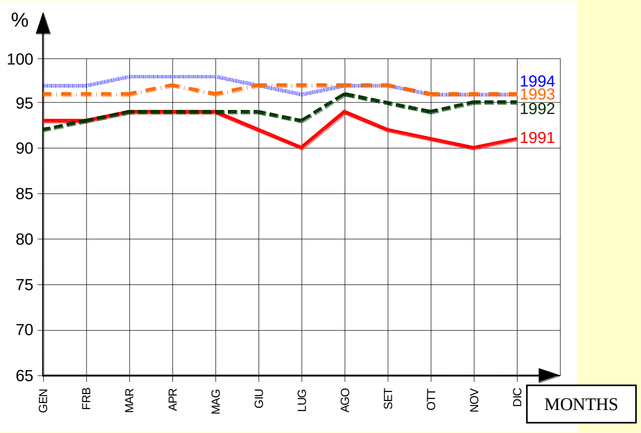
Results of traffic monitoring

% of trains arrived with delay: Italian network in period 1991-1994

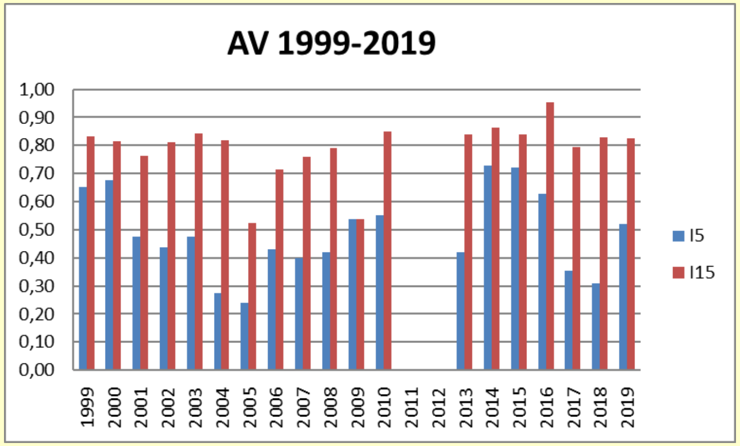
≤ 5 minutes



≤ 15 minutes



Global regularity indicators: Italian High-Speed trains in period 1999-2019



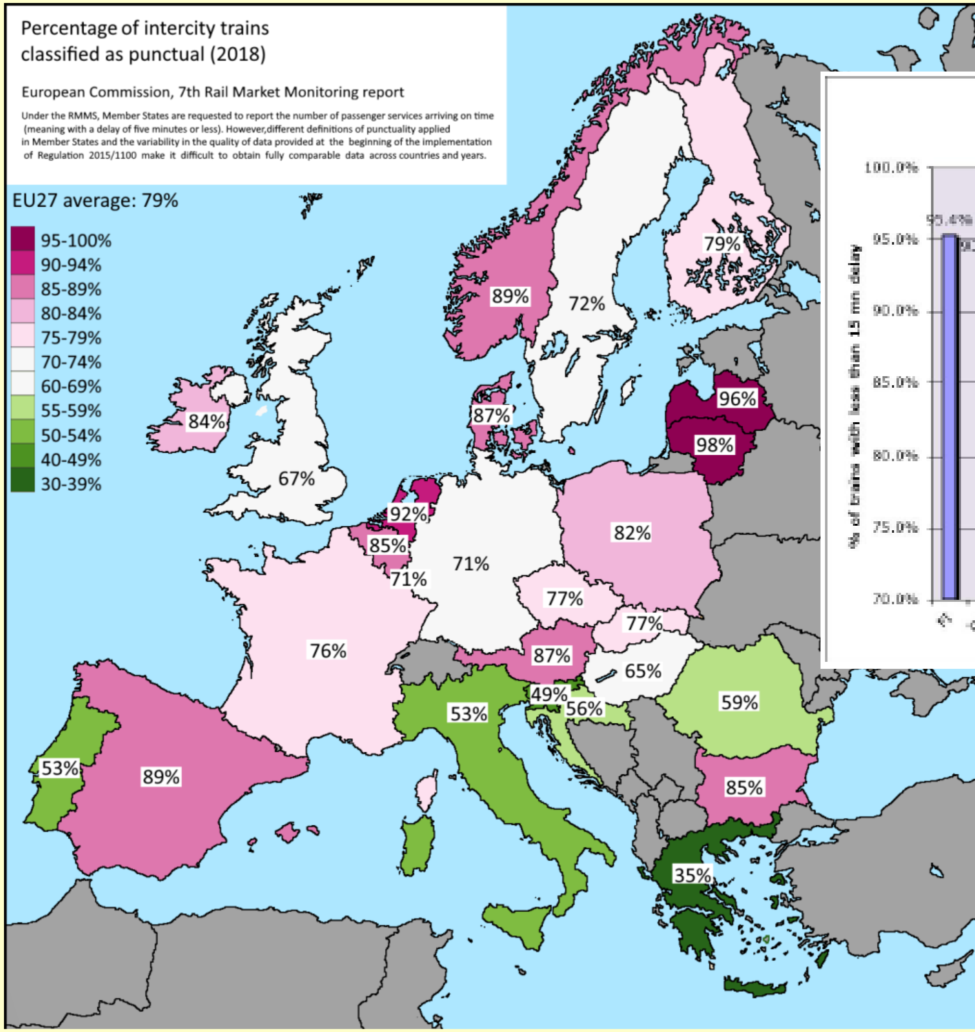
Punctuality and tolerance across networks

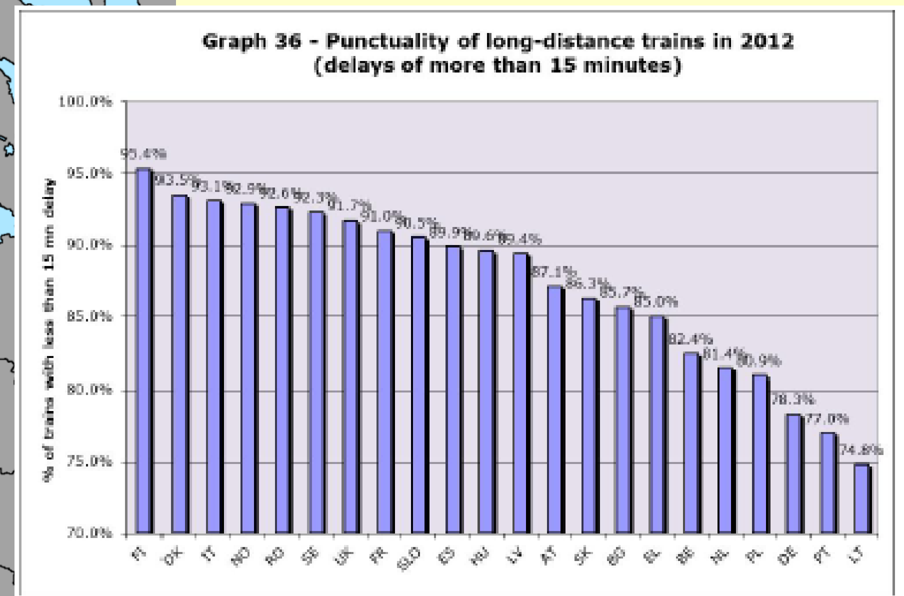
Data from some European railway networks

Country	*Network*	*Tolerance [min]*	*I (2005)*
Belgium	Infrabel	5	0.919
France	RFF	10	0.831
Germany	DB Netz	6	0.814
Lithuania	-	4	0.959
Luxembourg	CFL	3	0.956
Netherlands	Prorail	3	0.848
Spain	ADIF (whole network)	10	0.958
	ADIF (regional services)	5	0.965

Measured punctuality across European networks

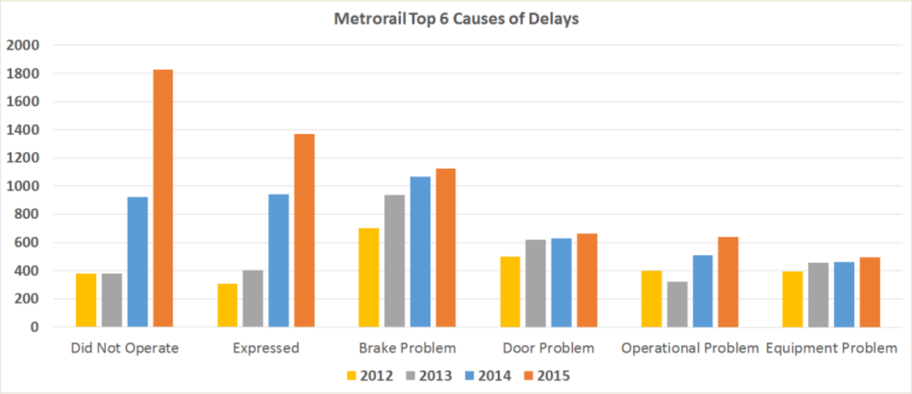
European statistics on Intercity and Regional trains





Main causes of irregularities and delays

1) Failures of infrastructure and vehicle
2) Behaviours of signalmen and on-board personnel
3) Interaction with transported persons and goods
4) Traffic conflict
5) Events external to railway system



<u>Failures</u>

Large effect on service regularity

Requiring maintenance activities out of planned maintenance intervals

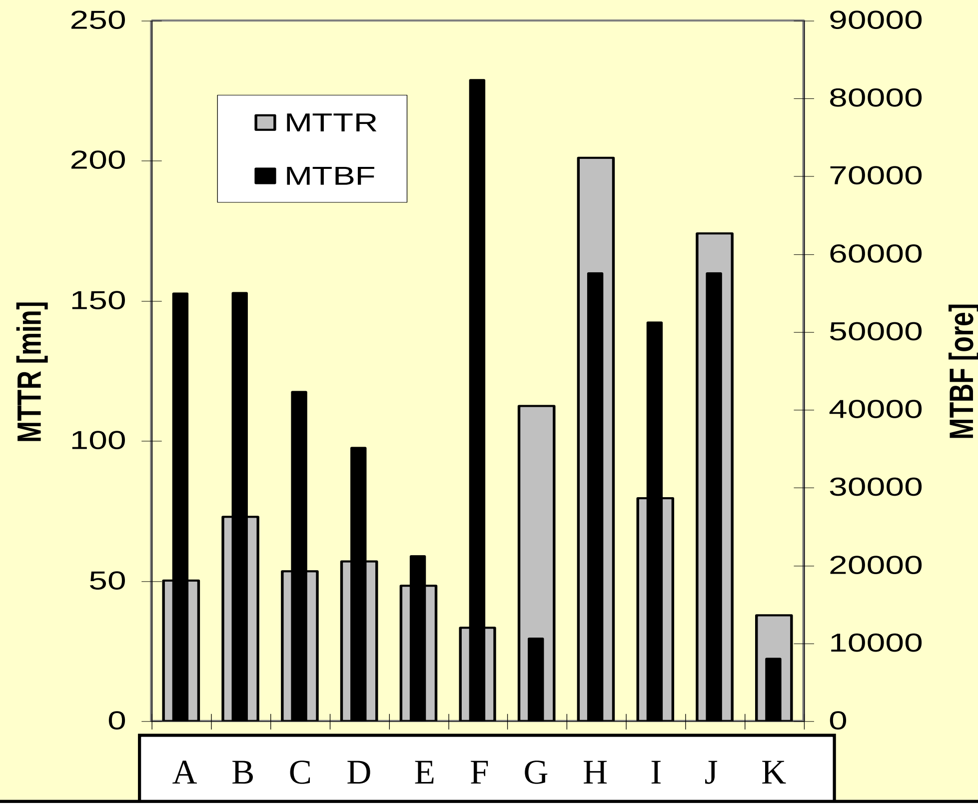
Low frequency: determining only 5-10% of total delays

<u>Extended analysis performed on RFI network (results in following pages)</u>

Period: 29 months

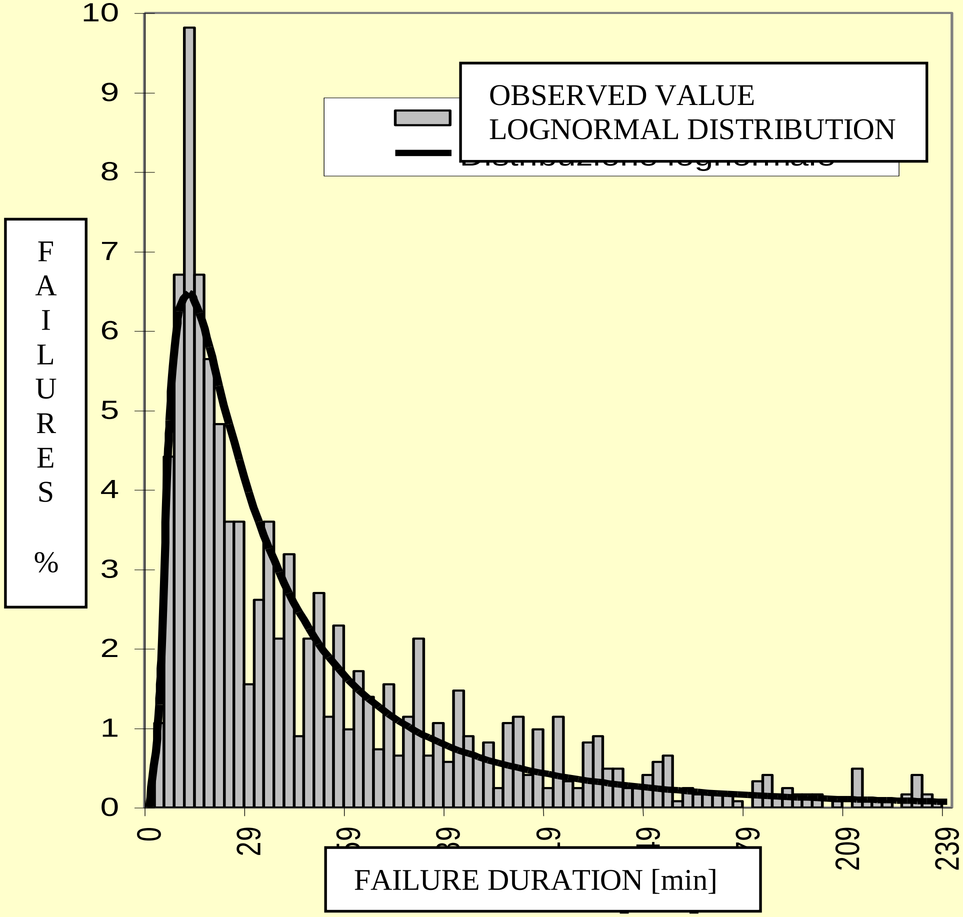
Network: 130 km for infrastructure and 280 km for rolling stock

MTBF and MTTR by monitored component

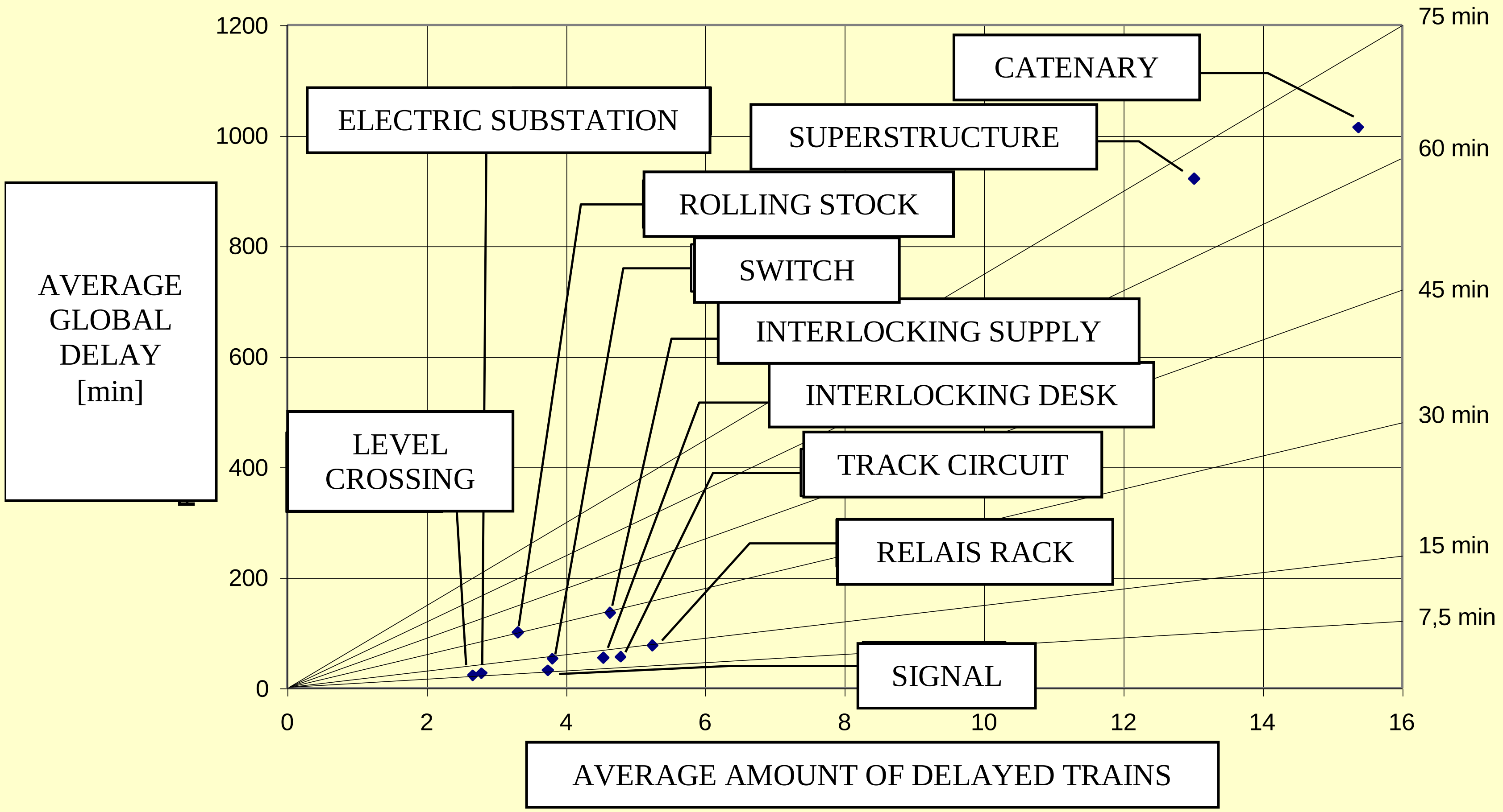


A = SIGNAL
B = TRACK CIRCUIT
C = SWITCH
D = RELAIS RACK
E = INTERLOCKING DESK
F = INTERLOCKING SUPPLY
G = LEVEL CROSSING
H = CATENARY
I = ELECTRIC SUB-STATION
J = SUPERSTRUCTURE
K = ROLLING STOCK

Frequency distribution of failures for monitored components



Effects of generic failures by monitored component



Not technical primary causes of delays

<u>Behaviour of personnel on board (drivers and guards)</u>
Delayed arrival to workplace
Delayed reactions to permissive aspects of signals
Running at speed lower than planned

Most frequent cause (50-70% of events)
Effects normally light (some minutes delay)

<u>Behaviour of ground personnel (dispatchers and signalmen)</u>
Delayed or un-correct actuation of operational measures (setting of a route, crossings or overtaking manoeuvres)

<u>Interaction with transported persons and goods</u>
Prolonged stops in stations due to boarding and alighting
Irregular loads of freight wagons

Secondary causes of delays

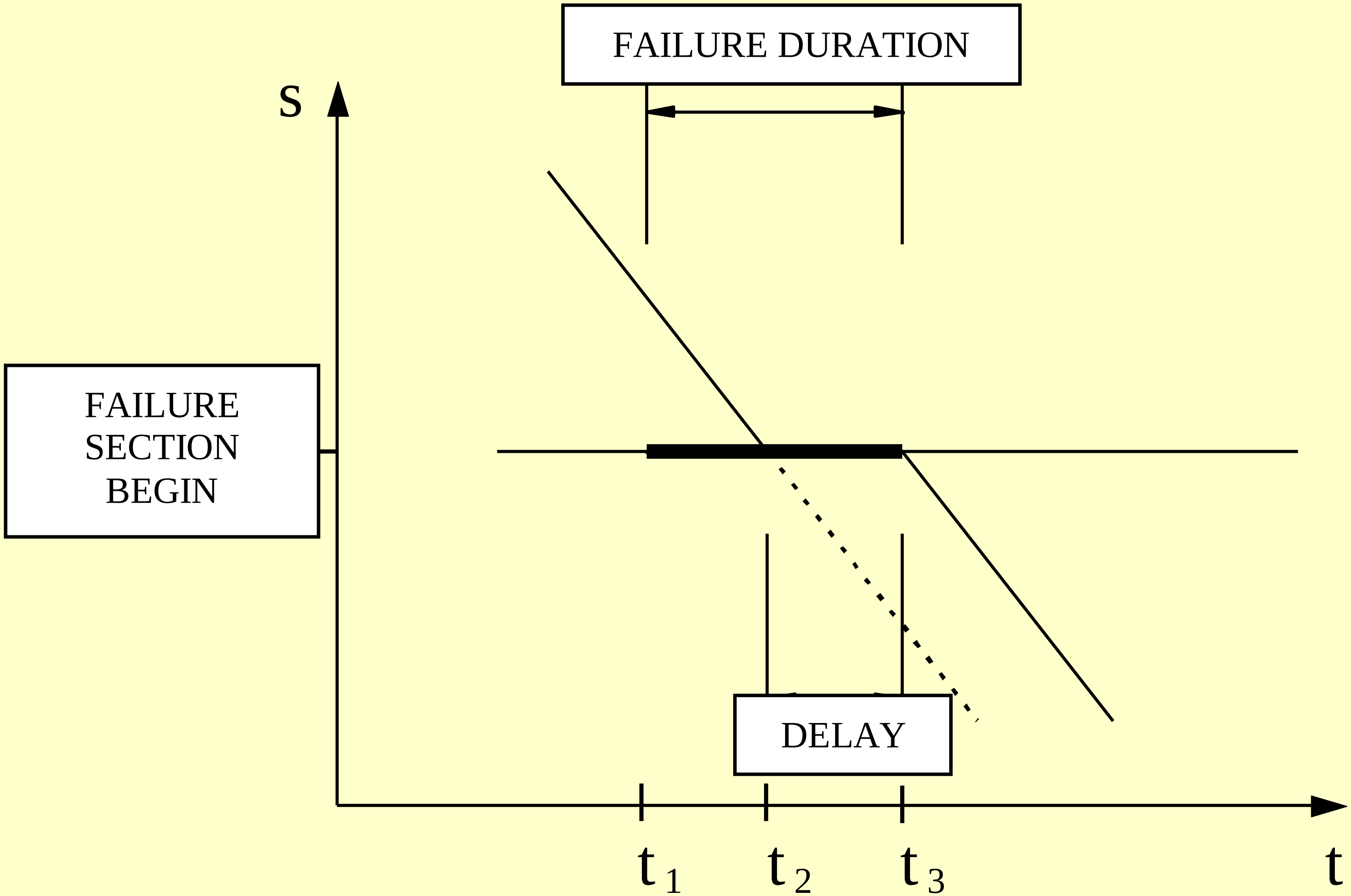
<u>Failed or forced timetable planning</u>

<u>Consequence of other perturbations</u>
Generation of deviations between actual and planned operation
(Second causal factor by frequency and effect)

<u>Events resulting in slowing down or unplanned stops</u>
Along line (too short train spacing)
In stations (incompatibility between entering and exiting routes)

<u>Causes external to railway system</u>
Natural events (fires, floods, landslips, etc.)
Social troubles (demonstrations, thefts, aggressions, vandalism, etc.)
Rare but potentially causing long and extended irregularities

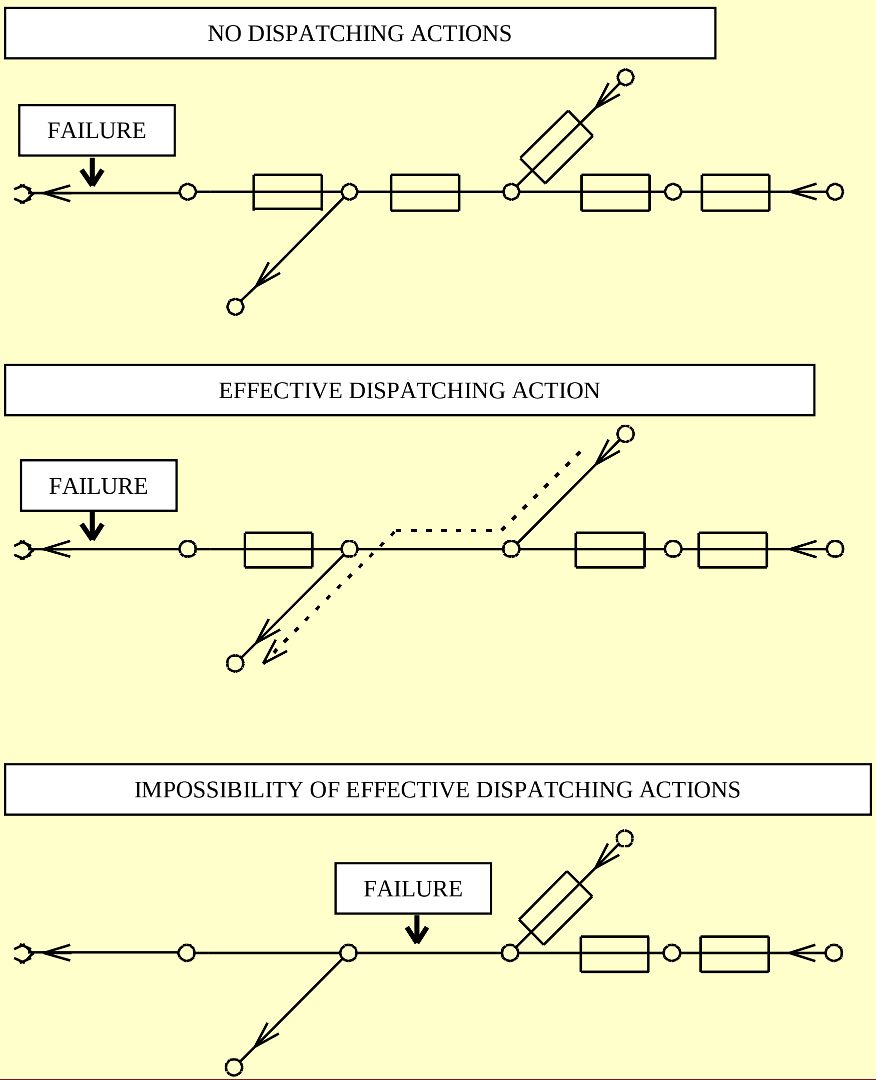
Delay generated by failure on a train



Actions to prevent perturbations

Typology of cause	*Events prevention actions*
Infrastructure and vehicle failures	**Increase of ordinary maintenance**
Inappropriate behaviours of personnel	**Formation, increase of responsibility and control of the personnel**
Interaction with transported persons and goods	**Increased frequency according to demand** **Correct dimensioning of stopping times** **Increased Sensibility of freight operators**
Traffic conflicts	**Accurate operation planning in potential conflict sections**
Events external to railway systems	**Cooperation with external bodies responsible for forecasting and prevention (e.g. meteorological institutes, civil protection, police, etc.)**

Implementation of dispatching actions



Traffic monitoring and dispatching systems

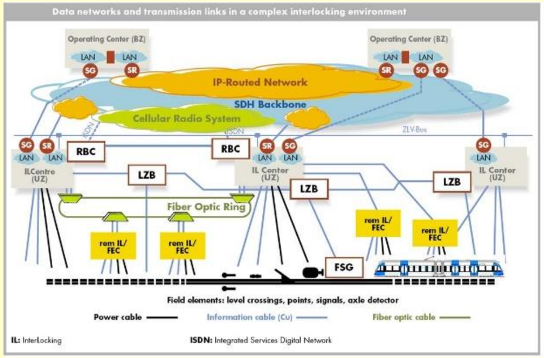
<u>Functions</u>

Ensuring regularity of services
- Customer satisfaction
- Higher efficiency of personnel, vehicles and infrastructures

<u>Requirements</u>

Centralised collection and representation of information

Choice of most effective dispatching actions
- Support of Decision Support Systems (DSS)
- Automatic implementation of best strategies



<u>Monitored and dispatched network extension</u>

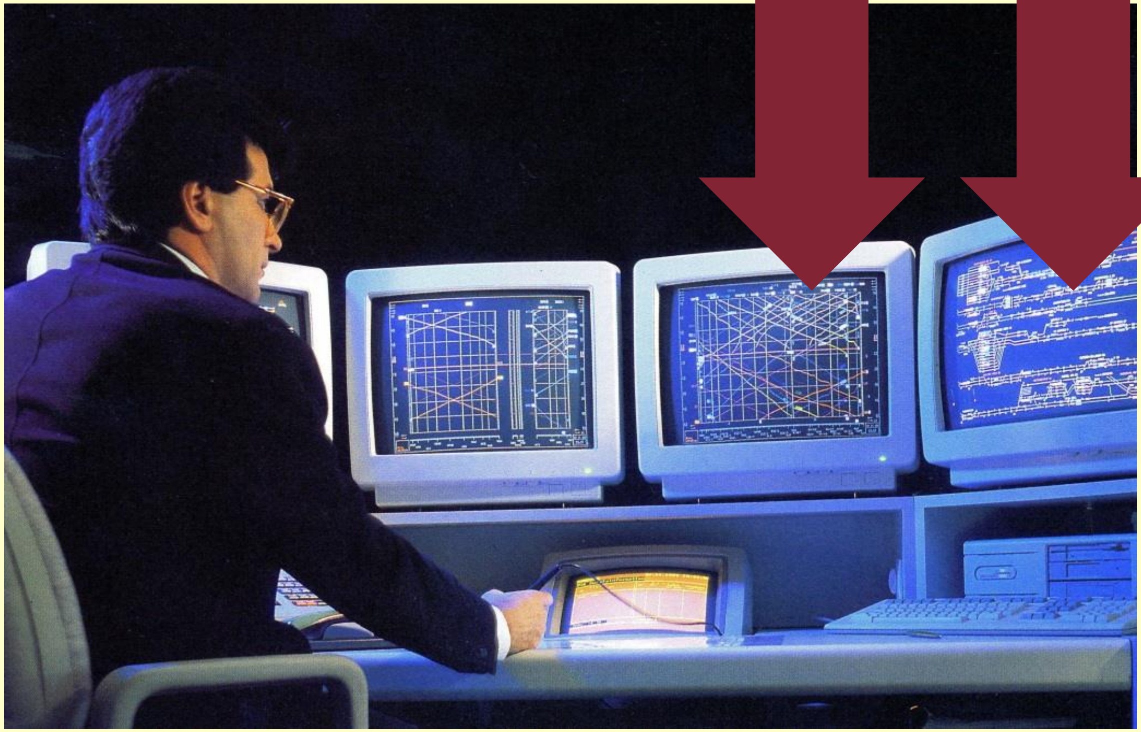
Traffic density: amount of managed data

Actions by dispatchers, available technologies and operation jurisdictions
- Line sections, including more stations (tens of km)
- Whole lines or extended sections of main lines (hundreds of km)
- Whole networks or sub-networks (thousands of km)

Dispatching tools

Real time automatic drawing

Trains graph **Trains describer**



https://www.youtube.com/watch?v=bQMW3Skn3FU

https://www.youtube.com/watch?v=pNRFsz3Sv7A

Automation of traffic control and management

Information collected from line equipment

Progressive occupation of track circuits associated to specific trains

Decision Support Systems for traffic management

1) Analysis of conflicts between trains due to perturbations

2) Proposition of dispatching actions with consequences for traffic

3) Search of optimal solutions for conflicts according to functions *F*

Example: Bologna–Parma section of Bologna–Milano line (1986)

$$F = \Sigma \, [C_i \, (R_i) \, R_i]$$

Example: Roma–Formia section of Roma–Napoli line (1992)

$$F = \Sigma \, [C_i \, (R_{i,30} - R_i)^2]$$

C_i = relevance coefficient of train *i*

R_i = delay of train *i*

$R_{i,30}$ = expected (forecasted) delay of train *i* after 30 minutes

Further use of collected data

Seasonal and daily timetable planning, including temporary changes

Real time data on actual traffic available for passengers

Storage and elaboration of historical data

IN9
Lines operation

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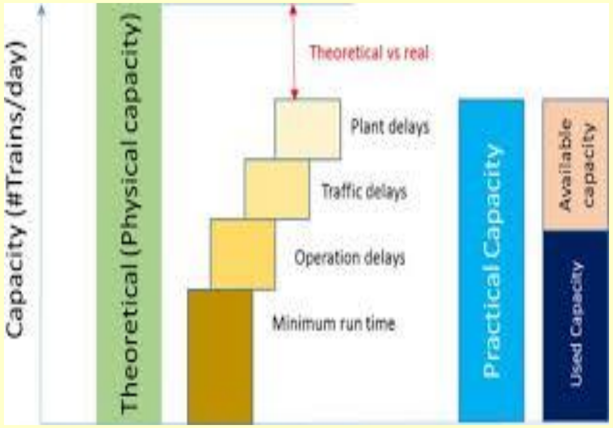
Capacity concepts



Depending upon functional characteristics

Lines and stations

Vehicles running on them

Multitude of heterogeneous affecting factors

Unique definition not possible

Literature rich in definitions and classifications

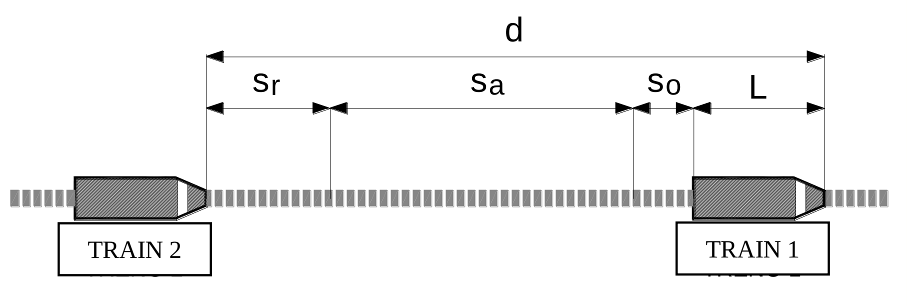
Theoretical Capacity

Maximum number of trains' movements manageable in a specific period

Practical Capacity

Maximum number of trains manageable under specified levels of Operational Quality corresponding to Minimum Headway (time spacing) between trains compatible with safe stop of train B after the stop of train A

Minimum headway



$$d = s_r + s_a + s_0 + L = v \cdot t_r + \frac{v^2}{2a} + s_0 + L$$

s_r* = space run during reaction time *t_r
(from perception of braking need to full operation of braking system)
***s_a* = braking distance**
***s_0* = safety margin**
***L* = length of longest train**
***v* = speed of fastest train**
***a* = service acceleration**

HEADWAY $$\Delta t = \frac{d}{v} = t_r + \frac{v}{2a} + \frac{s_0 + L}{v}$$

CAPACITY $$P = \frac{1}{\Delta t} = \frac{1}{t_r + \frac{v}{2a} + \frac{s_0 + L}{v}}$$

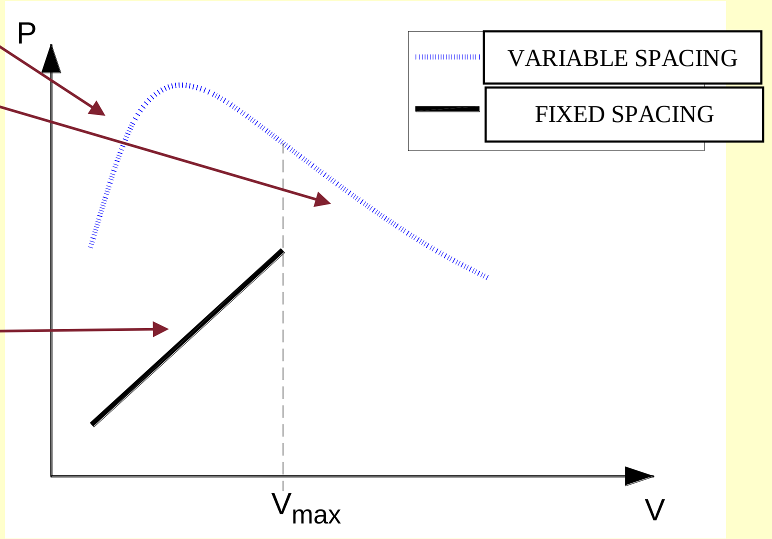
Theoretical and Practical Capacity

<u>Theoretical Capacity</u>
Low speed: increasing with speed
(second term under fraction negligible in comparison with third one)
High speed: decreasing with speed
(third term under fraction negligible in comparison with second one)

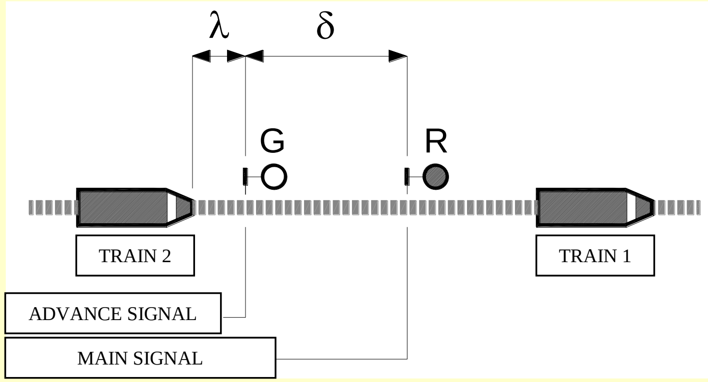
$$P = \frac{1}{\Delta t} = \frac{1}{t_r + \frac{v}{2a} + \frac{s_0 + L}{v}}$$

<u>Practical Capacity</u>
Variety of trains' speed
Performances of signalling systems

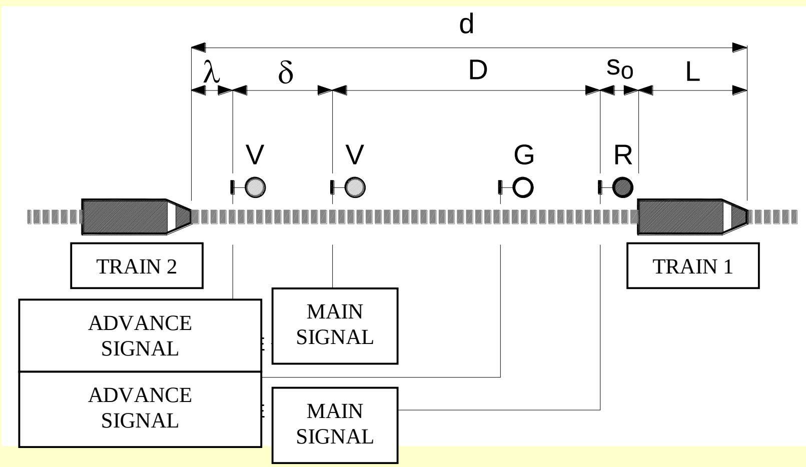
Based on fixed block sections
Precision depending on section length (occupation of track circuit)



Capacity with fixed spacing



$$\lambda + \delta \geq v t_r + \frac{v^2}{2a} + s_o$$



$$d = \lambda + \delta + D + s_0 + L$$

d **not depending upon speed**
(D = fixed block section)

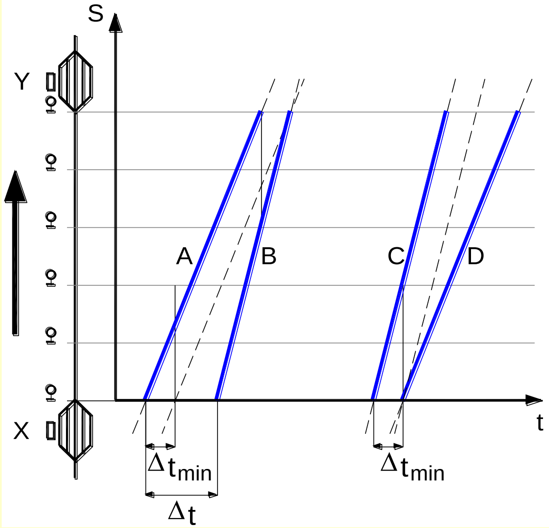
HEADWAY $\Delta t = \frac{d}{v}$

CAPACITY $P = \frac{1}{\Delta t} = \frac{v}{d}$

Line capacity = capacity of critical section (longest running time)

Factors affecting capacity

Speed variability



Reference period
Extension (hourly, daily, etc.)
Location within day (peak and smooth periods, etc.)

Traffic typology and sequence
Services differentiation
Distribution of arrival times

Operational regimes and signalling systems
Activations and resets (technical switching time)

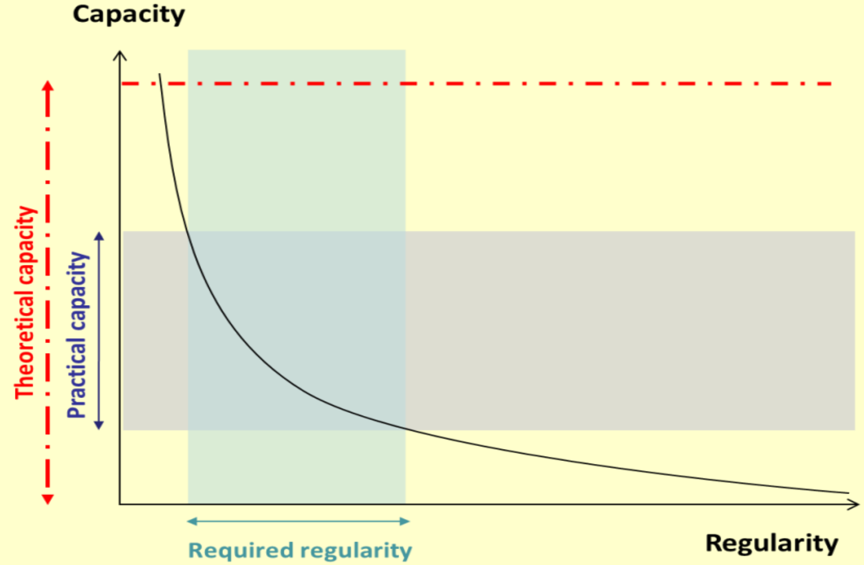
Stations
Number, typology, reciprocal distance

Regularity standards applied

Capacity vs. Regularity

<u>Qualitative relationships</u>

Generation of conflicts due to traffic density causing delays
Complex formalisation of relationships among relevant parameters
Full use of residual capacity by trains with similar performances



<u>Capacity calculation methods</u>

Analytical **(*Static*): deterministic formulas**
Analytical **(*Stochastic*): probabilistic formulas parameters**
(*considering the probability to fulfil services regularity standards*)
Analogical**: simulation procedures**

Capacity calculation by UIC methods

<u>**Probabilistic methods**</u>

References: Leaflet UIC 405-1 R (1978) and Leaflet UIC 406 R (2004)

User-friendliness

Able to consider

(Trains already running on line)

(Operation quality requirements)

(Infrastructural and technological features of lines)

Usability in infrastructure planning phase

Formulation of capacity for UIC 405 method:

$$P = \frac{T}{t_{fm} + t_r + t_{zu}}$$

t_{fm} **= average minimum headway between trains**

t_r **= elapsing time (link with regularity)**

t_{zu} **= additional time**

(depending upon number of intermediate sections in the critical section)

Average minimum headway calculation (UIC 405-1 R)

Global quantity of trains split into running time classes

Matrix [S]

(summation = total amount of running trains N – 1)

Occupation times of succession cases

Matrix [O]

Occupation times per trains successions

Matrix [S x O]

(summation = total infrastructure occupation time T_{ot})

Average minimum headway between trains weighted by succession cases

$$t_{fm} = \frac{T_{ot}}{N-1}$$

Elapsing time calculation (UIC 405-1 R)

<u>Line section as service station for trains running</u>

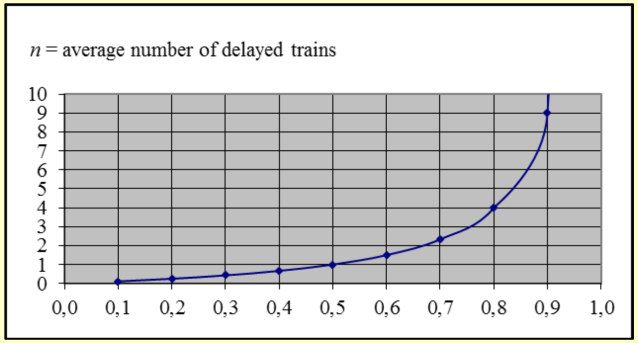
Application of queuing theory

Length of queue = amount of perturbed trains

Average amount of trains approaching critical section $\dfrac{1}{t_{fm} + t_r}$

Average amount of trains allowed running on critical section $\dfrac{1}{t_{fm}}$

Utilisation rate $\Psi = \dfrac{t_{fm}}{t_{fm} + t_r}$



Wide test campaign (UIC networks) to identify maximum values of Ψ

0.60 for average operational conditions (e.g. whole day)

(1.5 delayed trains corresponding to $t_r = 0.67\ t_{fm}$)

0.75 for high traffic density conditions (e.g. short peak periods)

(3.1 delayed trains corresponding to $t_r = 0.33\ t_{fm}$)

Additional time calculation (UIC 405-1 R)

<u>**Depending upon intermediate block sections within critical line section**</u>
(*Double track lines*)

Wide test campaign (UIC networks) to identify most suitable experimental expression taking into account the whole line operation

$$t_{zu} = 0{,}25\ a$$

a = amount of intermediate block sections within the critical section

Increase of capacity less than proportional to increase of number of intermediate block sections

Capacity calculation by DB method

Probabilistic method

Issued in '70 by German railways (DB)

Based on principles similar to UIC method

Main peculiarities

(Simplified minimum headway calculation)

(More articulated link with regularity)

$$P = \frac{T}{t_{fm}(1+q)}$$

t_{fm} = average minimum headway between trains

q = buffer parameter (link with regularity)

(considering trains already scheduled and regularity requirements)

Average minimum headway calculation (DB)

Trains succession cases

Two categories of trains: fast/slow

N_v **= amount of fast trains**

N_l **= amount of slow trains**

Occupation times of succession cases

t_{vv} **= average minimum headway for fast-fast trains succession**

t_{vl} **= average minimum headway for fast-slow trains succession**

t_{lv} **= average minimum headway for slow-fast trains succession**

t_{ll} **= average minimum headway for slow-slow trains succession**

Average minimum headway between trains

$$t_{fm} = \frac{t_{vv} N_v^{\,2} + (t_{vl} + t_{lv}) N_v N_l + t_{ll} N_l^{\,2}}{(N_v + N_l)^2}$$

(*Average value of headways weighted by succession cases*)

Buffer parameter calculation (DB)

Fluidity parameter H

P_f = global daily amount of tolerated primary delays generated in critical section, depending upon type of line and services (e.g. 200 min/day)

W_e = probability of arrival of delayed trains = delayed trains/running trains

Transfer factor U

t_{fm} = average minimum headway between trains

P_m = average delay of trains approaching critical section

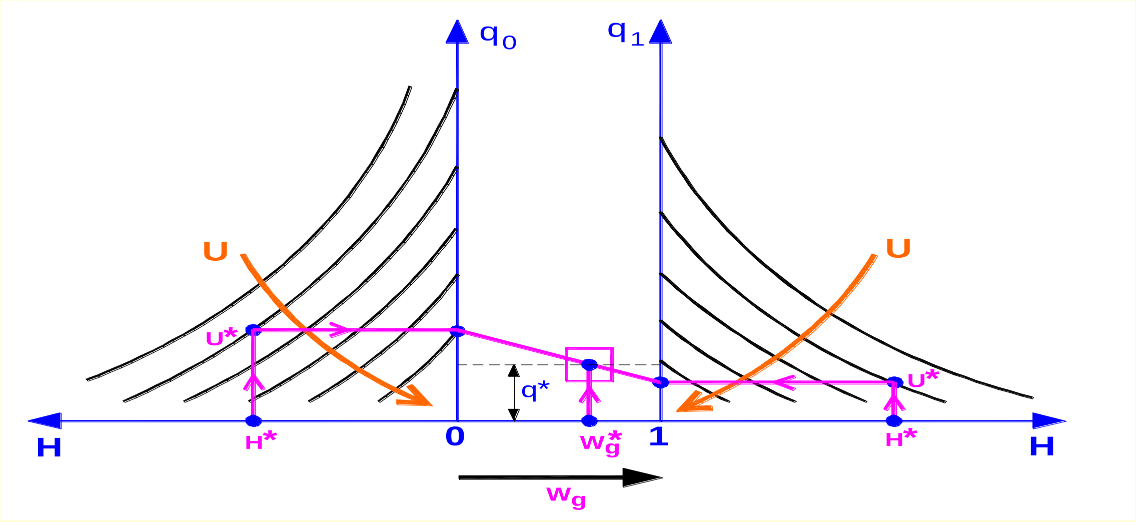
Probability of homogeneity of successive trains W_g

Extracted by pre-existing timetable or calculated

$$H = \frac{P_f}{1440 \cdot \left(W_e - \frac{W_e^2}{2}\right)}$$

$$U = \frac{t_{fm}}{P_m}$$

$$W_g = \frac{t_{vv} N_v^2 + t_{ll} N_l^2}{(t_{vl} + t_{lv}) N_v N_l}$$



Comparison between UIC 405-1 R and DB methods

<u>**Attitudes of probabilistic methods for capacity calculation**</u>

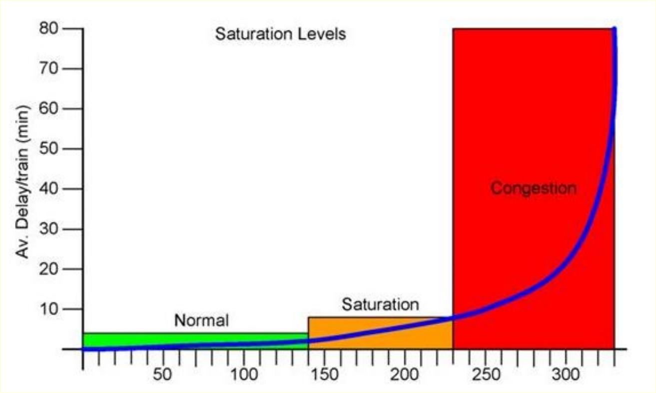
Management of interactions among traffic flows and services typologies

Calculation of capacity for planned infrastructure

(***input: weighted forecasts of trains' succession cases***)

Prudential results

(***input: random distribution of arriving trains***)



<u>**UIC 405 vs. DB methods**</u>

<u>**Average headway calculation**</u>

***UIC*: more careful (*infinite trains' categories*)**

***DB*: simplified (2 *train categories only*)**

<u>**Link with regularity**</u>

UIC: queuing theory algorithms with *Poisson* distribution of arrivals

DB: transparent pseudo-random approach considering both primary (*generated in critical section*) and secondary (*generated outside*) delays

Comparative application of methods

<u>**German line: Wurzburg–Hannover (2 tracks)**</u>

Standard layout:

(*max speed: 250 km/h, distance between overtaking stations: 20 km)*

(Calculated capacity: 152 trains/day (UIC) vs. 172 trains/day (DB))

<u>**Italian lines: Roma-Formia (2 tracks) and Campoleone-Nettuno (1 track)**</u>

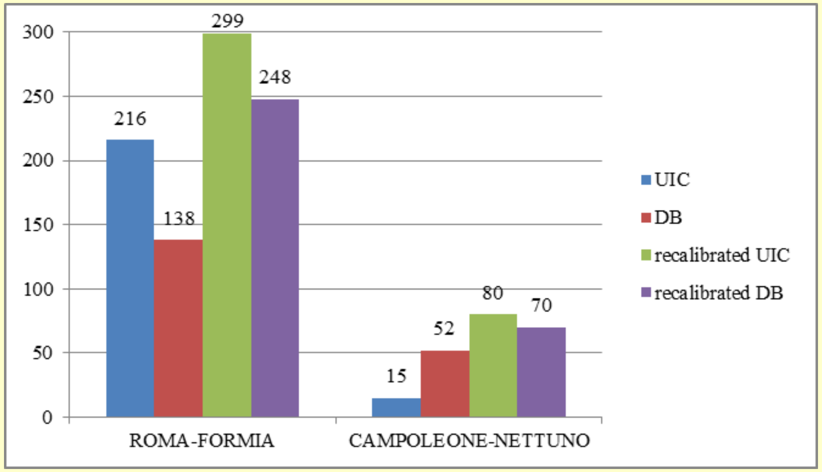
Mixed layout:

(*Re-calculation of capacity basing on monitoring of delays)*

(Adherence to real operation conditions)

(e.g. operational and commercial transactions between RU and IM)

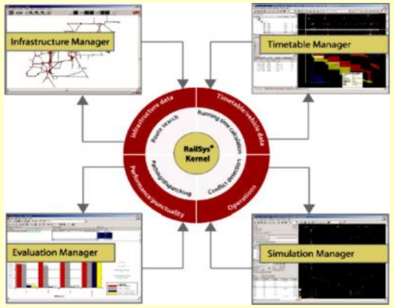
Convergence of results: reduced differences between methods



Simulation models

<u>Development of traffic starting from train running sequential events</u>
Occupation of block sections by track circuits

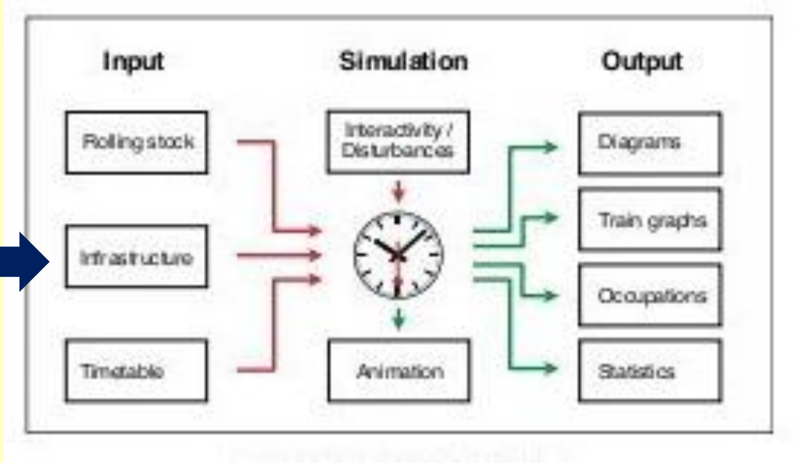
<u>Asynchronous simulation concept</u>
Progressive step by step acceleration to maximum speed
Jumps on sections without speed variation
Further step by step process whenever traces of trains are closer
(Follower potentially delayed by leader in section ahead)



<u>Inputs</u>
Infrastructural features of lines and stations
Dynamic performances and dimensions of rolling stock
Criteria adopted to regulate trains operation according to safety logic
<u>Outputs</u>
Train history, describing all events characterising movement of trains
Graphic elaborates (e.g. timetable graphics)
Synthetic indicators (e.g. variously elaborated and aggregated delays)

Simulation modeling technics

Technic	Optimal application field	Advantages	Disadvantages	Models (examples)
Graph theory	• Topology of the infrastructure	• Transparency • Topology representation • Physical process reproducibility	• Static nature • Unclear relationships	FAKTUS PROLOP SIMU
Petri Net	• Topology of the infrastructure • Operation control	• Synthesis between graph theory and discrete dynamics • Hierarchical structure	• Absence of continuous dynamics	DISPOS SABINE
Programming languages	• Topology of the infrastructure • Operation control • Timetable planning	• Flexibility • Objects oriented structure • User friendliness	• Poor possibility to analyse results • Discrete process representation	FAKTUS OPENTRACK RWS SIMU SITRAF/S TRANSIT
Descriptive formalism	• Safety technology	• Formal rigorousness • Abstraction	• Strong modelling need • Low flexibility	HOL VDM
Differential comparison (finite elements analysis)	• Motion dynamics • Vehicle dynamics	• Physical process reproducibility	• Impossibility to represent the safety systems • Discrete process representation	Several examples
Analytical Processes (sequences of algorithms)	• Operation control • Timetable planning • Line capacity	• Abstraction • Formal simplicity	• Difficulty to represent real data • Approximation of results • Impossibility to represent the safety systems	PROLOP STRELE



http://www.opentrack.ch/opentrack/opentrack_e/movies/opentrack_clipyoutube_e.html

https://www.youtube.com/watch?v=Cvy0PHZPHXc

Comparative analysis of simulation models

		COMPARATIVE ANALYSIS	Simulation Enviroments - TOOLS																																		
			AFAIG	CAPRES	CASSANDRA	CMS	DEMIURGE	DONS	FALKO	FAST TRACK II	FASTA	IRCIM	LIPARI	MOM MALLAS	MULTIRAIL	OPENTIMETABLE	OPENTRACK	PETER	PTG	RADIS	RAILCAP	RAILNET II	RAILPLAN	RAILSIM	RAILSYS	RASIM	ROMAN	SAMFOST	SIM-OBAU	SIMONE	SIMON(TOPSim)/ TTS	SISYFE	TNV	TPS/STRAX	TURNI	VILLON	VIRIATO	VirtuOS	XANDRA
		ID NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
input data	Infrastructure Parameters	Single/double tracks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	✓
		Moving Block System and signalling system	✓	?	✓	?	✗	?	✓	✓	?	✓	✓	?	✓	✓	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✗	?	✓	?	✓	✓	✓	?	✓	✗	✓	?
		Definition of lines, routes	✓	✓	✓	?	✓	?	✓	✓	✓	✓	?	?	✓	✗	✓	✓	?	?	✓	✗	?	✓	✓	?	✓	✗	?	✓	?	?	✓	✓	?	✓	✓	✓	?
	Network Effects	Track structure and speed limits	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Block occupation or blocking time	?	✓	?	?	✗	?	✓	✓	✓	✓	?	?	✓	?	✓	✓	?	?	✓	✓	?	✓	✓	?	✓	✗	?	✓	?	?	?	✓	?	✓	✗	✓	✓
		Headway distance	?	✓	?	?	✓	?	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✗	?	✓	?	✓	✓	✓	?	✓	✗	✓	✓
		Headway time	?	✓	?	?	✓	?	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✗	?	✓	?	✓	✓	✓	?	✓	✗	✓	✓
		Blocking time stairway	?	✓	?	?	✓	?	✓	✓	?	✓	?	✓	✓	?	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✗	?	✓	?	?	✓	✓	?	✓	✗	✓	✓
		Signal headway	?	?	?	?	✓	?	✓	✓	?	✓	?	✓	✓	?	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✓	?	✓	?	?	✓	✓	?	✓	✗	✓	✓
		Minimum Line Headway	?	✓	?	?	✓	?	✓	✓	✓	✓	?	✓	✓	?	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✗	?	✓	?	?	✓	✓	?	✓	✗	✓	✓
		Buffer time	?	✓	?	?	✓	?	✓	✓	?	✓	?	✓	✓	✓	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✗	?	✓	?	?	?	✓	?	✓	✗	✓	?
		Running time supplement	?	✓	?	?	✓	?	✓	✓	?	✓	?	✓	✓	✓	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✗	?	✓	?	?	?	✓	?	✓	✗	✓	?
		Dwell time	?	✓	?	?	✓	?	✓	✓	?	✓	?	✓	✓	?	✓	✓	?	?	✓	✓	✓	✓	✓	?	✓	✓	?	✓	?	?	?	✓	?	✓	✗	✓	?
		Total consumption time	✓	✓	?	?	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	✓	✓	?	✓	?	✓	✓	✓	✓	✓	✓	✓	?
		Train mix / Rolling Stock	✓	✓	?	?	✓	?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	✓	✗	?	✓	?	✓	✓	✓	✓	✓	✓	✓	✓
		Traffic peaking factor	✓	✓	?	?	✓	?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	?	✓	✓	✓	✓	✗	?	✓	?	✓	✓	✓	?	✓	✓	✓	✓
		Priority	?	✓	?	?	✗	?	✓	✓	?	✓	?	✓	✓	✓	✓	✓	?	?	✓	✓	?	✓	✓	?	✓	✗	?	✓	?	?	?	✓	?	?	✓	?	?
	Operating Parameters	Track Interruptions	?	✗	?	?	✓	?	✓	✓	?	✓	?	✓	✓	✓	✓	✓	?	?	✓	✓	?	✓	✓	?	✓	✗	✓	✓	?	?	?	✓	?	?	✓	?	?
		Train stop time	✓	✗	✓	?	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	?	✓	?	✓	✓	?	✓	?	✓
		Maximum trip time threshold	?	✗	?	?	✓	?	✓	✓	?	✓	✓	✓	✓	?	✓	✓	?	?	✓	✓	?	✓	✓	?	✓	✗	✓	✓	?	✓	?	✓	?	?	✓	?	?
		Quality of service, reliability, or robustness	✗	✗	?	?	✓	?	✓	✓	?	✓	✓	✓	✓	?	✓	✓	?	✓	✓	✓	?	✓	✓	✓	✓	✗	?	✓	?	✓	?	✓	?	?	✓	?	✓
output data	Capacity Analysis	Theoretical Capacity	?	✓	✓	✓	✓	?	✗	✓	?	✓	✗	✓	?	✓	?	✗	✗	?	✓	✗	✗	✓	✓	?	✗	✓	✗	?	✗	✗	✗	✗	✗	✗	✗	✗	✗
		Practical Capacity	✗	✗	✗	✓	✓	?	✗	✓	✗	✓	✗	✓	?	✗	?	✗	✗	?	✓	✗	✗	✓	✓	?	✗	✗	✗	?	✗	✗	✗	✗	✗	✗	✗	✗	✗
		Used Capacity	✗	✗	✗	✓	✓	?	✗	?	✗	✓	✗	✓	?	✗	?	✗	✗	?	✓	✗	✗	?	✓	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
		Available Capacity	✗	✓	✗	✓	✓	?	✗	?	✗	✓	✗	✓	?	✗	?	✗	✗	?	✓	✓	✓	?	✓	?	✗	✗	✗	?	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Main Functions	Crew Scheduling	✗	?	?	✗	?	?	?	?	?	✗	✗	✗	?	✗	✗	?	✗	✓	?	?	✗	?	?	✓	?	?	✗	✗	✗	✗	✗	?	✓	✗	✓	✗	✗
		Infrastructure Manager	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✗	✓	✓	✗	✗	✓	✓	✓	✓	✗	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓
		Station Manager	✓	✓	?	✓	✓	✓	✗	✓	✗	✗	✗	?	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	✓	✓	✓
		Timetable Manager	✗	✗	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗
		Timetable Optimization	✗	✓	✗	✓	✓	✓	✗	✓	✗	✗	✓	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	?	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
		Economic Evaluation	✗	?	✗	?	?	?	?	?	?	✗	?	?	?	?	?	?	?	✓	?	?	?	?	?	?	?	?	?	✗	?	?	?	?	✓	?	?	?	?
		Sensitivity Analysis	✗	?	✓	?	?	?	?	?	?	✓	?	?	?	?	?	?	?	✓	?	?	?	?	?	?	?	?	?	?	?	?	?	?	✗	?	?	?	?
		Simulation	✗	✗	✓	✓	✗	✓	✓	✓	✓	✓	✗	✗	✓	✗	✓	✗	?	✗	✓	✗	✓	✓	✓	✓	✓	✗	?	✓	?	✓	✗	✓	✗	✓	✗	✓	✓
	Statistical Analysis	elements	✓	✓	?	?	✗	?	?	✓	✓	✓	✗	?	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	?	?	?	?	✗	?	✓	?	?
		histograms of margins between trains	✓	✓	?	?	✗	?	?	✓	✓	?	✗	?	✓	✓	✓	✗	?	?	✗	✗	✓	✓	✓	?	✓	✗	✓	✓	?	?	?	?	✗	?	✗	?	?
		list of margins between trains	✓	✓	?	?	?	?	?	✓	✓	?	✗	?	✓	✓	✓	✗	?	?	✗	✗	✓	✓	✓	?	✓	✗	✓	✓	?	?	?	?	✗	?	✗	?	?
		statistics of train assignements by direction	✓	✓	?	?	✓	?	?	✓	✓	✓	✗	✓	✓	✓	✓	✓	?	✓	✓	✗	✓	✓	✓	?	✓	✓	✓	✓	?	?	?	?	✓	?	✓	✓	?
		Conflicts detection	✓	✓	?	?	✓	?	?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	?	✓	✗	✓	✓	?	?	?	✓	✓	✓	✓	✓	?
		Platform track occupation schedule	✓	✓	?	?	?	?	?	✓	✗	?	✗	?	✓	✗	✓	✗	✓	?	✗	✗	?	✓	✓	✓	✓	✗	✓	?	?	?	?	?	✓	✓	✓	✓	?

IN10
Simple nodes operation

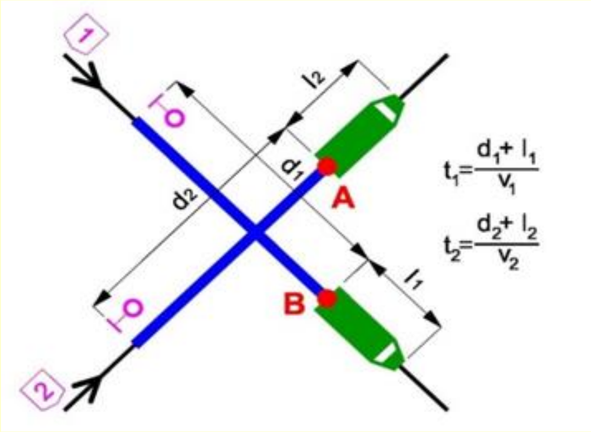
References

- **Malavasi G., Molkova T., Ricci S., Rotoli F. -** ***A synthetic approach to the evaluation of the carrying capacity of complex railway nodes*** **- Journal of Rail Transport Planning & Management, 4, 1–2, 28-42, 2014**
- **Pachl J. –** ***Railway Operation and Control (Fourth Edition)*** **– VTD Rail Publishing, Mountlake Terrace, 2002**

Key problems

<u>Design criteria of a station layout</u>
Enough traffic capacity for trains' movements
Enough stationary capacity for trains' stops

<u>Quantitative traffic assessment</u>
Most simple layout: two tracks crossing each other
Common area used by a single train
Potential conflict: train 2 delayed by train 1
Increasing complexity according to station's dimensions



Methodological approach

<u>1) Design of a new station</u>

Traffic not observable

Operational modes only drafted (timetable not available)

Condition of temporal congruity

> ***All movements and corresponding delays ≤ reference time***
>
> ***(Most appropriate approach: synthetic analytical methods)***

<u>2) Assessment of an operated station</u>

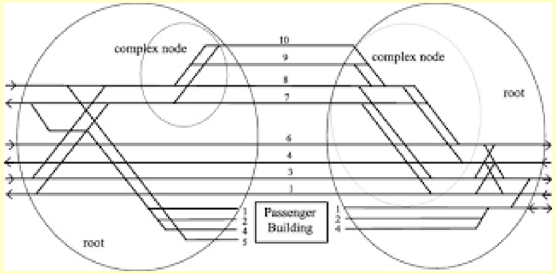
Existing compatibility between traffic and layout

Operation defined into details (available timetable)

Planned trains running + quantification of additional slots

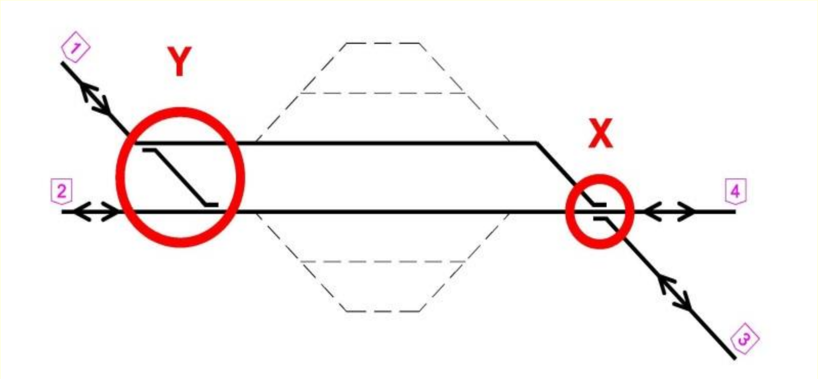
> ***(Most appropriate approach: full analytical methods)***

Basic approaches generalizable to more complex nodes



General capacity check condition

Simple crossing station layout

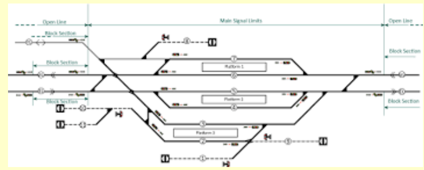


***Bold lines*: main tracks, trains joining from lines 1/2 to 3/4**
***Dotted lines*: tracks dedicated to trains stop**
(*number of trains depending upon duration of stops*)

Key capacity problem
Check of compatibility between traffic and station layout
(*qualified by assigned trains' schedule in defined periods*)
Quantification of margins to increase traffic

Reciprocally influencing components

<u>a) Station layout</u>



<u>b) Operational rules</u>

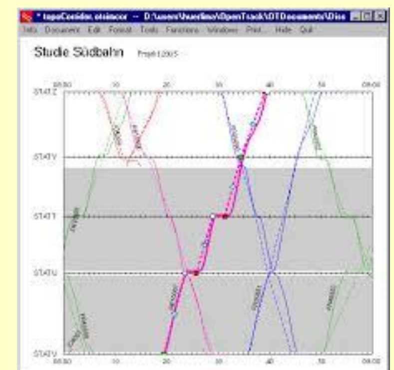
Defining behaviors of operators to ensure regular operation
(*e.g., criteria to solve conflicts between fast and slow trains*)
Defining safe operation according to rules and signalling

<u>c) Operational plan</u>

Timetable

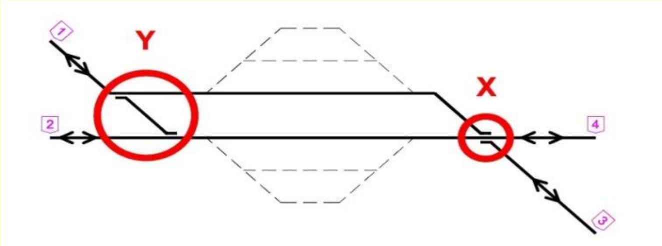
- Amount and typologies of trains
- Origin and destination
- Arrival and departure times
- Probability of delayed or early arrival

(*in design phase reference to similar/typical conditions*)



<u>d) Reference period</u>

Elementary critical nodes



<u>Node *X* run by a single train</u>

Reference time *T* shared between flows from/to 3 and 4

Waiting time due to conflicts reducing capacity of concerned lines

<u>Reference time *T* divided into three parts</u>

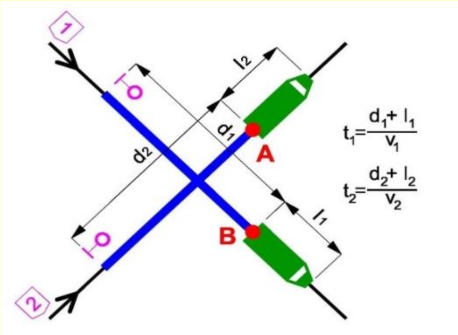
- Time required to cross intersection: occupation ($\Sigma t = B$)
- Waiting time: delays ($\Sigma t = R$)
- Time available for additional trains

<u>Congruity condition of traffic and layout</u>

$$T \geq B + R$$

$T = B + R$ corresponding to saturation (no time for additional traffic)

Simple node: two crossing lines



<u>Interdiction of trains running on lines 1 and 2</u>
- n_1 trains / T on line 1
- n_2 trains / T on line 2

<u>Interdiction situation</u>

Train stopped by the restrictive signal will wait a variable time

From zero to total occupation time of train crossing the node

Depending upon the time of arrival of the second train

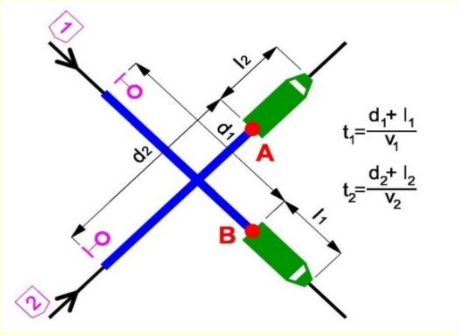
<u>Interdiction duration</u>

Start: signal showing permissive aspect

End: train's rear passing critical section (e.g. last switch of the route)

<u>Occupation times (single trains' category per line)</u>
- t_1 for line 1
- t_2 for line 2

Interdiction time: assumptions



<u>Waiting time of trains due to restrictive signal</u>

Variable depending upon arrival time

From 0 to total occupation time on the node: t_1 (line 1) or t_2 (line 2)

(negligible effects of speed variations)

<u>Average delays suffered by trains running on lines</u>

$t_2/2$ (line 1)

$t_1/2$ (line 2)

Conflicts depending upon timetable and arrivals process (probabilistic)

<u>Hypothesis</u>

Constant density of arrivals probability in T $\boxed{\frac{1}{T} = \cos t}$

Well representing design phase without a defined timetable

Interdiction time: calculation

Probability to meet a restrictive signal on line 1

=

Probability of node occupation by a train of line 2

$$p_1 = n_2 \frac{1}{T} t_2$$

n_2 **= number of events (occupation of line 2) produced during** T

Average delay suffered by n_1 **interdicted trains**

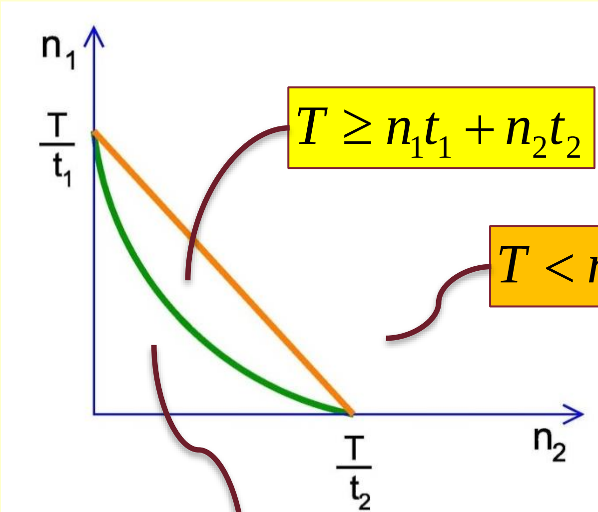
Subtracted by time to run on line 1

$$r_1 = p_1 \frac{t_2}{2} = n_2 \frac{t_2^2}{2T}$$

Global delay suffered by n_1 **trains on line 1 and** n_2 **trains on line 2**

$$R_1 = n_1 n_2 \frac{t_2^2}{2T} \qquad R_2 = n_1 n_2 \frac{t_1^2}{2T}$$

Congruity condition



$T \geq n_1 t_1 + n_2 t_2$

Delays ≥ $n_1 n_2 \dfrac{t_1^2 + t_2^2}{2T}$

$T < n_1 t_1 + n_2 t_2$ Impossible traffic situations

$T \geq n_1 t_1 + n_2 t_2 + n_1 n_2 \dfrac{t_1^2 + t_2^2}{2T}$ Regular traffic condition

Discussion of assumption

Constant density of arrivals probability in *T*

- Unrealistic for long periods (e.g., 24 hours)

- Realistic for short periods (e.g., rush hours)

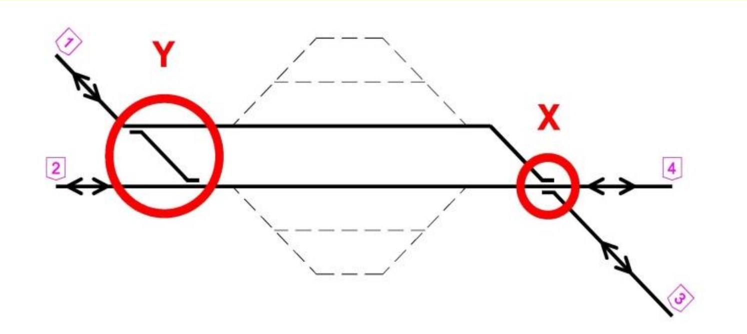
IN11
Complex nodes operation

<u>References</u>

- **Malavasi G., Molkova T., Ricci S., Rotoli F. -** ***A synthetic approach to the evaluation of the carrying capacity of complex railway nodes*** **- Journal of Rail Transport Planning & Management, 4, 1–2, 28-42, 2014**
- **Pachl J. –** ***Railway Operation and Control (Fourth Edition)*** **– VTD Rail Publishing, Mountlake Terrace, 2002**

From simple to complex nodes

<u>Generic station = complex node</u>
Multitude of compatible and incompatible movements
Operational situations potentially involving more than 2 trains
Variable configuration due to multiple positions of switches



<u>Capacity analysis</u>
Identification of potential traffic conditions
Simplification by focusing on critical areas conditioning the capacity
Nearby nodes conditioned due to proximity and common flows (common *management*)
Effective methodologies based on <u>extension of simple node concept</u>

Routes identification and compatibility

<u>**Typologies of movements**</u>

***Entering a station*: from main protection signal to main departure signal**

***Exiting from a station*: from main departure signal to last station switch**

***Within a station*: manoeuvre by groups of vehicles or whole trains (*normally not considered in capacity analysis, except specific situations*)**

<u>**Determination of routes according to positions of all switches**</u>

Potential operational configurations

Reciprocal compatibility

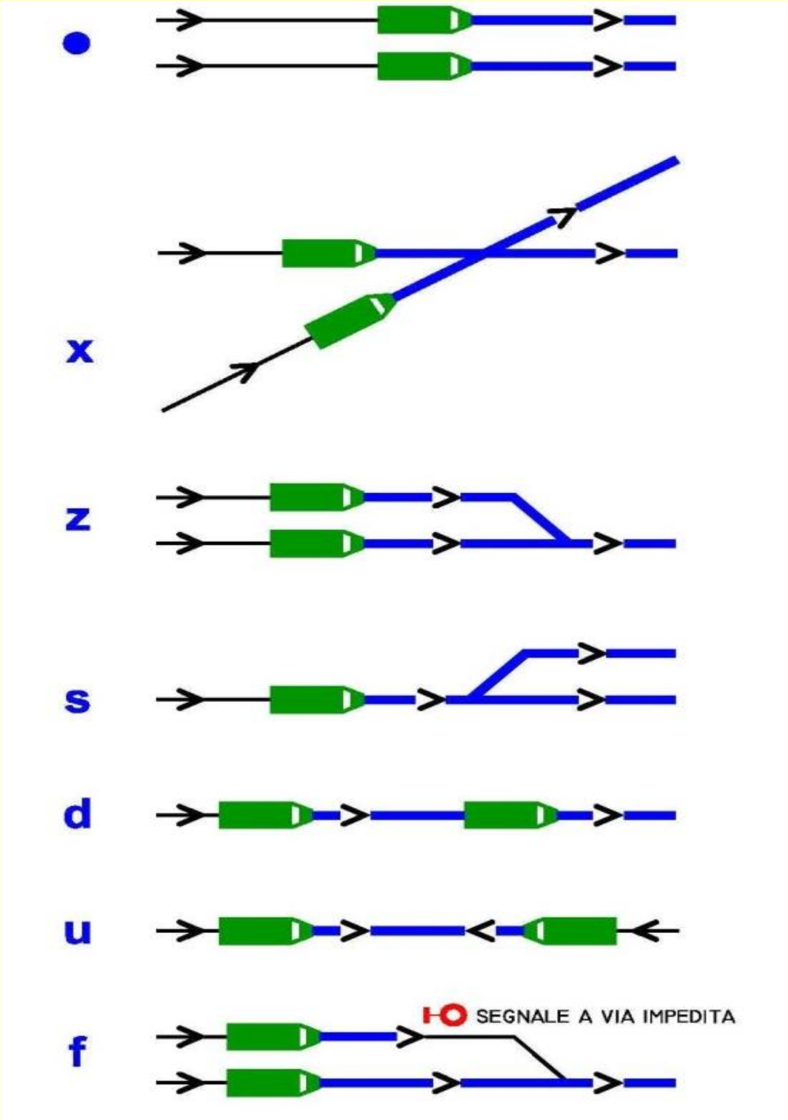
<u>**Systematic check of routes compatibility**</u>

***Matrix of routes*: logic structure allowing full comparison**

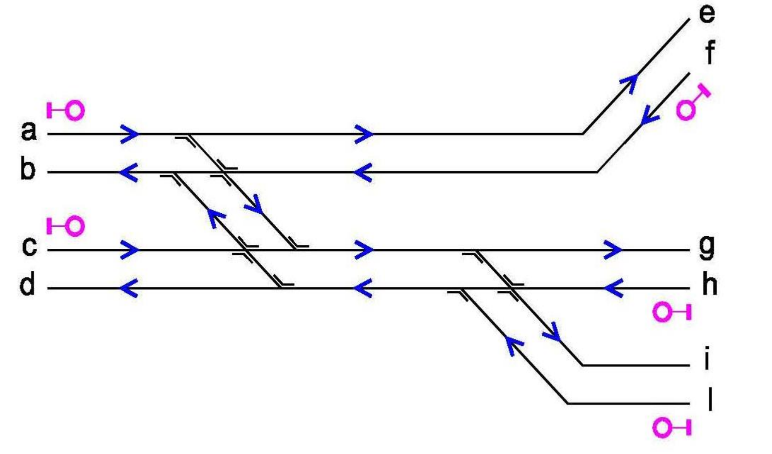
- **In rows and columns: routes**
- **In cells: compatibility / incompatibility symbols**

	1 ae	2 ag	3 ai	4 fb	5 cg	6 ci	7 hb	8 hd	9 lb	10 Ld
1 ae	a	s	s	c	c	c	c	c	c	c
2 ag		a	s	x	z	z	c	c	c	c
3 ai			a	x	x	z	x	x	c	c
4 fb				a	c	c	z	c	z	c
5 cg					a	s	x	c	x	c
6 ci						a	x	x	x	c
7 hb							a	s	z	x
8 hd								a	x	z
9 lb									a	s
10 ld										a

Compatibility / incompatibility cases and symbols



Compatibility matrix for a line junction



	1 ae	2 ag	3 ai	4 fb	5 cg	6 ci	7 hb	8 hd	9 lb	10 Ld
1 ae	a	s	s	c	c	c	c	c	c	c
2 ag		a	s	x	z	z	c	c	c	c
3 ai			a	x	x	z	x	x	c	c
4 fb				a	c	c	z	c	z	c
5 cg					a	s	x	c	x	c
6 ci						a	x	x	x	c
7 hb							a	s	z	x
8 hd								a	x	z
9 lb									a	s
10 ld										a

***N* x *N* matrix**

Relevant elements:
***N* x (*N*-1) / 2**

2 by 2 combinations of *N* elements without repetitions

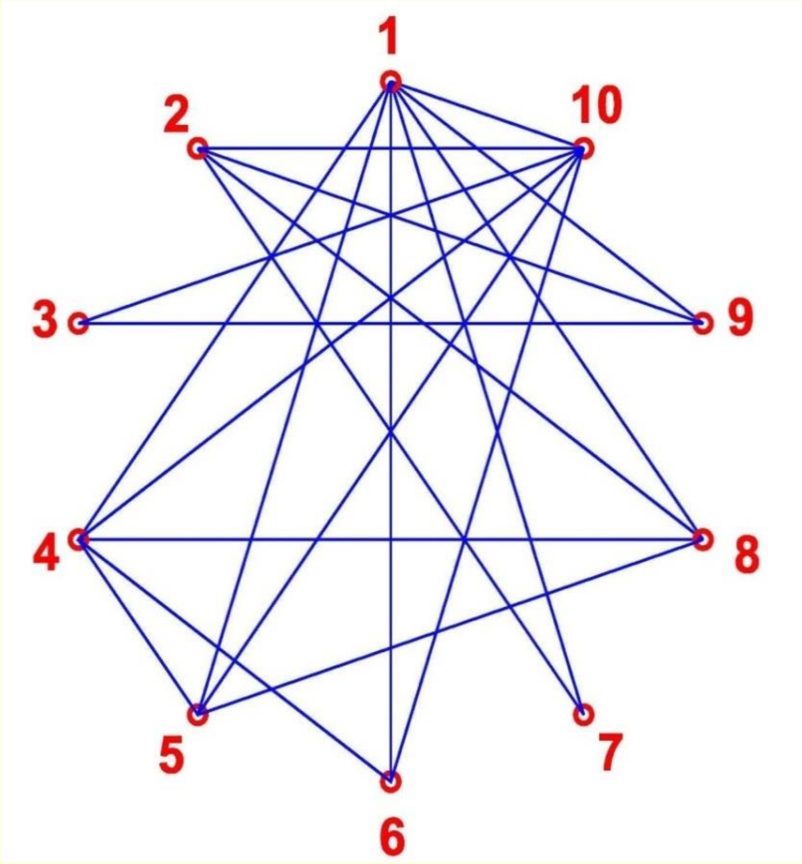
Compatible *N*-tuples search by graph of routes

Single routes represented by a point (node)

Pairs of compatible routes highlighted by a continuous line (link)

Triads of compatible routes represented by triangles (e.g., 1-4-5)

Higher order *N*-tuples of compatible routes represented by polygons with all diagonals (e.g., 1-4-5-8)



Systematic compatible *N*-tuples search by compatibility matrix

Process similar to compilation of compatibility matrix

Progressive consideration of pairs (e.g., 1-4, 1-5, 1-6) instead of routes

Possibility to skip away
- **Cells corresponding to columns including one route of concerned pair (e.g., 1-4 vs. routes 1 and 4)**
- **Pairs composed by routes including numbers lower than the second one of concerned pair (e.g., 1-4 vs. routes 2 and 3)**

Possibility to be replayed for *n*-tuples of higher order (groups of 3, 4, etc.)

	1 ae	*2 ag*	*3 ai*	*4 fb*	*5 cg*	*6 ci*	*7 hb*	*8 hd*	*9 lb*	*10 ld*
1-4	--	--	--	--	cc	cc	x	cc	x	cc
1-5	--	--	--	--	--	x	x	cc	x	cc
1-6	--	--	--	--	--	--	x	x	x	cc
1-7	--	--	--	--	--	--	--	x	x	x
1-8	--	--	--	--	--	--	--	--	x	x
1-9	--	--	--	--	--	--	--	--	--	x
1-10	--	--	--	--	--	--	--	--	--	--
2-7		--	--	--	--	--	--	x	x	x
2-8		--	--	--	--	--	--	--	x	x
2-9		--	--	--	--	--	--	--	--	x
2-10		--	--	--	--	--	--	--	--	--
3-9			--	--	--	--	--	--	--	x
3-10			--	--	--	--	--	--	--	--
4-5				--	--	x	x	cc	x	cc
4-6				--	--	--	x	x	x	cc
4-8				--	--	--	--	--	x	x
4-10				--	--	--	--	--	--	--
5-8					--	--	--	--	x	x
5-10					--	--	--	--	--	--
6-10						--	--	--	--	--

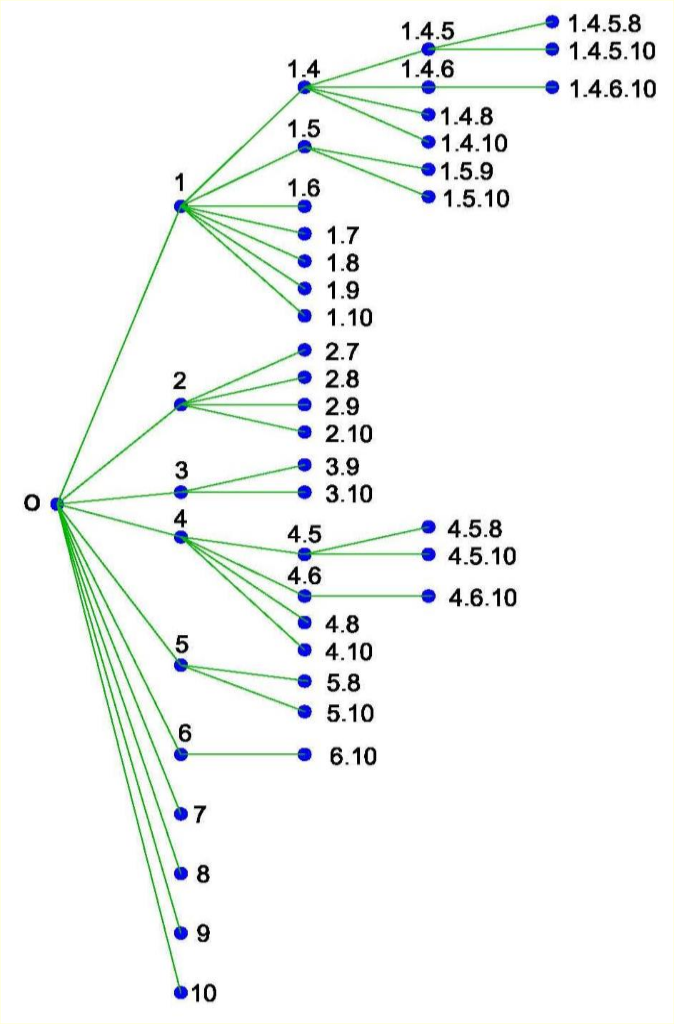
cc = compatible triad
x = incompatible triad

Compatible *N*-tuples representation by traffic solution tree

Intrinsically asymmetric
(e.g. pair 1-4 excludes pair 4-1)

Vertexes of tree corresponding to operational situations (traffic solutions)

- **Vertex 0 corresponding to absence of routes**
- **10 branching off vertexes corresponding to states including single routes**
- **20 vertexes from 1-4 to 6-10 corresponding to states including 2 routes**
- **etc.**



Improvement of a station layout

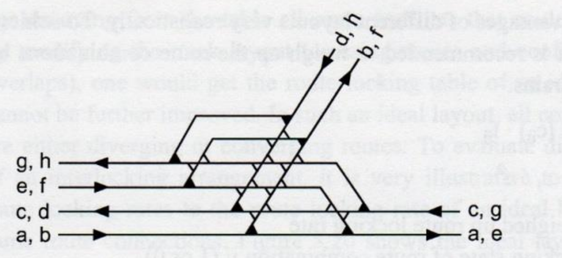
Goal

Increase of capacity by removing route conflicts

***Ideal* layout**

Obtained by removing all conflicts removable by layout modification

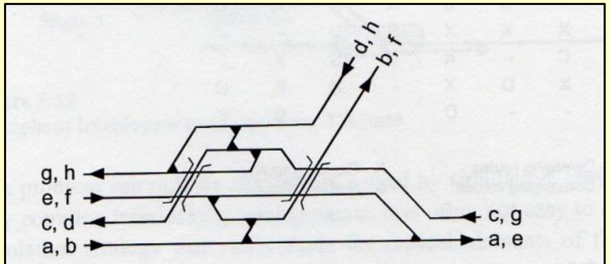
Basic layout



	a	b	c	d	e	f	g	h
a	S	D	-	-	C	-	-	-
b	D	S	X	-	X	C	X	-
c	-	X	S	C	X	-	D	-
d	-	-	C	S	X	X	X	D
e	C	X	X	X	S	D	-	-
f	-	C	-	X	D	S	X	-
g	-	X	D	X	-	X	S	C
h	-	-	-	D	-	-	C	S

D - Diverging routes
C - Converging routes
X - Crossing routes
S - Self correlation

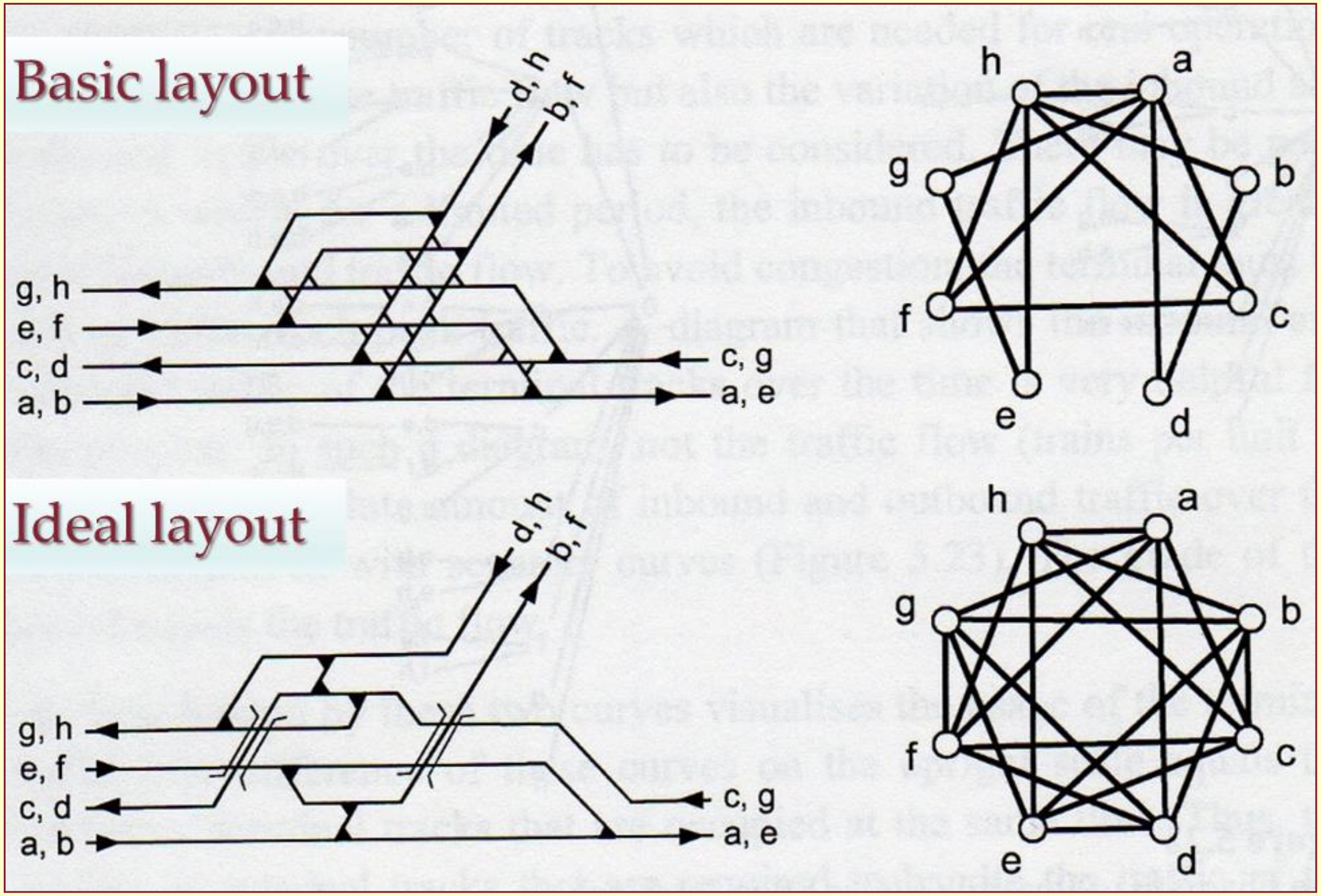
Ideal layout



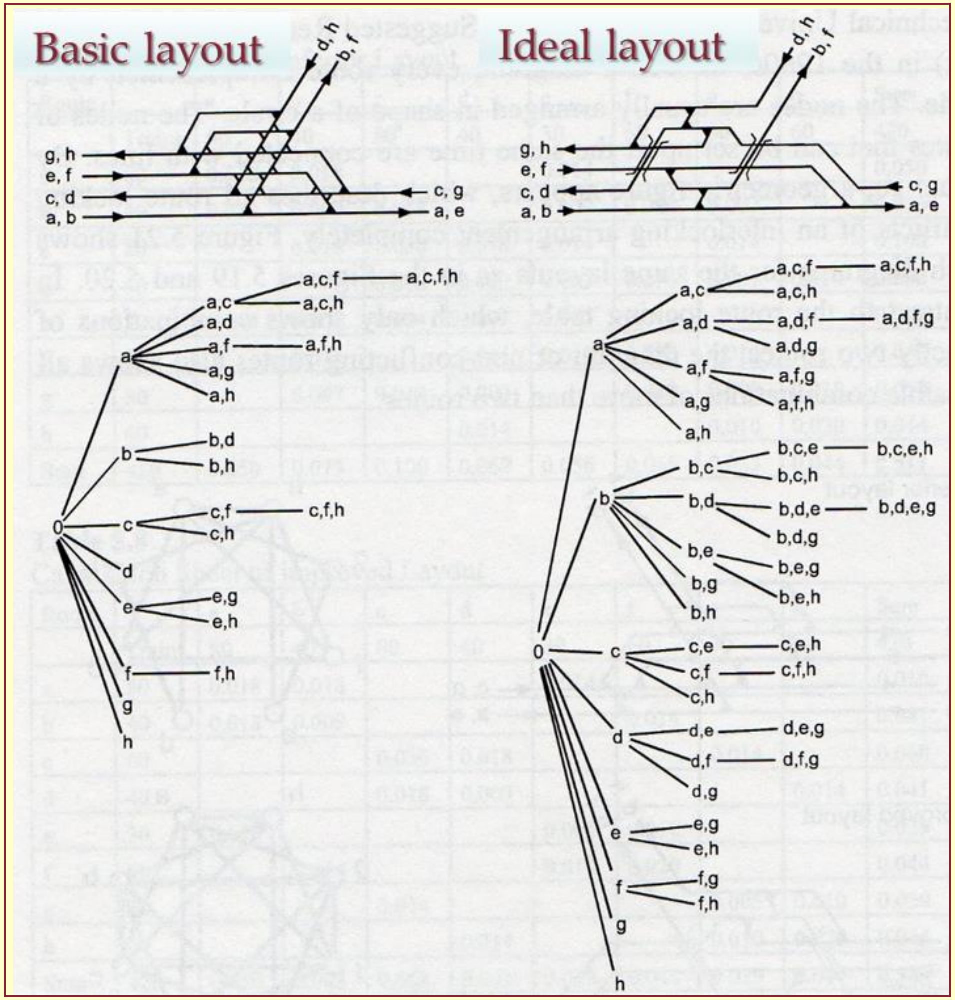
	a	b	c	d	e	f	g	h
a	S	D	-	-	C	-	-	-
b	D	S	-	-	-	C	-	-
c	-	-	S	C	-	-	D	-
d	-	-	C	S	-	-	-	D
e	C	-	-	-	S	D	-	-
f	-	C	-	-	D	S	-	-
g	-	-	D	-	-	-	S	C
h	-	-	-	D	-	-	C	S

D - Diverging routes
C - Converging routes
X - Crossing routes
S - Self correlation

Representation of station layout improvements by graph of routes



Representation of station layout improvements by Traffic solution tree



IN12
Stations capacity calculation

<u>References</u>

- **Malavasi G., Molkova T., Ricci S., Rotoli F. -** ***A synthetic approach to the evaluation of the carrying capacity of complex railway nodes*** **- Journal of Rail Transport Planning & Management, 4, 1–2, 28-42, 2014**
- **Pachl J. –** ***Railway Operation and Control (Fourth Edition)*** **– VTD Rail Publishing, Mountlake Terrace, 2002**

Analogy with simple node

<u>Input: Potential operational situations (single routes and combinations)</u>

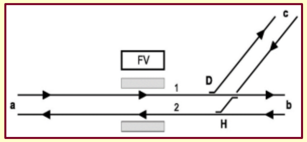
By Matrices, Graphs, Trees

<u>Output: Traffic physical and numerical parameters</u>

Number of manageable movements

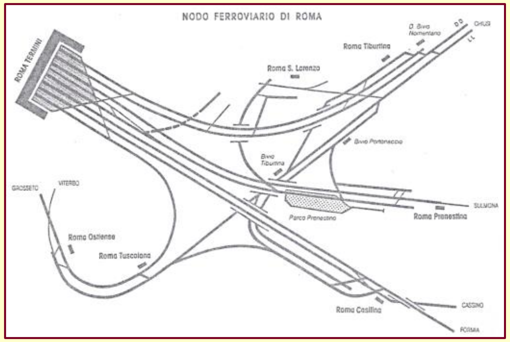
Global occupation time

Delays generated by traffic



<u>Traffic process</u>

Sequence of N/n_m events with n_m trains running simultaneously occupying the node for a time t_m



<u>Equivalent parameters</u>

T = reference time

N = total number of trains running during T

n_m = average number of compatible routes

t_m = average occupation time by groups of n_m trains

$\sum R$ = delay generated by N running trains

Capacity calculation parameters

Average occupation time

$$B = \frac{N}{n_m} t_m$$

Average delay

Resulting from incompatibility situations

Traffic quality indicator affecting the capacity

Summation of delays produced by single conflicts

Time subtracted to T due to simultaneous running of n_m trains:

$$\sum R / n_m$$

Global congruity condition

Ensuring regular traffic

$$T \geq \frac{N}{n_m} t_m + \frac{\sum R}{n_m}$$

n_m combinatorial calculation (optimized traffic)

<u>Parameters to consider (analytical formulation not available)</u>

1) Combination of compatible routes

2) Frequency of utilisation during *T*

<u>Weighting of traffic solutions saturating the node (assumption corresponding to the maximum utilization)</u>

n-tuples of compatible routes excluding all others: exclusion of compatible groups of order *n*-1 of a compatible *n*-tuple

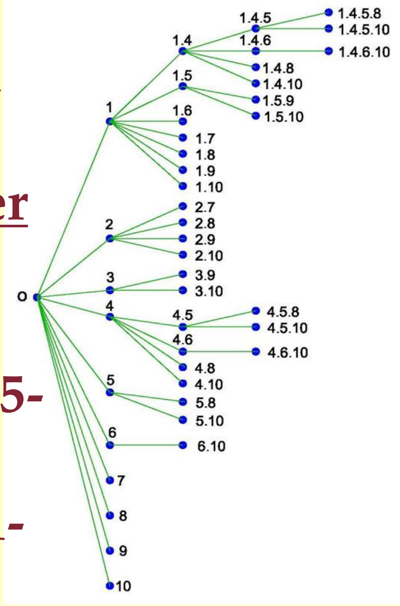
<u>Exploring traffic solutions tree from *n*-tuples of highest order</u> by progressive suppressions, e.g. from group 1-4-5-8 of:

a) *n*-tuples encountered towards 0: 1-4-5, 1-4 and 1

b) *n*-tuples not already suppressed by process in *a*: 1-4-8, 1-5-8, 4-5-8, 1-4, 1-5, 1-8, 4-5, 4-8, 8-5

Remaining *n*-tuples: 3 groups of 4 routes (1-4-5-8, 1-4-5-10 e 1-4-6-10) and 8 couples (1-7, 1-9, 2-7, 2-8, 2-9, 2-10, 3-9 e 3-10)

<u>Routes used according to their frequency of appearance</u> (3 triads and 8 couples) during *T*



$$n_m = \frac{3 \cdot 4 + 8 \cdot 2}{3 + 8} = 2{,}54$$

n_m empirical calculation (not optimized traffic)

Each route used by a single train during T

Assumption: number of trains = number of routes

Extreme conditions:

- **All routes incompatible ($n_m = 1$)**
- **All routes compatible ($n_m = n'$)**

Empirical expression fulfilling this conditions

n_m = cells of matrix / cells with incompatibilities

Weight of cells according to number of trains using the corresponding routes: n_i x n_j

(e.g., for routes used respectively by 3 and 4 trains = 3 x 4 = 12)

Total number of trains running during T: $N = \sum n_i = \sum n_j$

$$n_m = \frac{N^2}{\sum_I n_i \cdot n_j}$$

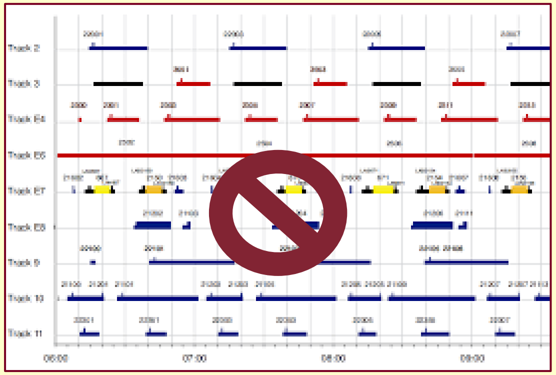
Summation extended to cells with incompatibilities only, including main diagonal ($i = j$)

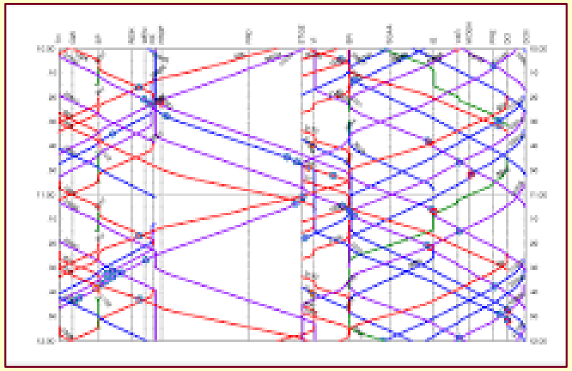
$$n_m = \frac{100}{60} = 1{,}67 < 2{,}54$$

Comparison of n_m calculations

<u>Combinatorial calculation = saturation condition</u>
Physical limit of capacity, rarely and shortly achievable
Considering the structure of the matrix and the higher order compatible *n*-tuples (optimized organization of traffic into lots)

<u>Empirical calculation = 20-50% lower</u>
More realistic (not optimized organization of traffic)
Compilation of timetables normally not considering constraints imposed by stations





t_m and expected delays calculations

<u>Calculation of occupation and interdiction times</u>

(*Based on infrastructures and rolling stock features*)

Compilation of *occupation time matrix* derived by matrix of routes

(*Values in cells = occupation/interdiction times of rows on columns*)

Not symmetric: $t_{ij} \neq t_{ji}$

Values in cells weighted by the number of possible events $n_i \times n_j$

$$t_m = \frac{\sum_I n_i \cdot n_j \cdot t_{ij}}{\sum_I n_i \cdot n_j}$$

Summations extended to all incompatible couples of routes

<u>Calculation of expected delays</u> $$R_{ij} = \frac{n_i \cdot n_j \cdot t_{ij}^2}{2T}$$

Incompatibilities not generating delays (*a* and *s*) <u>excluded</u>

Capacity check

Congruity condition

$$T \geq \frac{N}{n_m} t_m + \frac{\sum R}{n_m} \qquad T \geq \frac{\sum_I n_i \cdot n_j \cdot t_{ij}}{N} + \frac{\sum_L R_{ij} \cdot \sum_I n_i \cdot n_j}{N^2}$$

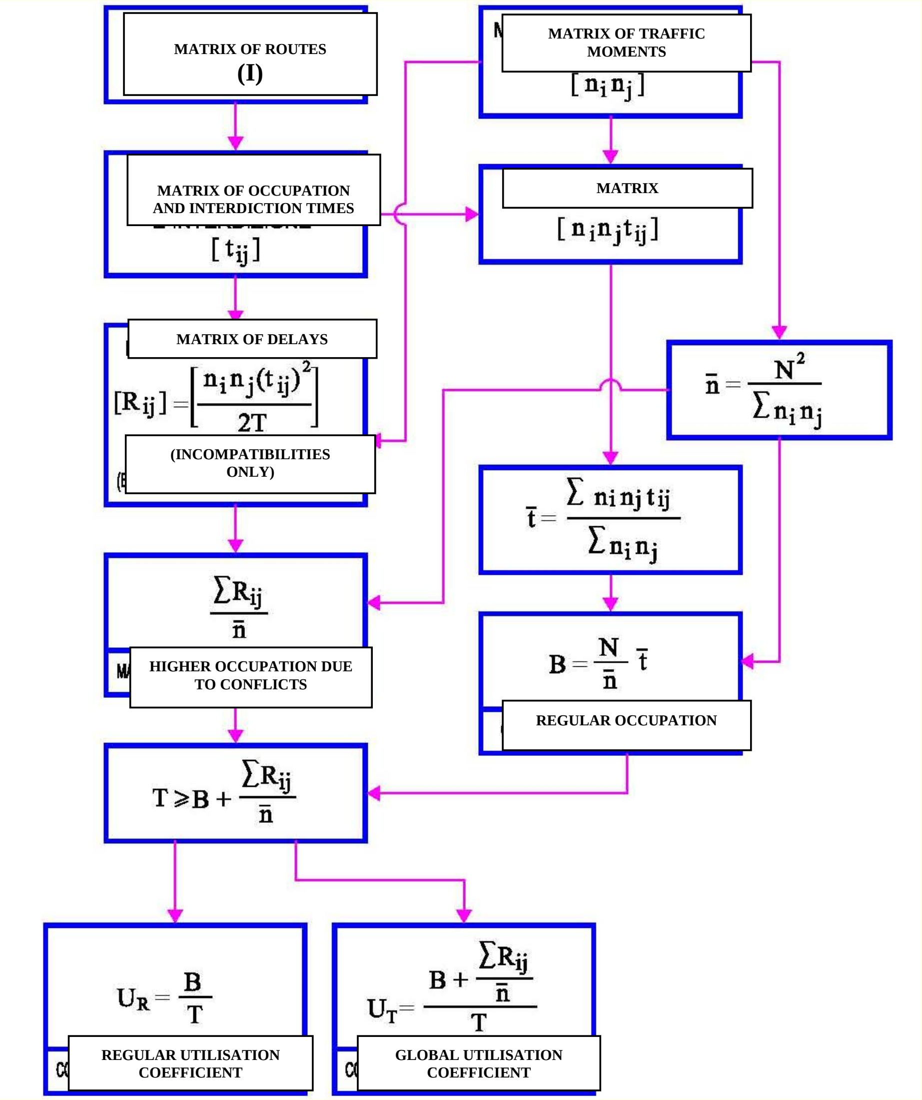
I **= set of incompatible routes**
L **= set of incompatible couples potentially generating delays (*a* and *s* excluded)**
Enough capacity to cover completely operational period *T*

Operational indicators
Utilization coefficients

Regular $U_R = (N\, t_m / n_m) / T$

Total $U_T = [(N\, t_m / n_m) + \sum R / n_m] / T$

Capacity check procedure

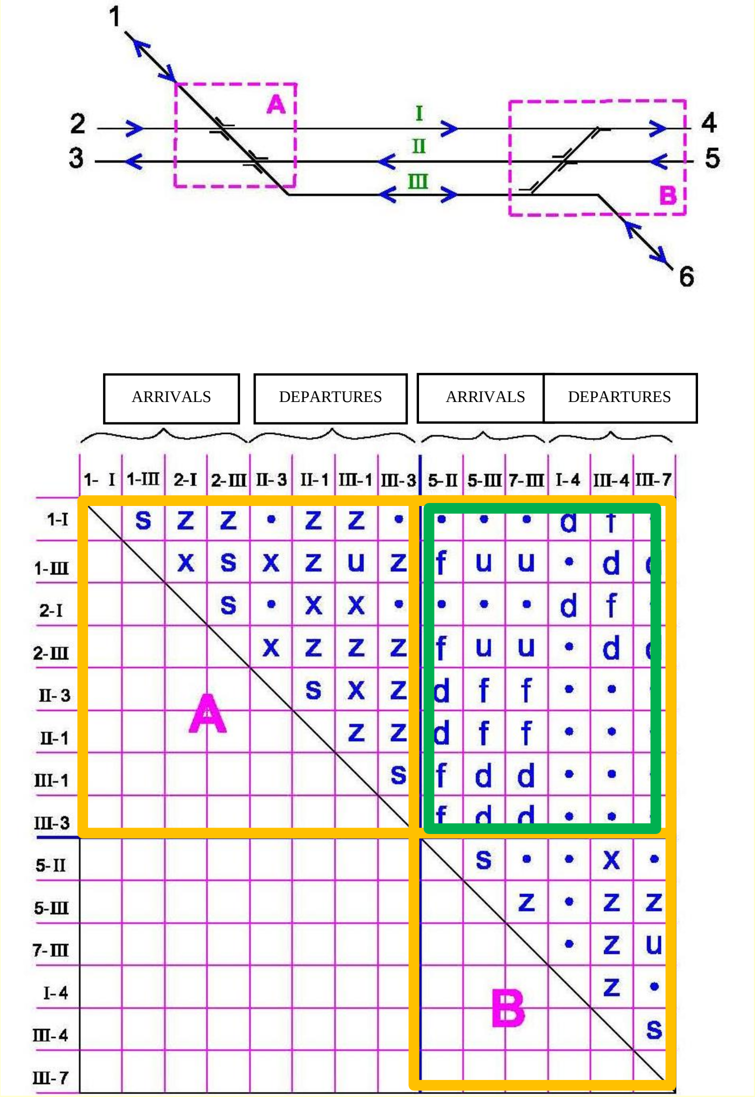


Decomposition of complex nodes

<u>*Dependent / Independent*</u> <u>sub-nodes</u>
According to contents of matrix of routes

<u>*Dependent*</u>
- Routes in (A) incompatible with some routes in (B) represented in *green* rectangular matrix beside them
- Check of nodes by 2 *orange* rectangular matrices

<u>*Independent*</u>
- Square matrices (A) and (B) with common vertex along main diagonal
- Compatibilities only in the *green* rectangular matrix



Mixed traffic in complex nodes

<u>**Alternate running trains with different speed**</u>

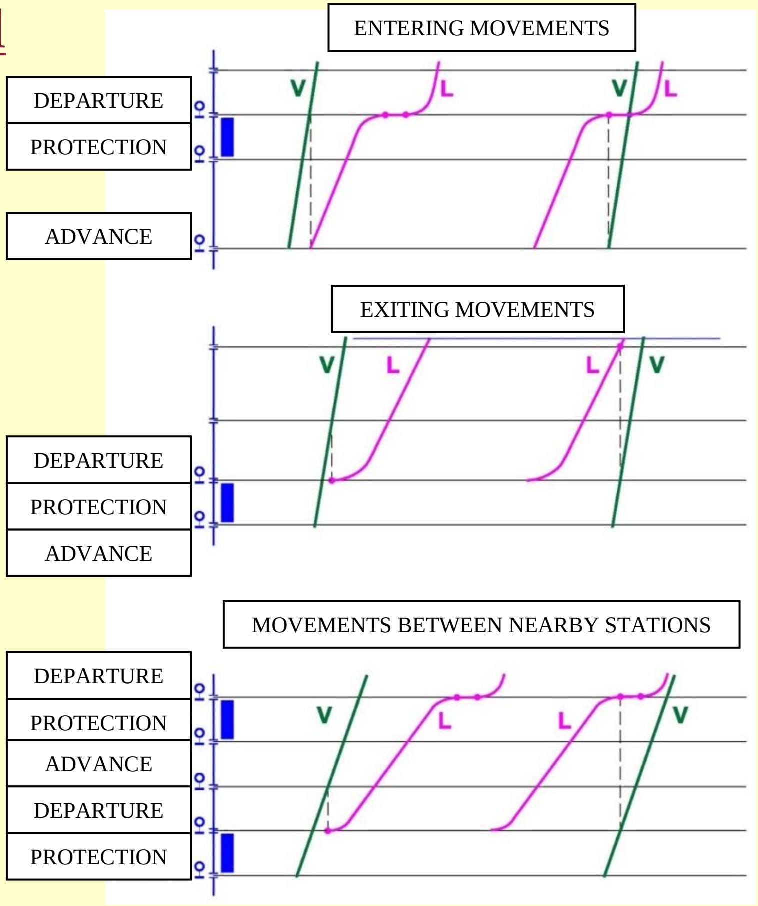
Fast train *V* not calling stations

Slow train *L* calling stations

<u>***L* conditioning *V*, with following exceptions:**</u>

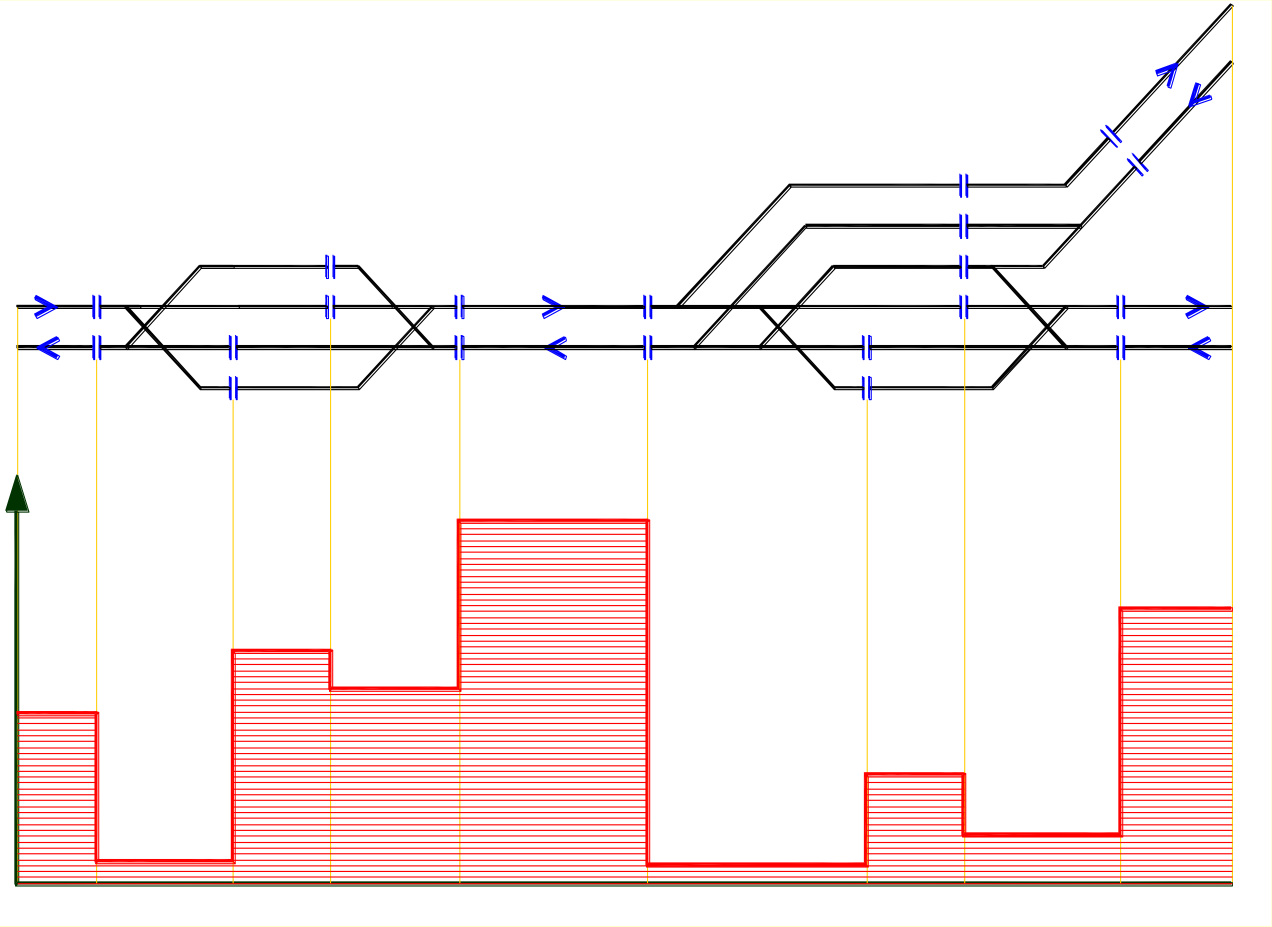
- ***Entering movement*: *V* reaching advance signal when *L* released entering routes**
- ***Exiting movement*: *V* reaching departure signal when *L* released second line block section after station**
- ***Movements between nearby stations A and B* (departure signal of A coinciding with the advance signal of B): *V* reaching departure signal of A after release of departure signal from B by *L***

Station capacity depending upon sequence of trains and length of line block sections



Capacity of stations and linking sections in complex nodes

Line-station capacity dependence



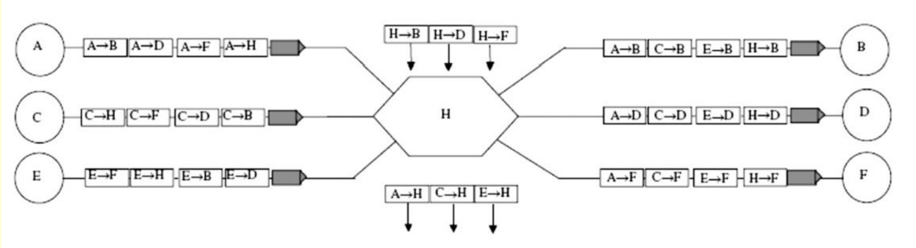
IN13
Marshalling yards

References

- **Khoshniyat F. – Simulation of Planning Strategies for Track Allocation at Marshalling Yards – KTH, Stockholm, 2012**

Functions and main characteristics

<u>Variation of trains composition according to destinations of wagons</u>



<u>Sequence of operations performed</u>

a) Arrival, waiting and preparation for following operations
b) Classification by directions: wagons destined along the same line sorted in same track to progressively compose train
c) Re-ordering of wagons by destination according to progressive order of destination stations along line
d) Preparation to departure, waiting and departure itself

<u>Moderate quantity of wagons (max 200-300/day)</u>
Group of tracks for manoeuvring in series with a single locomotive
<u>Large quantity of wagons (over 200-300/day)</u>
Yard allowing continuous operation by equipment maximizing capacity

General scheme

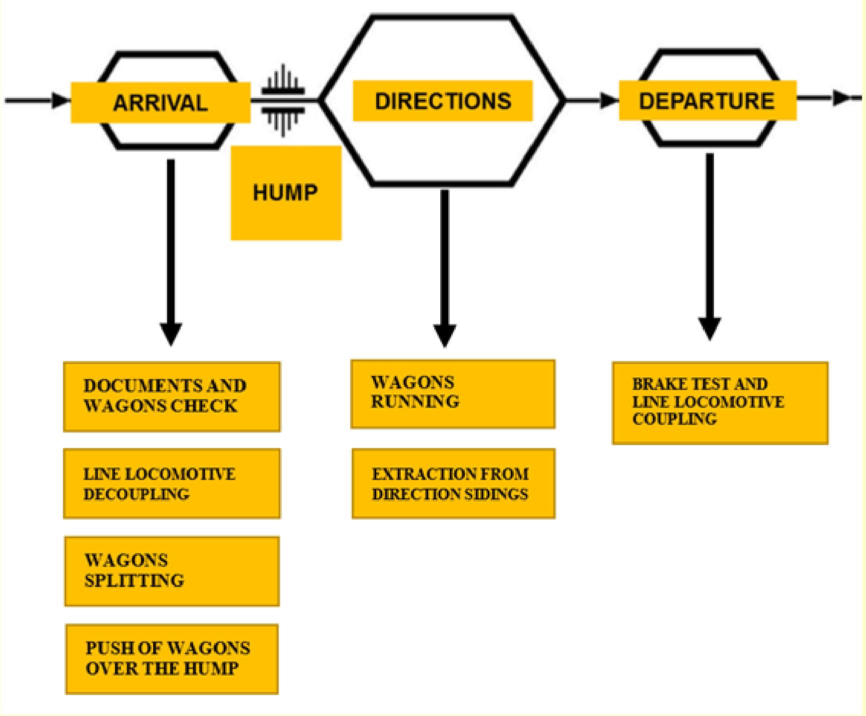
<u>Location depending upon morphology of network</u>

Easily accessible to converging/diverging lines

Maximum daily quantities of handled wagons:

- Standard techniques: 2000-3000 wagons/day
- 4000-5000 wagons/day by bi-directional operation, e.g. Maschen (DE)

<u>Sequence of operations performed in temporal and local sequence</u>



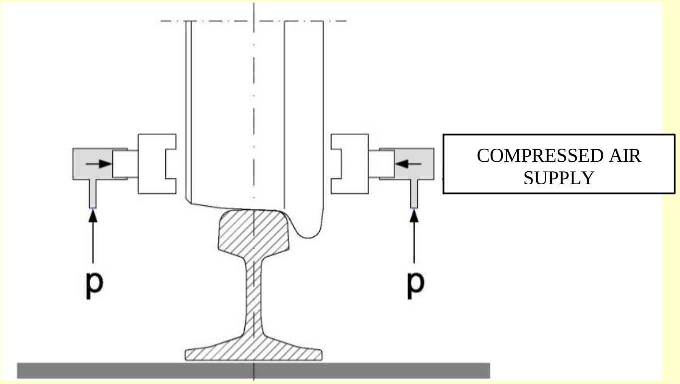
Equipment peculiarities

<u>Movements of groups of wagons with same destination</u>

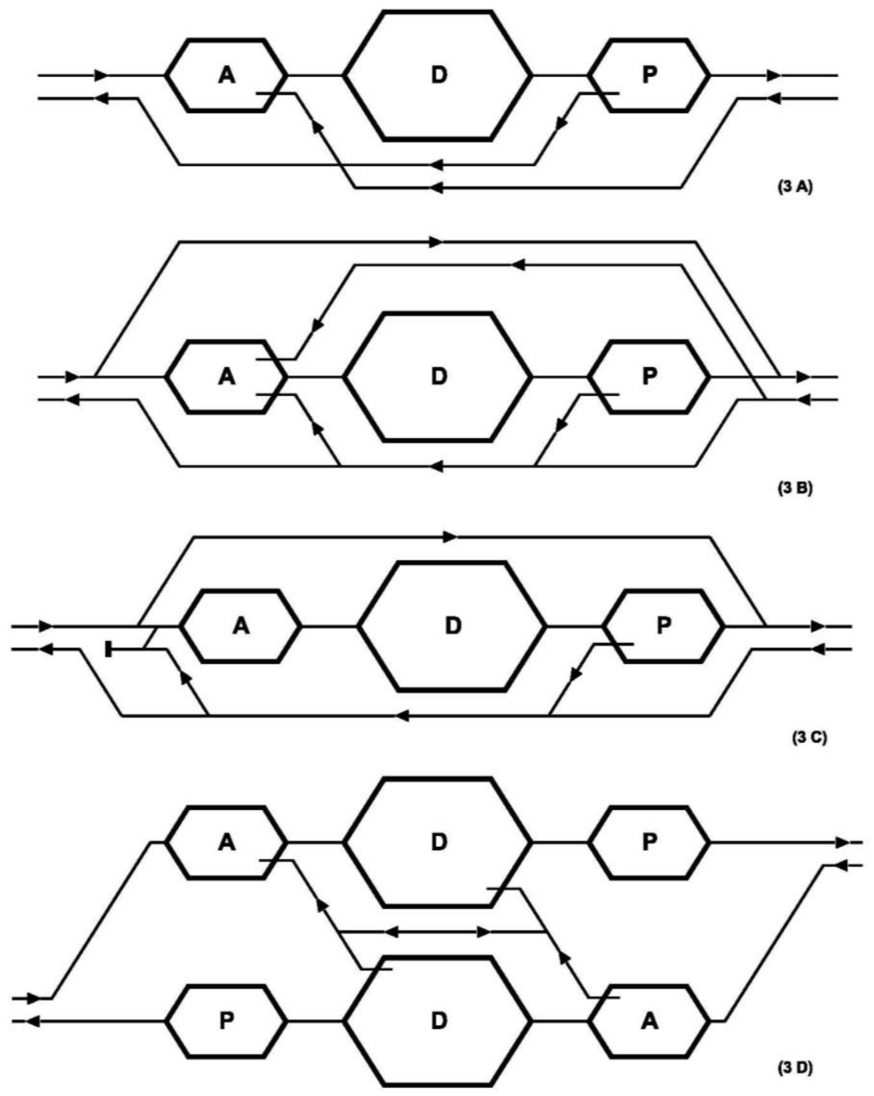
1) Pushed uphill the hump by a locomotive
2) Running downhill by gravity (no energy required) to respective direction tracks
3) Braking with intensity depending on:
   - Routes to be run
   - Specific rolling resistances of wagons
   - Wagons’ speed limitation

Most diffused braking systems

- Couples of *shoes* acting on wheels by friction



Possible connections among sidings



Arrival sidings functions

<u>Physical operations</u>

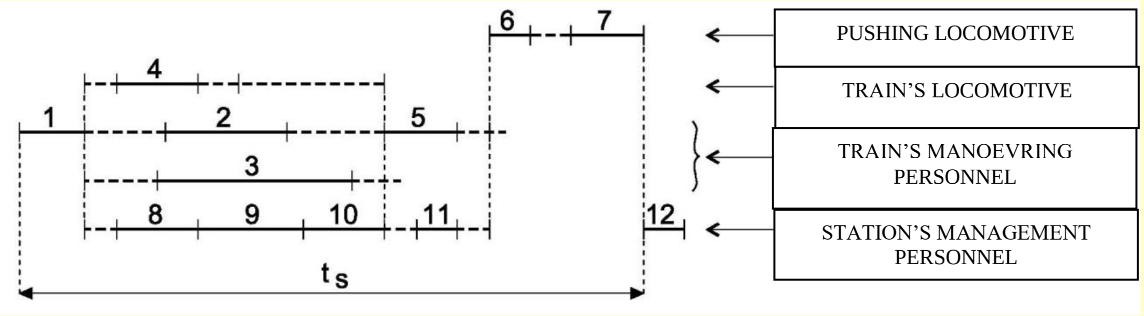
Reception of arriving trains

Release of brakes and couplings

Separation of locomotive and groups of wagons with the same direction

Approach of pushing locomotive

Pushing of train uphill the hump



<u>Accompanying informative flows and administrative processes</u>

Delivery of train's documents to station's personnel

Check of documents and actual train's composition

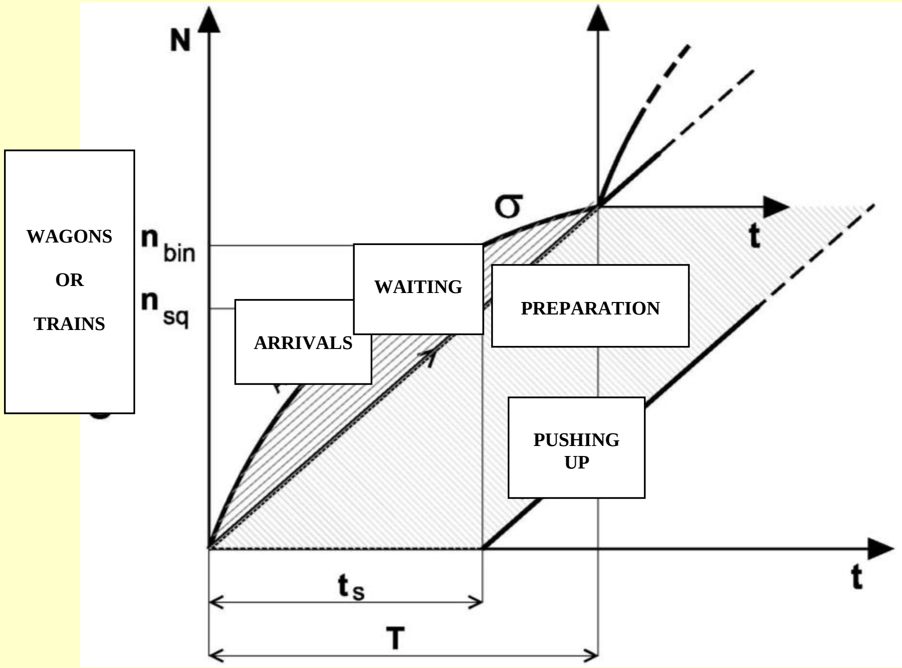
Planning of manoeuvres

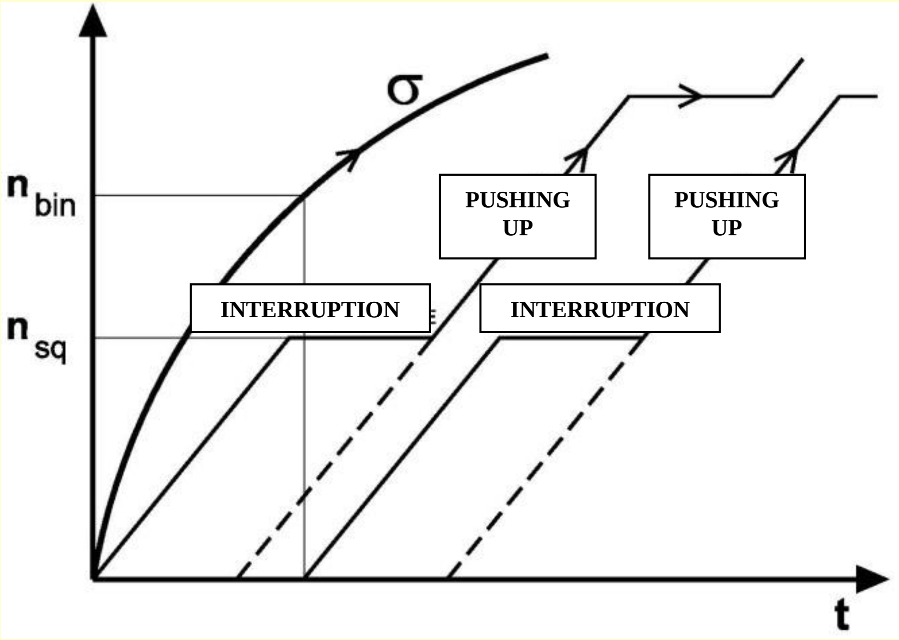
Start of pushing up manoeuvre

Progressive updating of directions sidings situation

Tracks and personnel needs in arrivals sidings

Filling/emptying curves





Filling/emptying curves with temporary interruption of manoeuvres

Operational times

t_1 = time dedicated to sorting of wagons from hump

$$t_1 = \frac{N n_m}{n_{ct}} \left(\frac{l_t}{v_m} + \Delta t \right)$$

t_2 = time required by pushing locomotive to move from hump to the next train to be pushed

$$t_2 = N \left(\frac{l_{mv}}{v_{mv}} + \Delta t_{mv} \right)$$

N = daily amount of handled trains
n_m = average number of wagons per train
n_{ct} = average number of wagons per group (same destination)
l_t = average length of a group of wagons
v_m = average speed downhill the hump
Δt = average time interval between two following groups of wagons
l_{mv} = average trip of a locomotive from hump to following train to push
V_{mv} = average maneuvering speed
Δt_{mv} = time interval required to receive orders from traffic control center for backing maneuvers and additional waiting times

Capacity of the hump

Congruity check

$$T \geq t_1 + t_2 + t_3 + t_4$$

t_1 = time dedicated to sorting of wagons from the hump
t_2 = time required by locomotive from the hump to the next train to push
t_3 = planned interruption of wagons sorting (e.g., due to maintenance)
t_4 = time of interruption due to failures

$$T \geq \frac{Nn_m}{n_{ct}}\left(\frac{l_t}{v_m} + \Delta t\right) + N\left(\frac{l_{mv}}{v_{mv}} + \Delta t_{mv}\right) + t_3 + t_4$$

$$n_{\max} = \frac{T - (t_3 + t_4)}{\frac{1}{n_{ct}}\left(\frac{l_t}{v_m} + \Delta t\right) + \frac{1}{n_m}\left(\frac{l_{mv}}{v_{mv}} + \Delta t_{mv}\right)}$$

Measures increasing the capacity of the hump

$$n_{\max} = \frac{T-(t_3+t_4)}{\frac{1}{n_{ct}}(\frac{l_t}{v_m}+\Delta t)+\frac{1}{n_m}(\frac{l_{mv}}{v_{mv}}+\Delta t_{mv})}$$

Increasing the number of wagons with the same destinations (n_{ct})

Involving transport chain organisation

(e.g. collection criteria, incentives for big quantities, reduced frequencies)

Partially neutralised due to increased l_t and Δt

Increasing the speed from the hump (v_m)

Restricted variation

($\Delta t \geq$ time required to run on track circuit of switch discriminating two following trains' directions + technical time for switch manoeuvring)

Increasing the composition of trains (n_m)

Increasing the speed of manoeuvring locomotive (v_{mv})

Reduction of the waiting time between trains push (Δt_{mv})

Remote control of locomotive

Alternating use of two pushing locomotives

Operational problems and techniques

<u>Kinetic and energetic issues</u>

a) Group of wagons with the same direction powered by potential energy and small quantity of initial kinetic energy enough to reach the end of the longest track of directions sidings
b) Route to be run progressively shorter due to partial occupations of direction track by previously manoeuvred wagons
c) Dissipation of energy exceeding the quantity to reach target point in the direction tracks

<u>Targets of braking regulation</u>

a) To ensure the approach of wagons at a speed not causing damages to other wagons and transported goods (≤ 1.25 m/s)
b) To ensure the most intensive use of length of directions tracks (minimum distance between wagons)
c) To push the wagons downhill the hump as fast as possible to maximise the global capacity of the marshalling yard

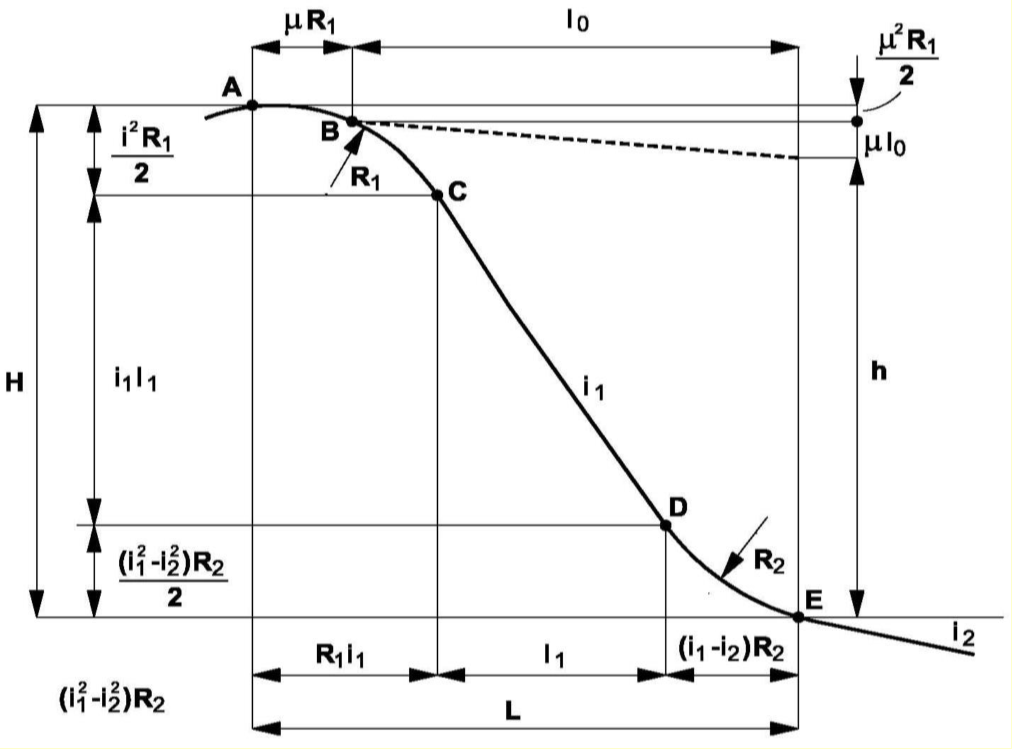
Geometry of hump's profile

Potential energy + initial kinetic energy enough to reach the end of the longest track of directions sidings

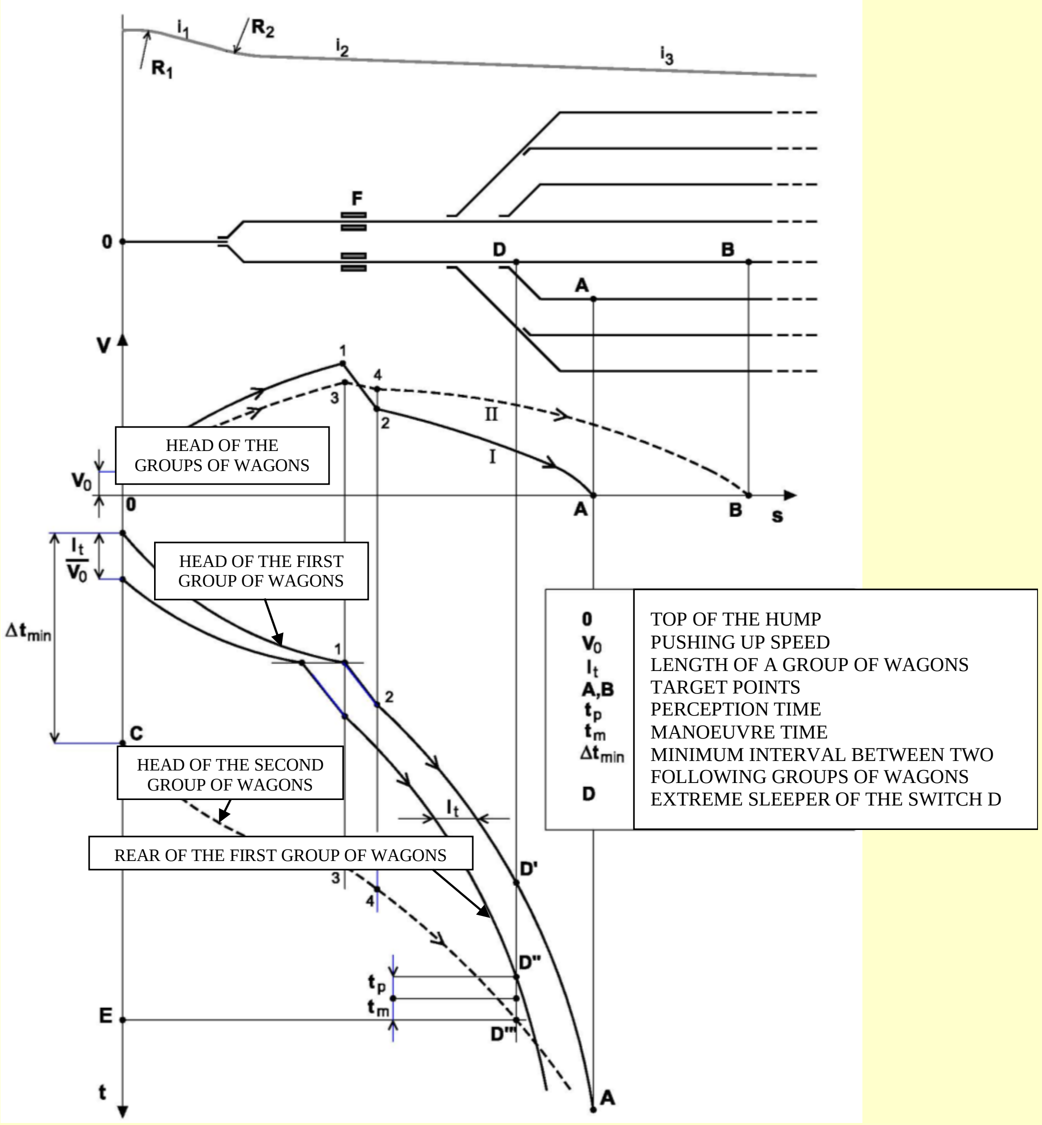
$$H = \frac{i_1^2 + R_1}{2} + i_1 l_1 + \frac{i_1^2 - i_2^2}{2} R_2 = \frac{\mu^2 R_1}{2} + \mu l_0 + h$$

Transition arcs AC, DE with R ≅ 400 m

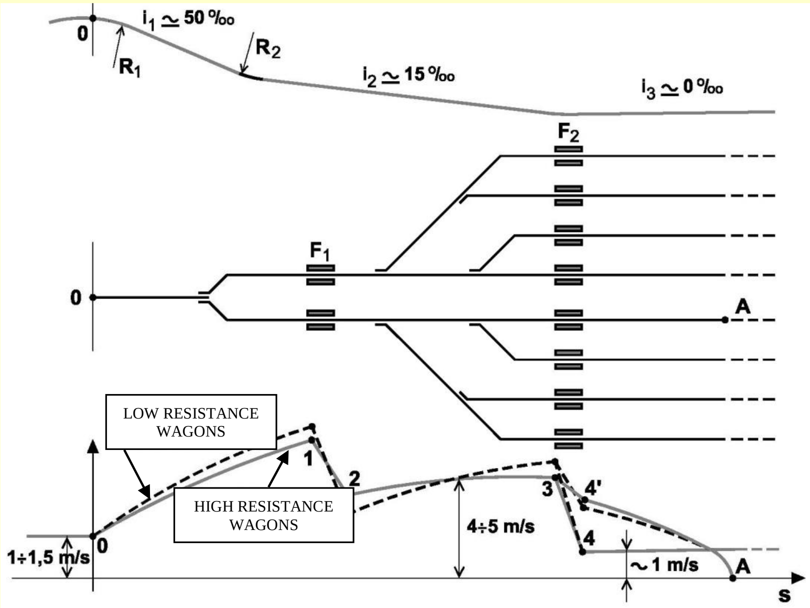
$$L = R_1 i_1 + l_1 + (i_1 - i_2) R_2 = \mu R_1 + l_0$$



Running diagram of groups of wagons



Braking concepts and technologies: rail brakes



French solution

Automatic shooting to target

- Estimation of motion resistances and distance to run on directions sidings
- Regulation of braking intensity in F2 based on it

https://www.youtube.com/watch?v=LzPqpQUDtEQ

German solution

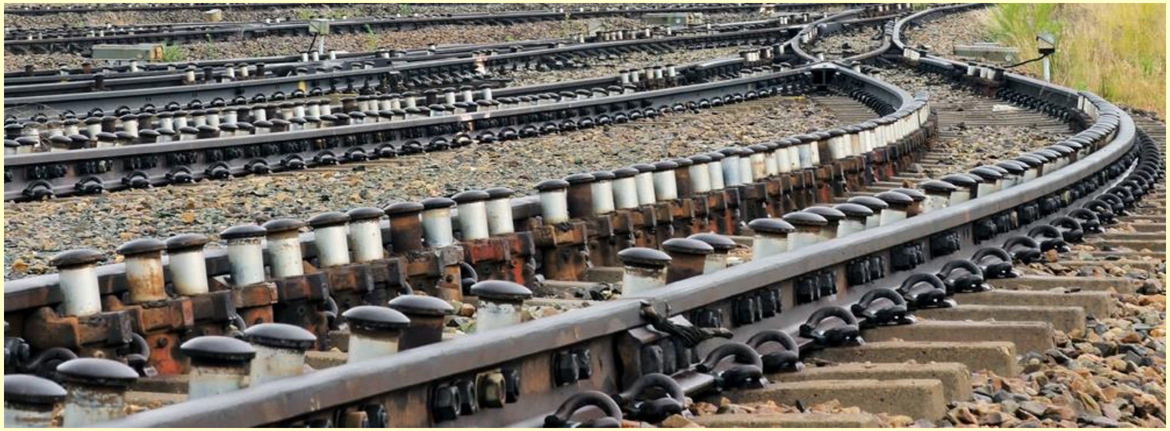
- Second braking equipment F2 reducing speed of all wagons to 1 m/s
- Small trolleys pushing the wagons closer each other on direction tracks

https://www.youtube.com/watch?v=tSfmNBelU7w

Braking concepts and technologies: dumpers

<u>*British* and *Austrian* solution</u>

- Dissipation of exceeding kinetic energy in comparison with pre-defined running diagram by equipment distributed along tracks
  - Hydraulic dampers positioned aside rail pushed by wheels' flange (absorbing part of kinetic energy)
  - Resistance proportional to local speed
- Energy subtracted whenever running speed is over a fixed threshold
- Slopes helping slower wagons to reach targets for any motion resistance
- Wagons running intrinsically safe without specific control equipment
- High levels of noise



Length of direction sidings

Typical accumulation problem

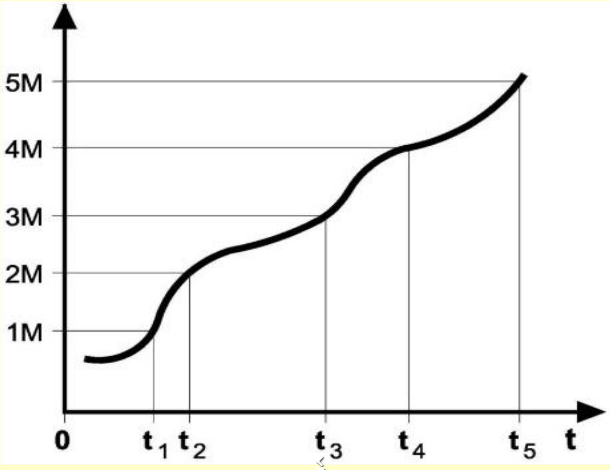
- **Compatibility of arrivals and extraction processes**
- **Pseudo-random external factors depending upon transport chains**
- **Internal yard management controlling trains' extraction process**

Opposite criteria of yard management

A. **Full flexibility of departure timetables with constraints to plan optimal trains' compositions according to selected criteria (e.g. identification of a critical mass *M*)**
B. **Full rigidity of departure timetables with possible decision on suppression of trains (e.g. depending on a critical mass *M*)**

Critical mass identification

Departure *when* (criteria A) or *if* (criteria B) the critical mass M is reached (times t_1, t_2, etc.)



Quantity of wagons by track never exceeding M

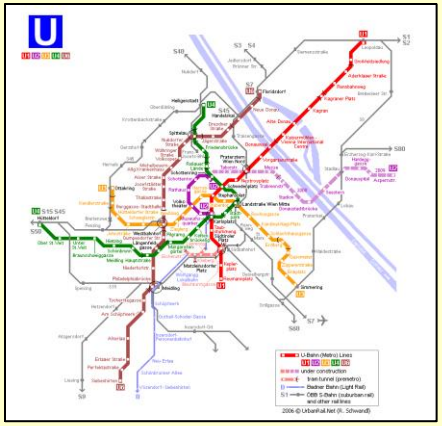
- Length of tracks in directions sidings
  - Not directly depending upon sequence of arrivals
  - Depending on economic evaluations
- External operational constraints
  - M compatible with line performances and locomotive power
  - M compatible with length of overtaking and crossing tracks along lines

IN14
Metro systems

References

- **Connors P. –** ***Metro Operation Planning*** **- Railway Technical Web Pages Infopaper N. 4, 2011**
- **London Underground –** ***Station Design Idiom*** **- London, 2015**
- **Vuchic V. –** ***Urban Transit. Operations, Planning, and Economics*** **(ISBN: 978-0-471-63265-8) – Wiley, Hoboken, 2005**

Peculiarities of metro systems



<u>Simple operation</u>

- Single traffic typology
- Interferences in terminals and junctions only
- Passenger only service
- Short line extension

<u>High frequency</u>

<u>Operational invariability for long periods</u>

- Difficulty to modify fixed installations under operation

<u>Short sections between stations</u>

- Stop times at stations relevant in comparison with station-station running time

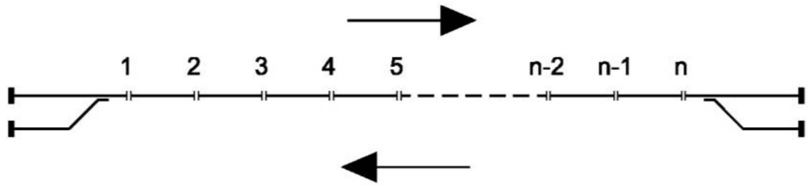
<u>Closed networks, not physically connected with other lines</u>

- High attitude to introduce automation

Origin-destination matrix and flows along line

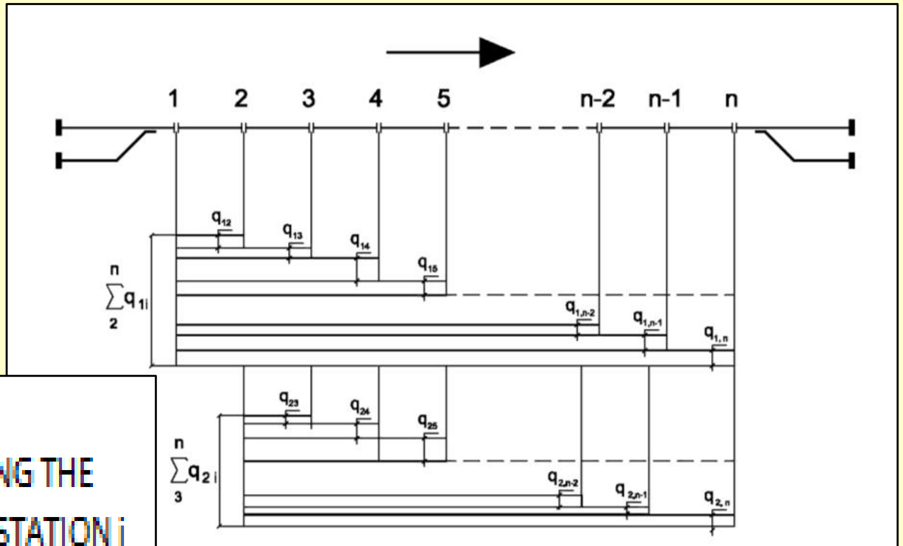
<u>Origin-destination matrix among stations from traffic forecasting</u>

- Reference period *T*
- Traffic variability during relevant *T* (hours, days, weeks, etc.)



	1	2	3	4			n-1	n
1		q_{12}	q_{13}	q_{14}			$q_{1,n-1}$	$q_{1,n}$
2	q_{21}		q_{21}	q_{21}			$q_{2,n-1}$	$q_{2,n}$
3	q_{31}	q_{32}		q_{34}			$q_{3,n-1}$	$q_{3,n}$
4	q_{41}	q_{42}	q_{43}				$q_{4,n-1}$	$q_{4,n}$
n-1	$q_{n-1,1}$	$q_{n-1,2}$	$q_{n-1,3}$	$q_{n-1,4}$				$q_{n-1,n}$
n	$q_{n,1}$	$q_{n,2}$	$q_{n,3}$	$q_{n,4}$			$q_{n,n-1}$	

O/D MATRIX REPRESENTING THE PASSENGERS BOARDING IN STATION i AND ALIGHTING IN STATION j



Walking movements in metro stations

<u>Movement typologies</u>

- Plane ground
- Stairs
- Escalators

<u>Operational target</u>

- Ensuring unconditioned movement of pedestrians

<u>Experimental studies on plane ground</u>

- Platforms with walking alighting passengers
  - Observations of average speed (95% of sampling) (Germany)

$$V = 1.29 \pm 0.03 \text{ m/s} = 77{,}6 \pm 1{,}5 \text{ m/min}$$

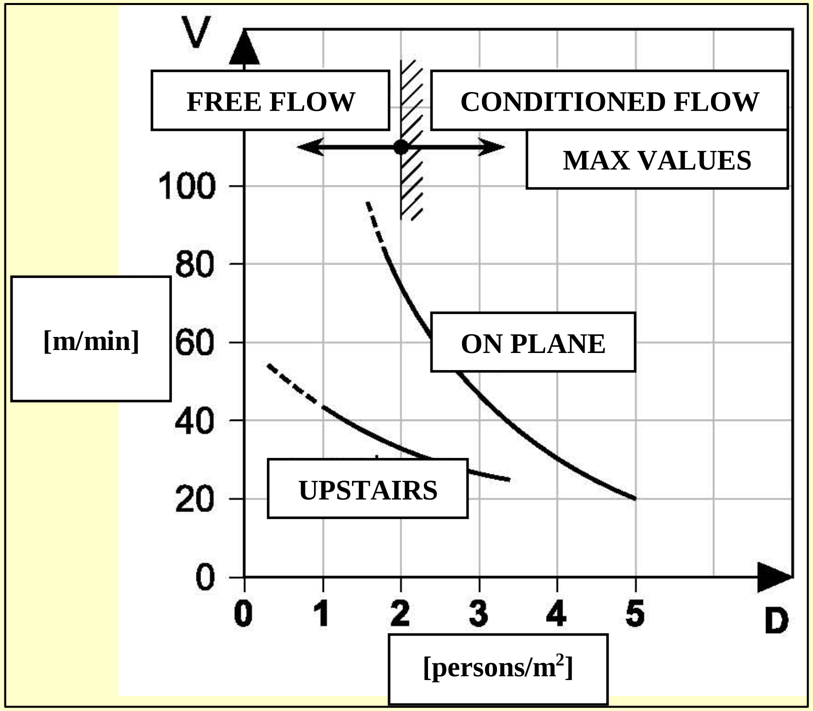
  - More generic conditions (USA): $V^2 - AV + B\Phi = 0$

A and B = parameters characterizing movement typology

Φ = flow by width and by time

Typology of movement	A [m/min]	B / A [m2]	V [m/min]	Vmax [m/min]	Average Φ [pers./m x min]	Max Φ [pers./m x min]	Density [pers./ m^2]
Shopping	79	0.25	39	52	79.2	108	1.9
Students	98	0.36	49	93	85.3	86	1.4
Mixed	90	0.26	45	75	80.8	111	2.0
Ordered	-	-	-	91	-	157	-

Walking on plane: typical flow characteristics



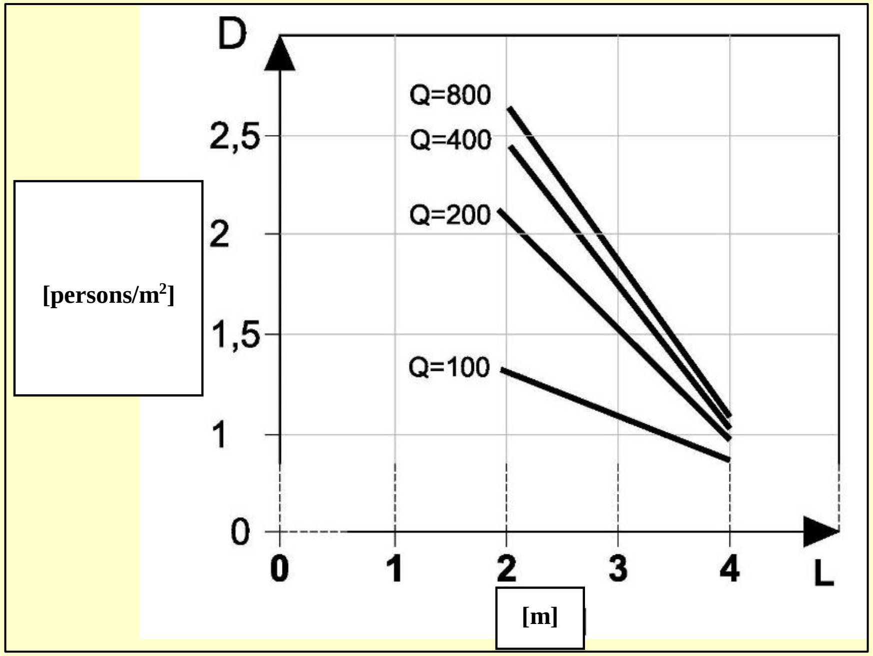
Speed (*V*) decrease for density (*D*) > 2 persons/m^2

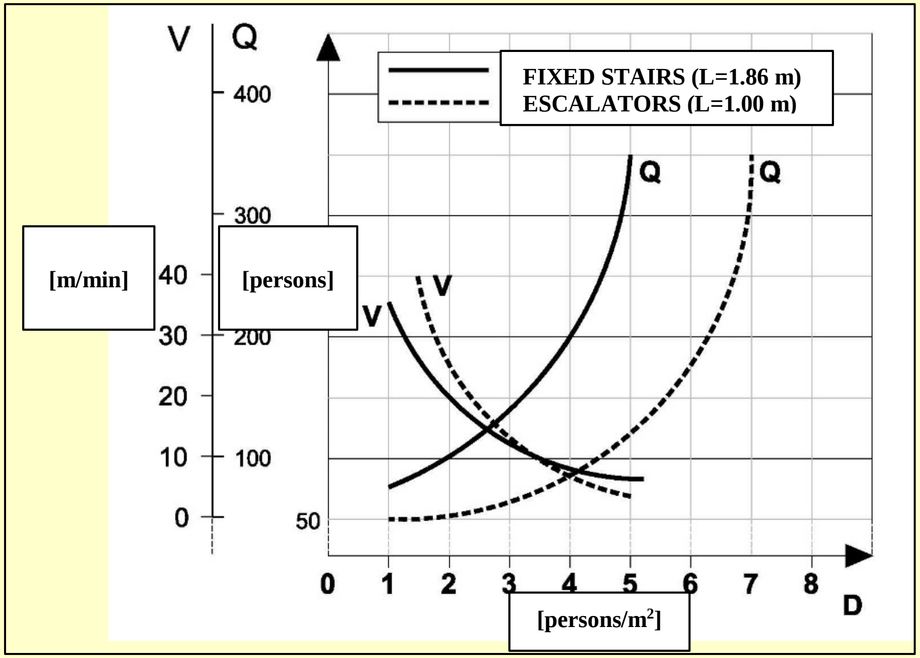
- Reciprocal conditioning of pedestrians
- Progressive reduction of flow

Design requirement

- Density (*D*) < 2 persons/m^2

Walking on stairs: typical flow characteristics

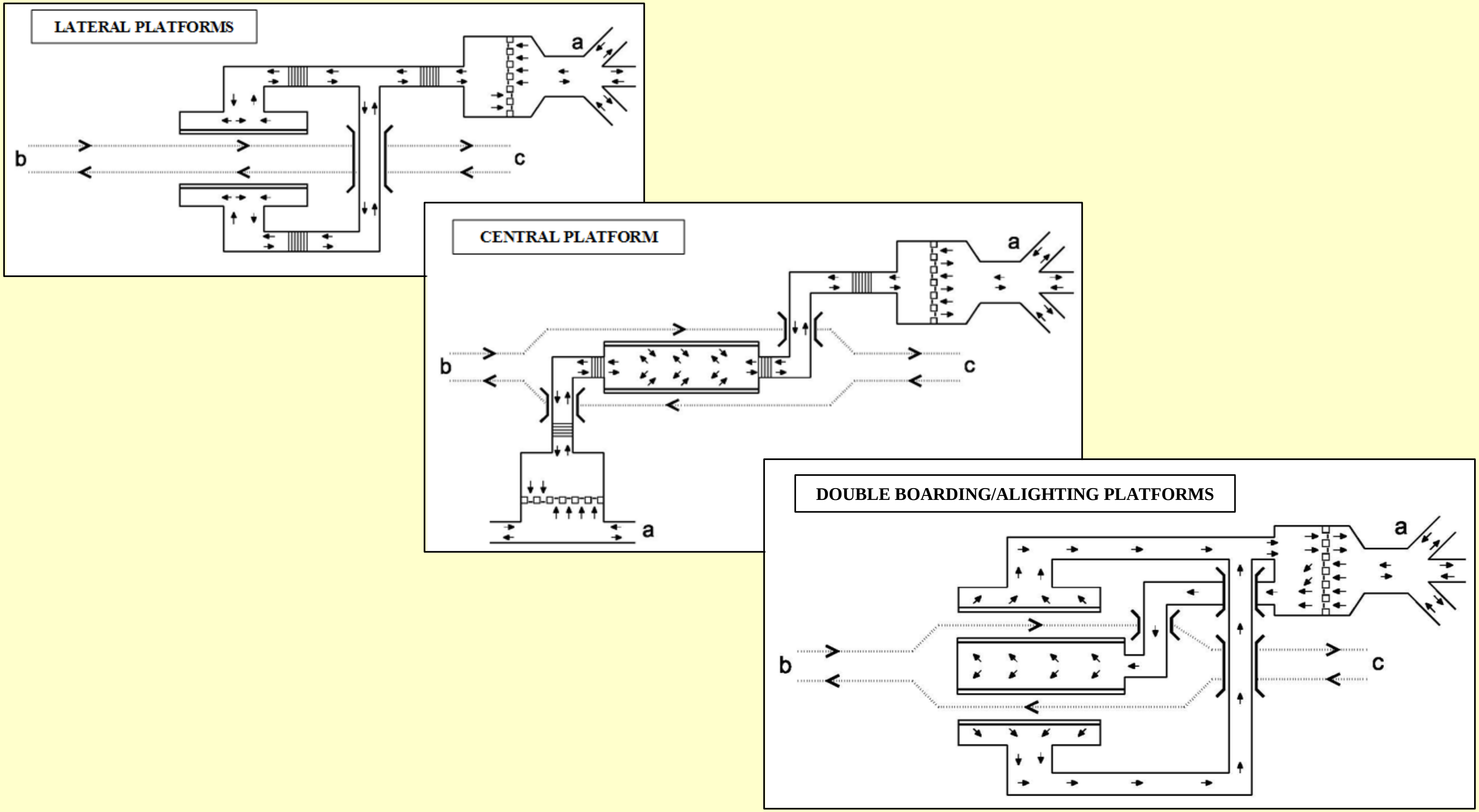




- **Maximum density (*D*) decreasing with stairs' width (*L*)**

- **Speed (*V* = 5-40 m/min) decreasing by**
  - **Increasing density (*D* = 1-5 person/m^2)**
  - **Increasing flow (*Q* = 50-350 person/min)**

Typical schemes of stations with representation of pedestrians' flows



Service frequency and length of platforms

<u>**Typology of vehicle and service quality**</u>

- **Number of coaches: N_u**
- **Length of coaches: L_u**
- **Passengers' capacity: Q_u**
- **Acceptable filling grade (4-6 persons/m^2)**

WEEKDAY	AM Rush	Midday	PM Rush	Evening	Late Night
RD	3-6 min*	12 min	3-6 min*	6-10 min	15-18 min
OR BL YL GR	6 min	12 min	6 min	12 min	20 min

* Additional Red Line trains operate between Grosvenor and Silver Spring during the AM and PM Rush. Service at these stations is every 3 minutes

SATURDAY	Daytime	Late Night
RD	12 min	15 min
OR BL YL GR	12 min	20 min

SUNDAY	Daytime	Late Night
RD	15 min	15 min
OR BL YL GR	15 min	20 min

<u>**Required nominal frequency in peak periods**</u>

- **Nominal headway: Δt**
- **Frequency: $F = 3600/\Delta t$ [trains/h]**

$$F\, N_u\, Q_u \geq \Phi_{max}$$

- **Typical headway values [s]: 60, 90, 120, 150, 180**
- **Typical corresponding frequency [trains/h]: 60, 45, 30, 24, 20**

- **Highest frequency ($\Delta t < 120$ s) performed by automation only**
- **Length of stations' platforms: $L_b \geq L_u\, N_u$ (tolerance: 10-20 m)**

Estimation of stop time in stations

<u>Relevant parameters</u>

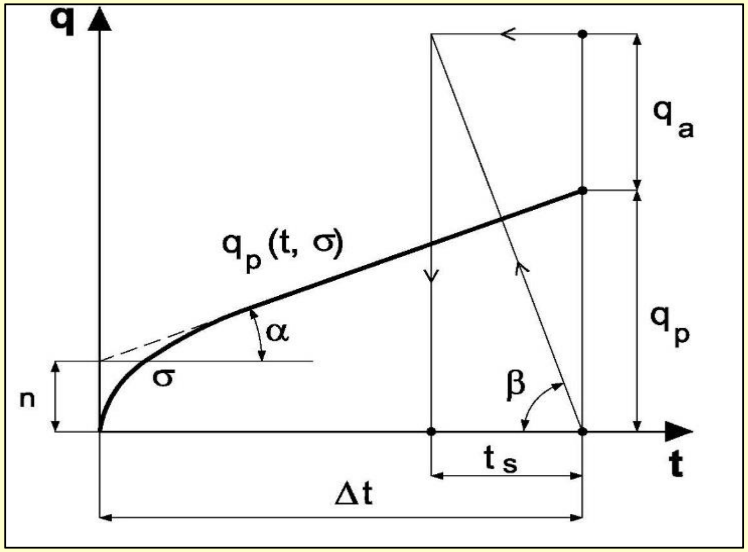
- Number (N_{pu}) and width (L_p) of trains' doors
- Irregular behaviours of passengers and operators (e.g. driving styles)
- Typical filling and emptying problem: flows (q) vs. time (t)

<u>Passengers boarding and alighting process</u>

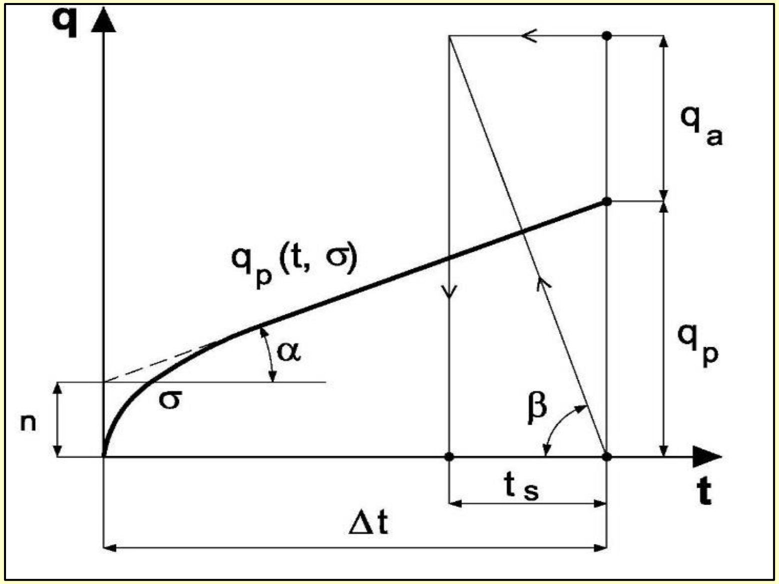
- Time origin corresponding with generic train doors' closure before departure (all passengers boarded = empty platform)

Headway (Δt) = period between door closures of two following trains

- Including stop time t_s



Passengers boarding and alighting process



$$t_m = \frac{T}{\sum_{i=j+1}^{n} q_{j,i}}$$

$$q_a = \sum_{i=1}^{j-1} q_{i,j} \frac{\Delta t}{T}$$

- $q_p = m\ \Delta t + n$ ($m = tg\alpha$) accumulation of departing passengers (e.g., arrival rate according to Poisson distribution)
- t_m = average interval between two passengers arriving to station
- q_a = passengers boarding on train
- V_{is} = average speed of 1 passenger through doors (e.g., 1 person/m/s)
- V_s = average speed of all passengers through all doors

Congruence condition: $V_s\ t_s = q_a + q_p$

Effect of delays on stop time in stations

- Delay: θ_a
- Effect: increase of passengers q_p waiting for departure
  - Queues prevention condition

$$t_s \leq \Delta t - \delta$$

(δ = buffer time required by departing train to release platform and ensure unperturbed run of following train)

Potential operational situations

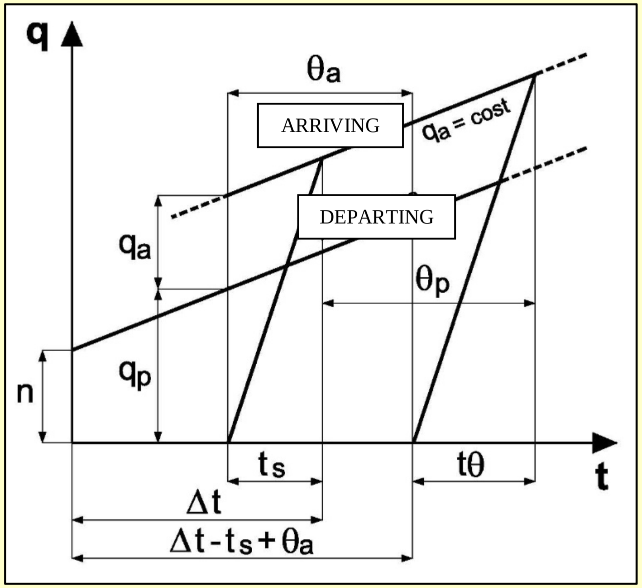
1) q_a (quantity of arriving passengers) not varying (delay generated on section immediately before)

Departing delay > Arriving delay

- $\theta_p = \theta_a + (t_\theta - t_s)$
- $t_\theta > t_s$

2) Larger q_a (delay generated on previous sections)

Larger delay



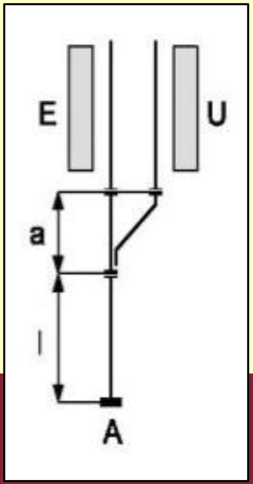
Stations without buffer time δ

- Perturbations propagated and amplified

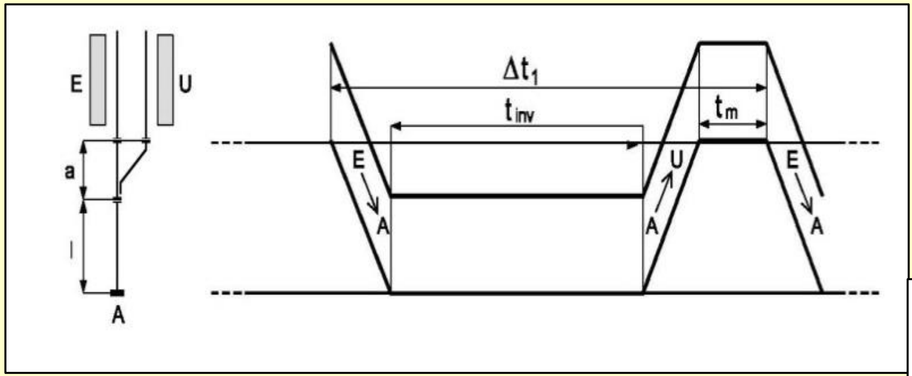
Reverse at terminus

<u>Headway on metro lines</u>
Depending upon *reverse time at terminus*
<u>Reverse time at terminus</u>
Depending upon *morphology of layout*
<u>Morphology of layout</u>
Depending upon *number of side-tracks* and *operation organisation*

<u>Key parameters for calculation</u>
t_{inv} = time required by reverse of driving cabin, including cabin-cabin walking time
t_m = average releasing time of interlocking system
l = length of inversion track
a = length of track circuits including switches
v_m = average manoeuvring speed in station



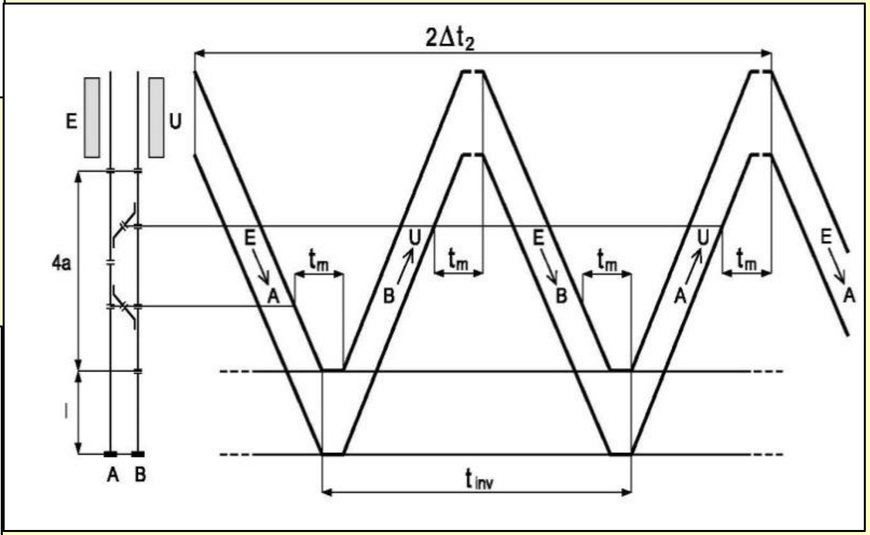
Calculation of minimum headway at terminus

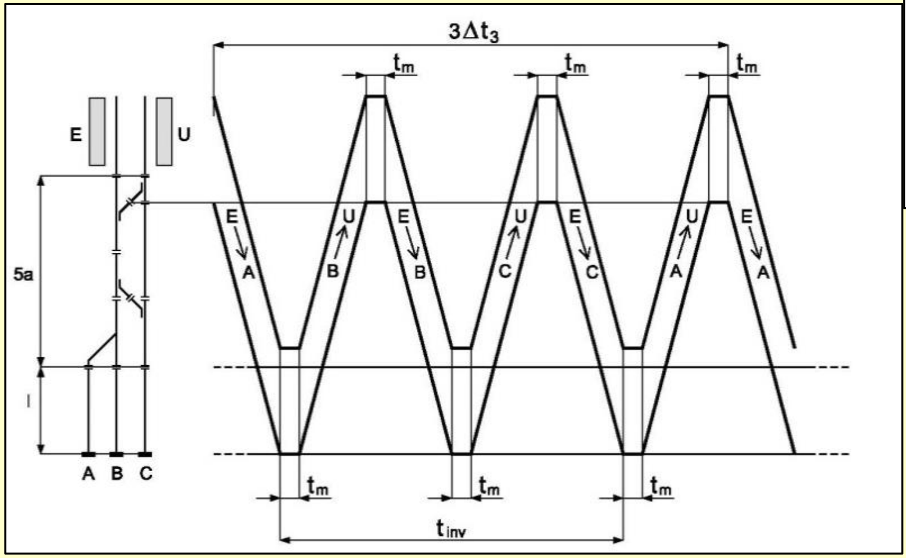


$$\Delta t_1 = t_{inv} + t_m + \frac{2(l+a)}{v_m}$$

$$\Delta t_2 = \frac{1}{2}\left[4t_m + \frac{2(l+4a)}{v_m}\right] < \Delta t_1$$

if inversion time > t_{inv} with a single reverse track





$$\Delta t_3 = \frac{1}{3}\left[6t_m + \frac{2(l+5a)}{v_m}\right] < \Delta t_2 < \Delta t_1$$

if inversion time > t_{inv} with a single reverse track

IN - PROJECT WORK 1
Calculation of maximum speed along curves

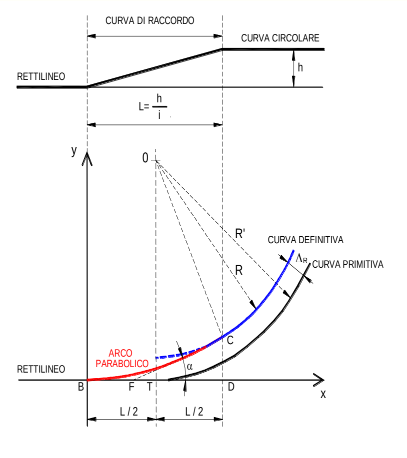
For the section from Castel Lagopesole to Potenza Centrale
(Planimetry-Profile provided)
(https://www.openrailwaymap.org/)

1) To determine the maximum allowed speed along all curves considering the following hypothesis:
- Maximum super-elevation of external rail: 160 mm
- Maximum unbalanced acceleration: 0.8 m/s^2

2) To represent the maximum allowed speed in a v-s diagram

IN - PROJECT WORK 2
Determination of horizontal and vertical transition curves

For the section from **Castel Lagopesole to Potenza Centrale** (Planimetry-Profile provided) (https://www.openrailwaymap.org/)

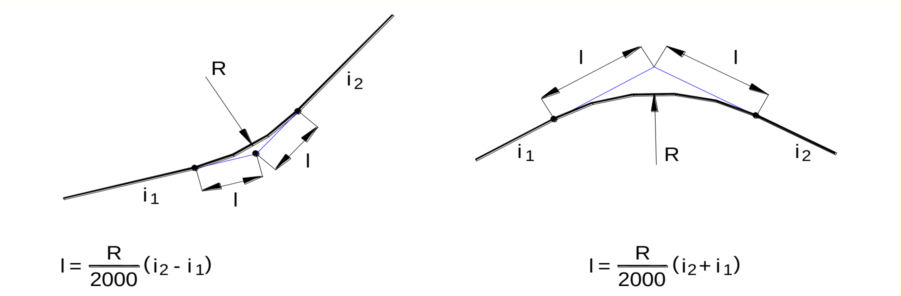


1) To determine the length and schematically draw the horizontal transition curves (cubic parabola) between curves and straight sections taking into account the following hypothesis:

- Acceleration variation = speed x unbalanced acceleration / length
- Maximum acceleration variation: 0.14 m/s^3

2) To determine the length and schematically draw the vertical circular transition curves between the couples of slopes taking into account the following hypothesis:

- Radius = (speed)^2 / vertical acceleration
- Maximum vertical acceleration: 0.4 m/s^2



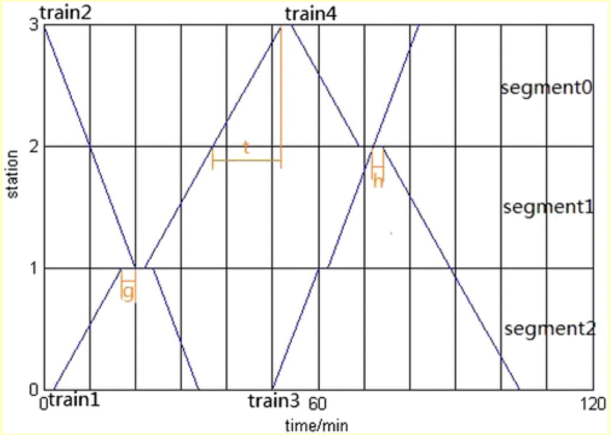
IN - PROJECT WORK 3
Timetable design

For the section from Castel Lagopesole to Potenza Centrale:

1) To determine departure and arrival times from/to stations for both directions considering:
- the maximum speed allowed in each section
- an additional (buffer) running time
- an additional time for acceleration and deceleration and a stop time in stations

2) To design a 3-hour timetable considering:
- the crossing of trains in stations only
- a reference frequency of 2 trains/hour/direction

3) To determine the commercial speed of the resulting service on both directions



IN - PROJECT WORK 4
Signals positioning

For the section from Castel Lagopesole to Potenza Centrale

1) To position Main Signals (MS) and Advance Signals (AS) to protect stations and Level Crossings (LC), all considered automatically controlled, by adopting the following reference (not mandatory) distances:
- AS-MS: 1000 m
- MS-MS: 1350 m
- MS-LC: 50 m
- Single signal protecting various LC within 1500 m
- Distance between all signals > 400 m

2) To plan the doubling of the track and correspondingly position track circuits (optionally signals) and balises for operating with ERTMS by assuming:
- Track circuits length: 2000 m

IN - PROJECT WORK 5
Minimum headway and capacity calculation by UIC 405 method

For the section from Castel Lagopesole to Potenza Centrale

To calculate the minimum headway between two trains running in the same direction and the bidirectional capacity by using the UIC 405 method for:
1) Single track layout (present scenario);
2) Double track layout (upgraded scenario).

Hypothesis for the calculation: single typology of traffic operated with: D) diesel referenced train, E) electric reference train.

The expression to use for the calculation is: $$P = \frac{T}{t_{fm} + t_r + t_{zu}}$$ **where are:**

- T = **reference time;**
- t_{fm} = **minimum headway;**
- t_r = **buffer time;**
- t_{zu} = **additional time, taking into account the number (a) of intermediate block sections on the double track critical line section calculated as:** $t_{zu} = 0{,}25\ a$

IN - PROJECT WORK 6
Station routes schematisation, occupation and interdiction times calculation

1) To draw a simplified schematic layout of Potenza Centrale station and the corresponding Müller figure.

2) To identify the routes allowed by the layout:
- Entering routes: main protection signal - main departure signals;
- Exiting routes: main departure signal - last switch along the exiting route.

3) To compile the matrix of routes including the following typologies of incompatibility described at slide n.178.

4) To build up graph of routes, matrix of n-tuples and traffic solutions tree.

5) To build up occupation/interdiction times matrix based on these assumptions or others:
- All trains stop in the station and depart after a stop of 60 s;
- Trains entering on deviated switches start the deceleration at main protection signals;
- Trains exiting on deviated switches accelerate after having overpassing entirely it;
- Preparation and waiting times (before occupation) of routes: 90 s entering, 60 s exiting;
- Maximum speed on switches: 30 km/h (deviated), 60 km/h (direct).

IN - PROJECT WORK 7
Traffic assignment and station capacity calculation

For Potenza Centrale station

1) To formulate an operational plan, by assigning flows of trains to routes, balanced by lines and directions, starting from the traffic hypothesis adopted for the Potenza - Castel Lagopesole line

2) To calculate regular and total utilisation rates by the following formulations:

$$C_{reg.util.} = \frac{B}{T} \qquad C_{ut.tot.} = \frac{B + \frac{\sum R_{ij}}{\bar{n}}}{T}$$

3) To increase the flows on the various route, to check the corresponding variations of the utilization rates

4) To fix thresholds for the utilization rates and to calculate the global capacity of the station accordingly

IN – TECHNICAL VISIT 1
Roma San Pietro station

For **Roma San Pietro** station:

1) To observe, ask the guide and take note of components and design choice adopted for:
   - Supestructure
   - Signaling
   - Layout
   - Traffic

2) To prepare a presentation to describe the points above

IV.8 UNIROMA1 - Master of Science in “Transport Systems Engineering” - “Public Transport Management” module

Dipartimento di Ingegneria
Civile Edile e Ambientale

Sapienza
Università di Roma

“Public Transport Management”

Proff. Luca Rizzetto & Cristiana Piccioni

Tram-train system

A.Y. 2023/2024

“Tram-train”: a typical example of interoperable public transport system

- “Tram–train” systems carry out the integration of a urban tramway with the surrounding railway network, by means of light rail vehicles adapted or specifically designed to run both on tramway and on heavy railway.
- This integration of an urban tramway and a regional railway allows to join directly the city centre with suburban areas, while eliminating the need to change transport system and the respective waiting times for passengers.
- Using on suburban railway light rail vehicles, with higher acceleration/braking performances than railway vehicles, it is possible to reach higher commercial speeds, that allows higher frequency of the service and the possibility of introduce in railway lines new intermediate stops without increasing travel time.

"Tram-train": main characteristics of the system

- The above-mentioned tram–train concept originates from "Karlsruhe model", which is based on the following main characteristics:
  1. the use of tramway rolling stock;
  2. the mixed operation of these "dual mode" vehicles with heavy rail vehicles in conventional railway.

Karlsruhe tram-train vehicle

In the following, we will always refer to this concept of "tram-train" (developed not only in Karlsruhe but also in Saarbrücken and Kassel), although there are improper "tram-train" systems in which tram vehicles use a railway line dedicated to them (Croydon, Aulnay-Bondy) or where Diesel Multiple Units (DMU) share the tramway tracks with tram vehicles in the city center (Zwickau).

"Tram-train" examples:
Karlsruhe (Germany)

City population	290.000 inhabitants
Metropolitan area population	500.000 inhabitants
First Line Activation Year	1992
Number of lines in operation	10
Extension of the network	400 km
Tramway infrastructure	existing
Railway infrastructure	existing
Tramway network power supply	750 V d.c.
Railway network power supply	15 kV a.c.
Vehicle particularities	dual-voltage electric vehicles, special wheel profile
Infrastructure particularities	raising of the counter-rail of the railway switches

Karlsruhe "Tram-train" vehicle GT 8-100 D/2S-M series

Karlsruhe Bombardier Flexity Swift vehicle

"Tram-train" examples:
Kassel (Germany)

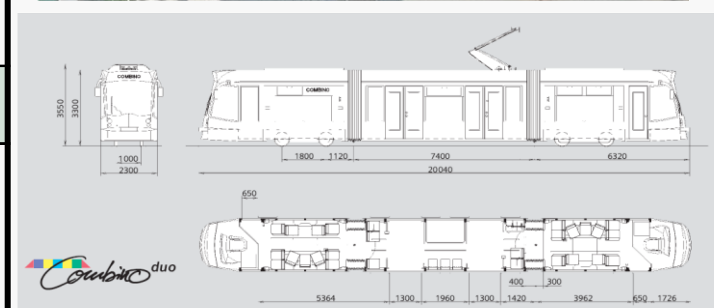
City population	290.000 inhabitants
Metropolitan area population	550.000 inhabitants
First Line Activation Year	1995
Number of lines in operation	4
Extension of the network	122 km
Tramway infrastructure	existing
Railway infrastructure	existing
Tramway network power supply	750 V d.c.
Railway network power supply	15 kV a.c. - diesel
Vehicle particularities	dual-voltage and hybrid electric vehicles (diesel-electric), special wheel profile
Infrastructure particularities	4-rail section in the stops (different width between trams and "tram-trains")

Kassel Alstom RegioCitadis on railway tracks

Kassel Alstom RegioCitadis on tramway tracks

"Tram-train" examples:
Nordhausen (Germany)

City population	45.000 inhabitants
Metropolitan area population	90.000 inhabitants
First Line Activation Year	2004
Number of lines in operation	1
Extension of the network	14 km
Tramway infrastructure	existing
Railway infrastructure	existing
Tramway network power supply	600 V d.c.
Railway network power supply	diesel
Vehicle particularities	hybrid vehicles (diesel-electric), metric gauge
Infrastructure particularities	tramway and railway both metric gauge



Nordhausen Siemens Combino-Duo vehicle

“Tram-train” examples”:Saarbrücken (Germany-France)

City population	180.000 inhabitants
Metropolitan area population	1.000.000 inhabitants
First Line Activation Year	1997
Number of lines in operation	1
Extension of the network	25 km
Tramway infrastructure	new
Railway infrastructure	existing
Tramway network power supply	750 V d.c.
Railway network power supply	15 kV a.c.
Vehicle particularities	dual-voltage electric vehicles, special wheel profile but very similar to the railway one
Infrastructure particularities	-

The Bombardier Flexity Link vehicle on Saarbrücken tramway tracks

… and at the railway station of Sarreguemines (France)

“Tram-train” examples: Zwickau (Germany)

City population	97.000 inhabitants
Metropolitan area population	-
First Line Activation Year	1999
Number of lines in operation	1
Extension of the network	18,5 km
Tramway infrastructure	existing
Railway infrastructure	existing
Tramway network power supply	750 V d.c.
Railway network power supply	diesel
Vehicle particularities	Diesel Multiple Unit (DMU)
Infrastructure particularities	Tramway metric gauge and standard railway gauge (1,435 mm), third rail in the city

Siemens DUEWAG Regio Sprinter DMU on Vogtlandbahn railway tracks

... and on Zwickau city tramway tracks

"Tram-train" examples: Paris line T4 from Aulnay-sous-Bois to Bondy (France)

City population	-
Metropolitan area population	11.175.000 inhabitants
First Line Activation Year	2006
Number of lines in operation	1
Extension of the network	8 km
Tramway infrastructure	-
Railway infrastructure	existing, adapted to the "tram-train" service
Tramway network power supply	-
Railway network power supply	750 V d.c.
Vehicle particularities	dual-current vehicle (750 V d.c. and 25 kV a.c.)
Infrastructure particularities	Improper "tram-train", there is no mixed operation

Paris Siemens Avanto vehicle

"Tram-train" examples:
Sassari (Italy)

City population	130.000 inhabitants
Metropolitan area population	-
First Line Activation Year	2009
Number of lines in operation	1
Extension of the network	4,3 km
Tramway infrastructure	existing (gauge 950 mm)
Railway infrastructure	existing (gauge 950 mm)
Tramway network power supply	750 V d.c.
Railway network power supply	750 V d.c.
Vehicle particularities	special wheel profile
Infrastructure particularities	Improper "tram-train", there is no mixed operation

Sassari AnsaldoBreda Sirio tram vehicle

“Tram-train” examples:
Cagliari (Italy)

City population	157.000 inhabitants
Metropolitan area population	-
First Line Activation Year	2008
Number of lines in operation	1
Extension of the network	6,3 km
Tramway infrastructure	-
Railway infrastructure	existing, adapted to “light rail” (gauge 950 mm)
Tramway network power supply	750 V d.c.
Railway network power supply	750 V d.c.
Vehicle particularities	-
Infrastructure particularities	Improper "tram-train", there is no mixed operation

Cagliari Skoda 06 T tram vehicle

Cagliari CAF tram vehicle

“Tram-train”: technical barriers to be overcome

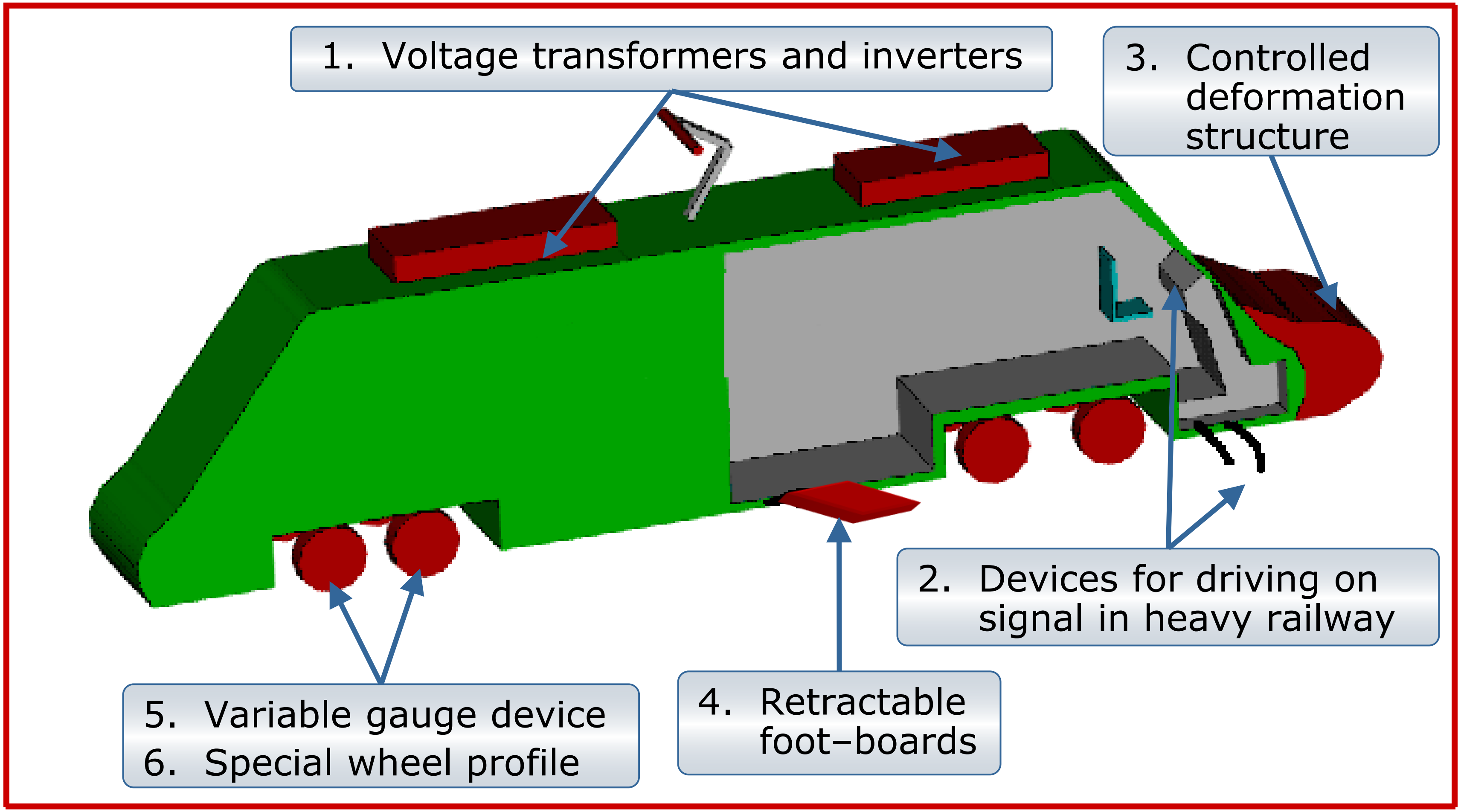
- Adapting a tramway vehicle to be able to operate on these two different existing infrastructures requires overcoming some technical barriers depending both on different safety and geometric requirements between tramway and heavy railway.

The Alstom RegioCitadis for Kassel on the railway tracks (left) and tram tracks (right)

“Tram-train”: technical barriers to be overcome

1. Different power supply between tramway (600 V d.c.) and railway (3000 V d.c.) – (e.g. in Rome)
2. Driving on sight in the urban tramway and on signal in the heavy railway
3. Different structural body resistance in buffer zones between tram–trains (max 600 kN) and railway vehicles (1500 kN)
4. Different platform width and height between tramway and conventional railway
5. Different gauge between railway (1435 mm) and tramway (1445 mm) – (e.g. in Rome)
6. Different wheel-rail interaction between tramway (grooved rails) and railway (flat–bottomed rails with a slight inclination)

Summary of the possible solutions of the main technical issues that are to be solved in order to operate tramway rolling stock both on tramway and railway



1. Different power supply between tramway and railway

***Possible solution*: vehicles should be provided with voltage transformers and inverters**

- The adoption of a dual voltage system for the tram–train vehicles is a tried and tested solution (e.g. Karlsruhe), although the additional traction equipment on the roof increases the vehicles costs and weights.
- Moreover, the voltage changeover of the power supply can be done automatically, without the intervention of the driver, during the vehicle’s passage between tramway and railway networks, by means of a zero voltage stretch of the overhead contact line and a voltage detection device on the vehicle’s roof.

2. Driving on sight in the urban tramway and on signal in the heavy railway

***Possible solution*: tram vehicles should be equipped with devices in order to drive on signal in the heavy railway**

- ATP (Automatic Train Protection System)
- a suitable on-board equipment able to collect and encode coded track–circuit currents in order to carry out cab signaling and to control train speed
- specific safety devices, that carry out the monitoring of drivers' presence and vigilance

3. Crashworthiness characteristics of vehicles

***Possible solution*: design of vehicle ends with structures that deform in a controlled manner**

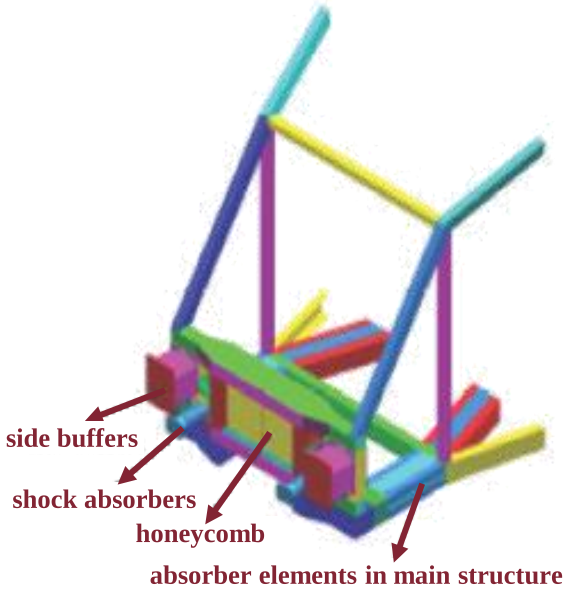
- Although a tram–train vehicle cannot meet UIC standards and EN 12663 standard for category P-II (fixed units and coaches), which state that structural body resistance of these vehicles has to be 1500 kN in buffer zones and/or at coupling hook, it should reach the maximum structural strength of German and French tram-trains vehicles (600 kN) compatible with the acceleration/braking performances required to tramway vehicles and the need for visibility for driving on sight, and higher than 400 kN required by the EN 12663 standard for category P-IV (heavy duty tramway vehicles).

3. Crashworthiness characteristics of vehicles

***Possible solution*: design of vehicle ends with structures that deform in a controlled manner**

This result could be achieved following design specifications provided by European Project Safetram, which suggests the following three impact absorption zones, developed in order to absorb the collision energy in three successive steps:

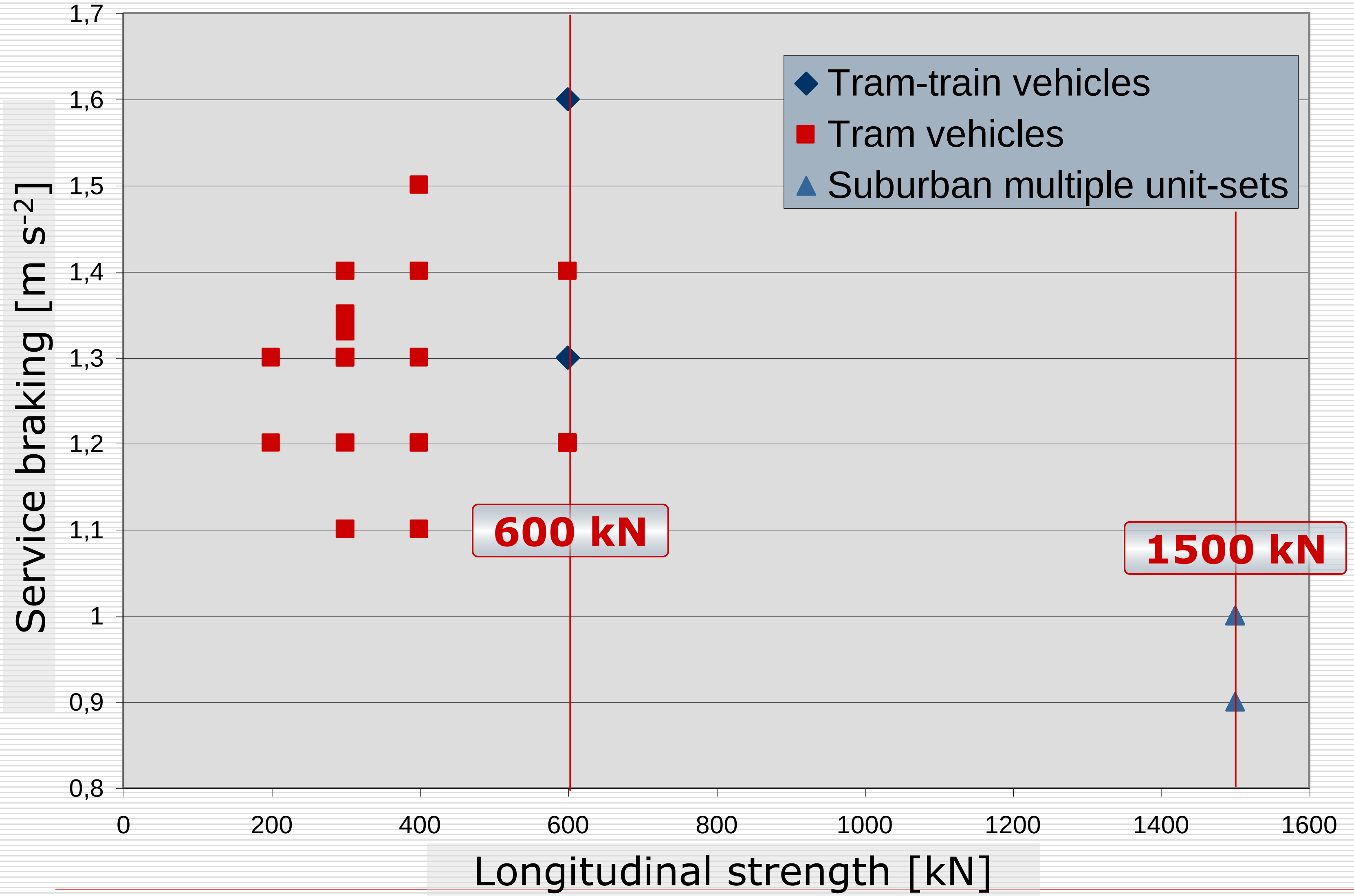
1. an elastic absorption zone made up of two shock absorbers joint by an elastic sleeper;
2. a plastic absorption zone made up of two side buffers and a honeycomb;
3. a controlled deformation zone made up of absorber elements being part of the carbody.



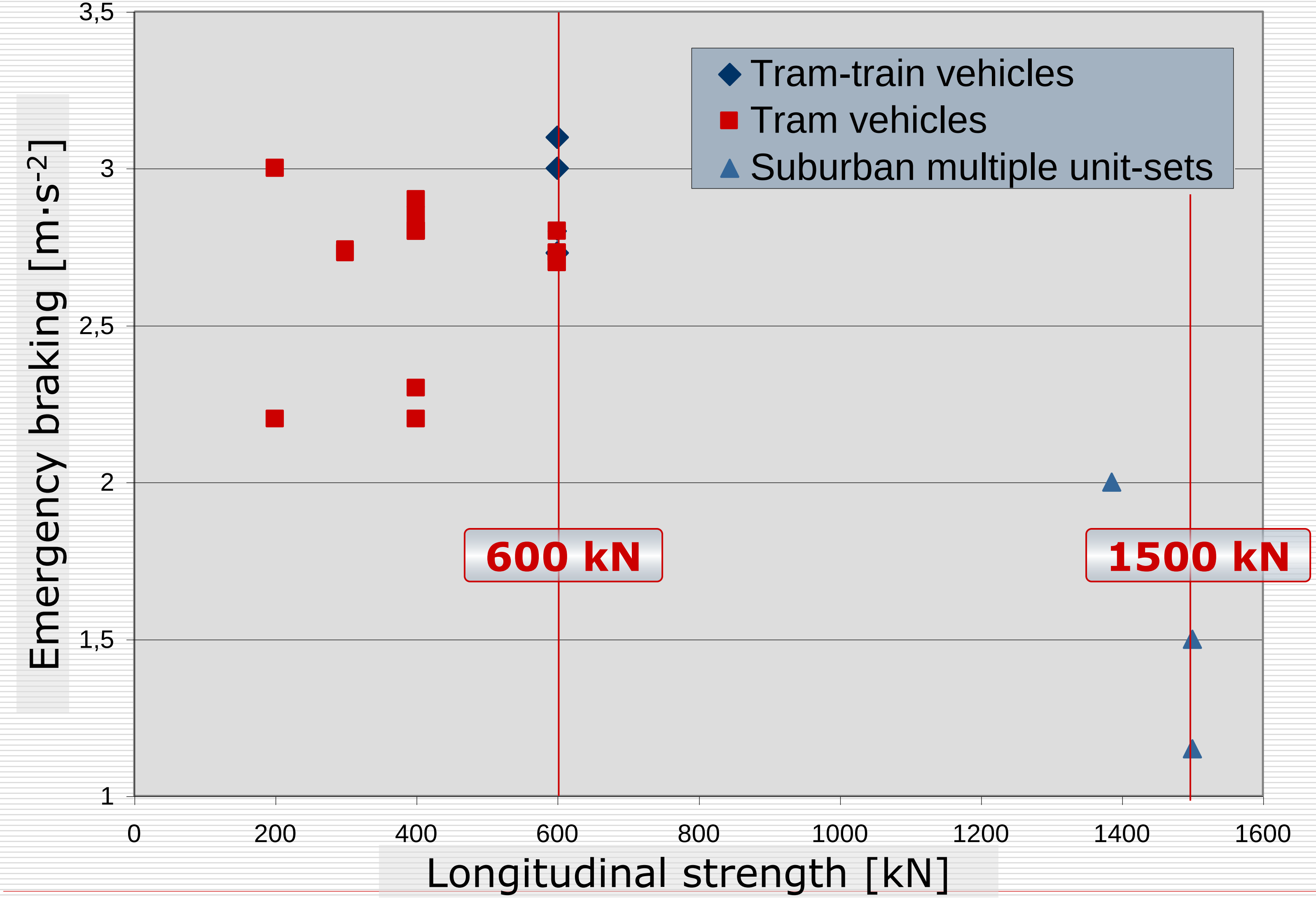
Active and passive safety (introduction)

- The *decrease of passive safety* that tram–train vehicles introduce when run in a conventional railway network, due to their low crashworthiness characteristics, is partially offset by the *increase of active safety* that light rail vehicles can provide, thanks to their excellent acceleration/braking performances.
- *Diagrams 1 and 2* show the correlation between vehicles characteristics related to passive safety (longitudinal strength) and the ones related to active safety (service and emergency braking). *Diagram 3* shows the structural characteristics of vehicles.
- In these diagrams *tram–trains* are compared with *trams* and *suburban multiple unit–sets* (the heavy rail vehicles nearest to light rail ones).

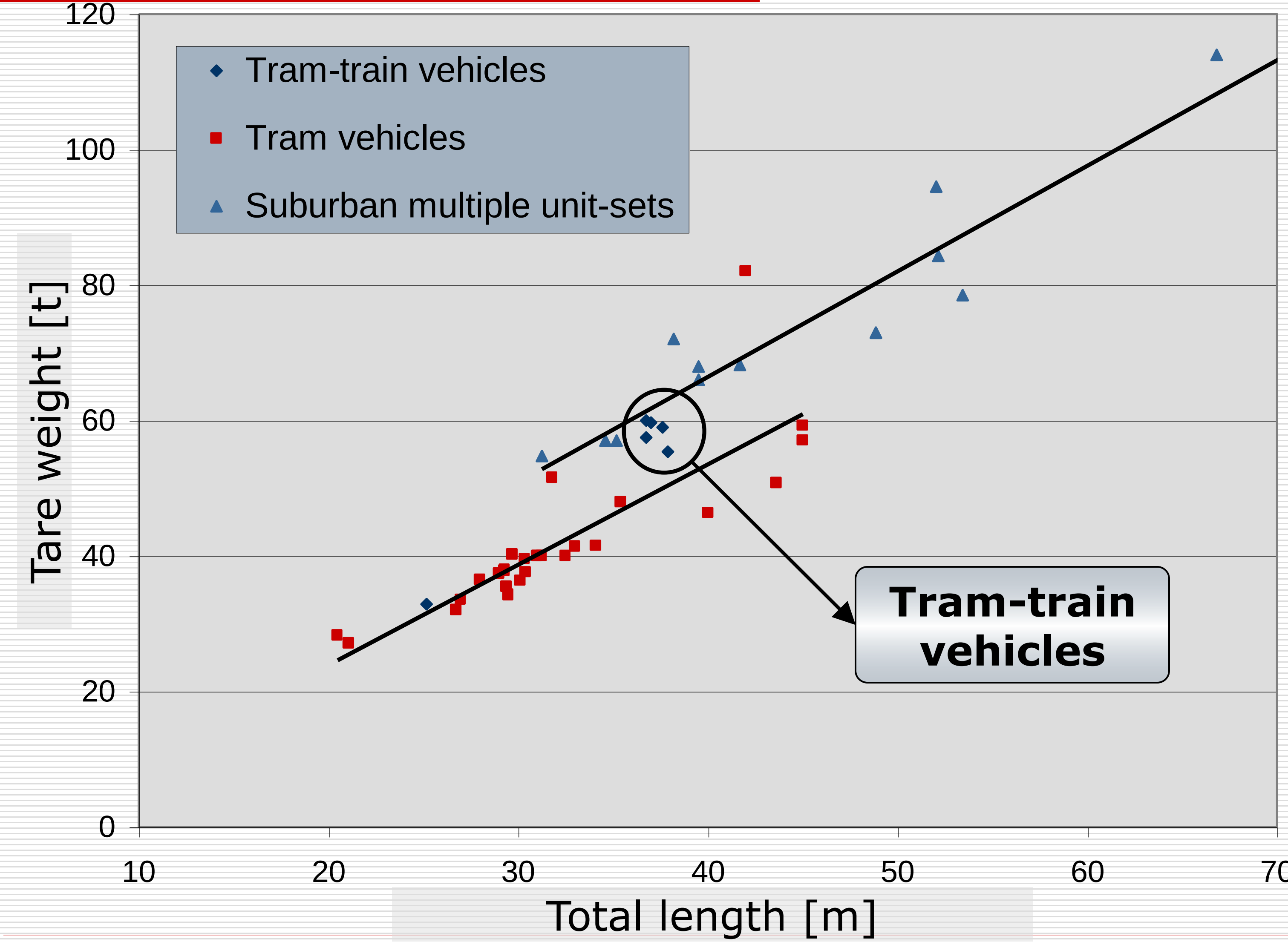
Active and passive safety (diagram 1)



Active and passive safety (diagram 2)



Active and passive safety (diagram 3)



Active and passive safety (conclusions)

- *Diagrams 1 and 2* show that tram–trains (generally developed from tram vehicles) have *active safety characteristics comparable to the best trams and considerably higher than multiple unit–sets*.

- *Diagram 3* shows that tram–train vehicles present particular structural characteristics, so that they can represent *a well defined type of vehicles*, intermediate between trams and suburban multiple unit–sets, satisfying exact technical specifications that are to be developed at European level.

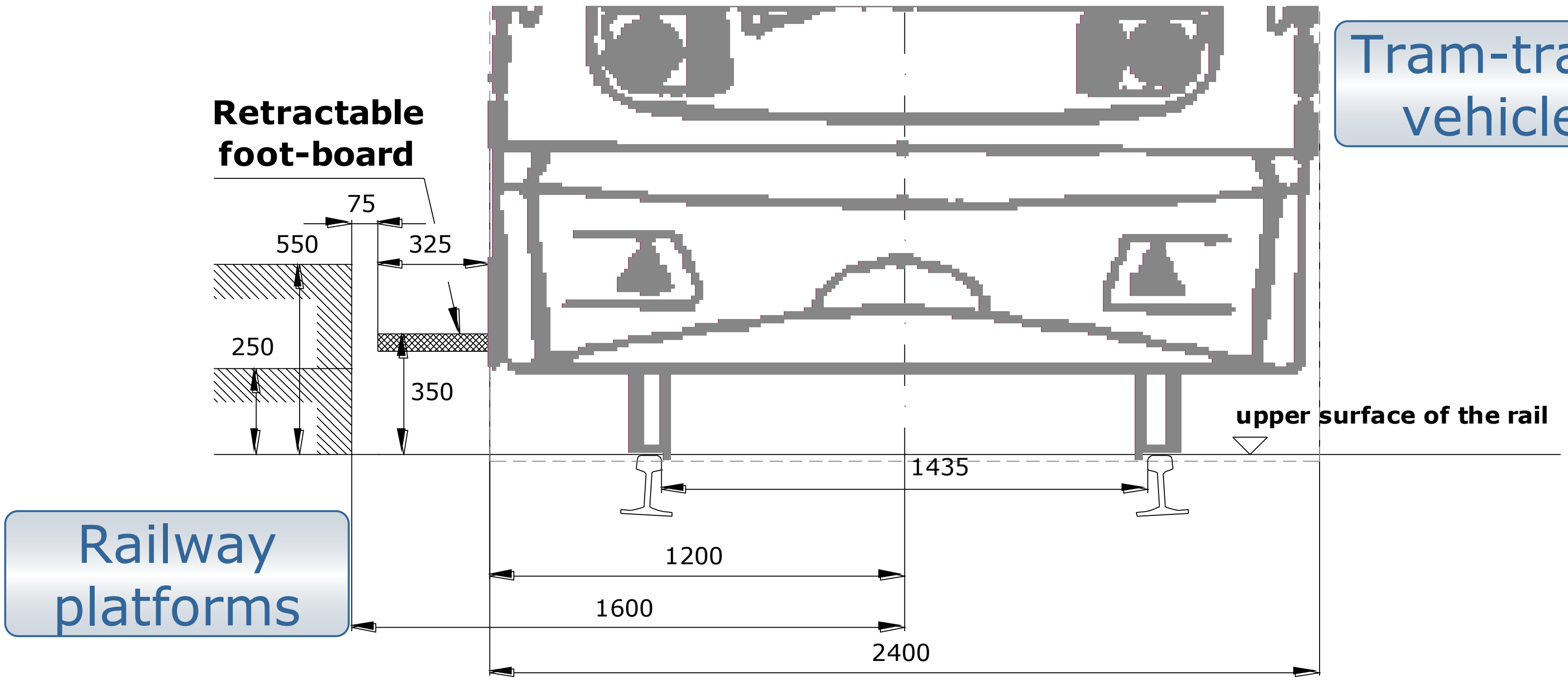
4. Different platform width and height between tramway and conventional railway

***Possible solution*: vehicles should be provided with retractable foot–boards or ramps**

- In Italy railway platforms are generally in the range of 250 mm to 600 mm high, so the maximum **vertical gap** between a modern tram floor (e.g. Cityway 2 floor is 350 mm high above the upper surface of the rail) and railway platforms can be higher than the maximum value of 250 mm stated by European standard EN 14752.
- Moreover, tram bodies are narrower than those of trains, so the **horizontal gap** between a tram vehicle and railway platforms can exceed the maximum value of 275 mm stated by EN 14752. Therefore, the above mentioned vertical and horizontal gaps could require to be fitted with **retractable foot–boards or ramps**.

4. Different platform width and height between tramway and conventional railway

***Possible solution*: vehicles should be provided with retractable foot–boards or ramps**



5. Different gauge between railway (1435 mm) and tramway (1445 mm) - (e.g. in Rome)

***Possible solution*: tram-train vehicles should be equipped with a variable wheel gauge device**

- In the city of Rome, as in the main italian cities, there is a singular difference of only **10 mm** between tramway (built at the extremely unusual gauge of 1445 mm) and railway track gauge (1435 mm).
- This difference is too small to be solved by installing a third rail alongside the existing tramway, in order to carry out dual gauge tram tracks (e.g. Zwickau), and too big to be solved by developing a special wheel profile able to fit both tramway and railway track gauge.

Rome tramway newest rolling stock: Fiat Ferroviaria Cityway "Roma 2"

In this investigation we'll always refer to Fiat Ferroviaria Cityway "Roma 2" vehicle (7 bodies model), in service in Rome from 2001.

It is a *full low floor* tram (floor is 350 mm high above the upper surface of the rail, 390 mm in corrispondence of bogies), having both *trailer and motor bogies* with *independently–rotating wheels*.

Thanks to this fact this vehicle follows the latest trend in tram designing.

Fiat Ferroviaria Cityway "Roma 2": technical data

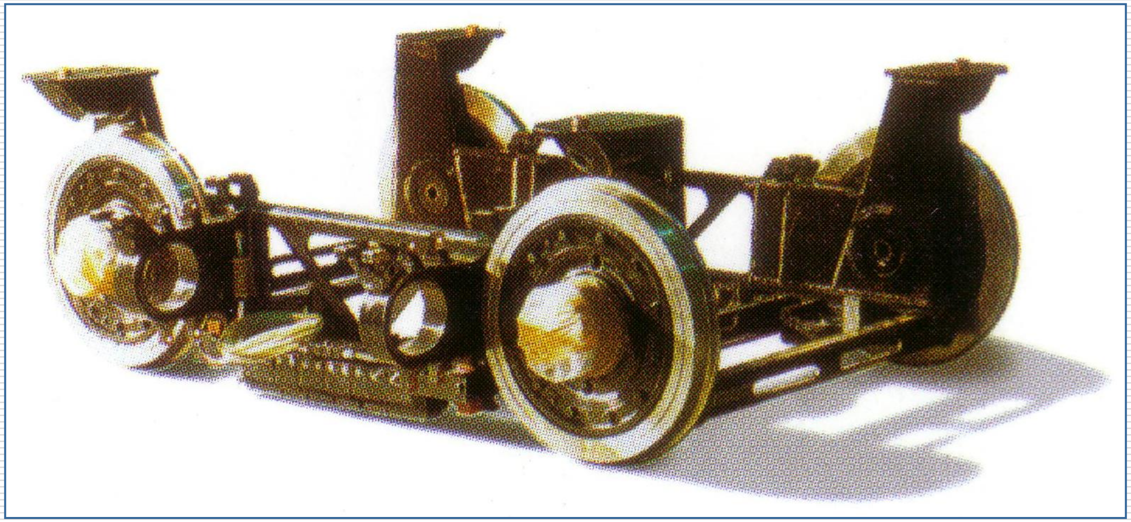
Fiat Ferroviaria Cityway "Roma 2"	
Wheels arrangement	2-Bo-Bo-2
Track Gauge [mm]	1.445
Length [mm]	33.000
Width [mm]	2.400
Height without trolley [mm]	3.500
Tare weight [t]	41,4
Seated passengers	54
Minimum floor height [mm]	350
Maximum floor height [mm]	390 (over bogies)
Power supply	600 V d.c.
Minimum curve radium in line [m]	18
Wheel diameter, new [mm]	680
Wheel diameter, max wear [mm]	630
Wheel width [mm]	84

The variable wheel gauge device: application to “Cityway Roma 2” vehicle

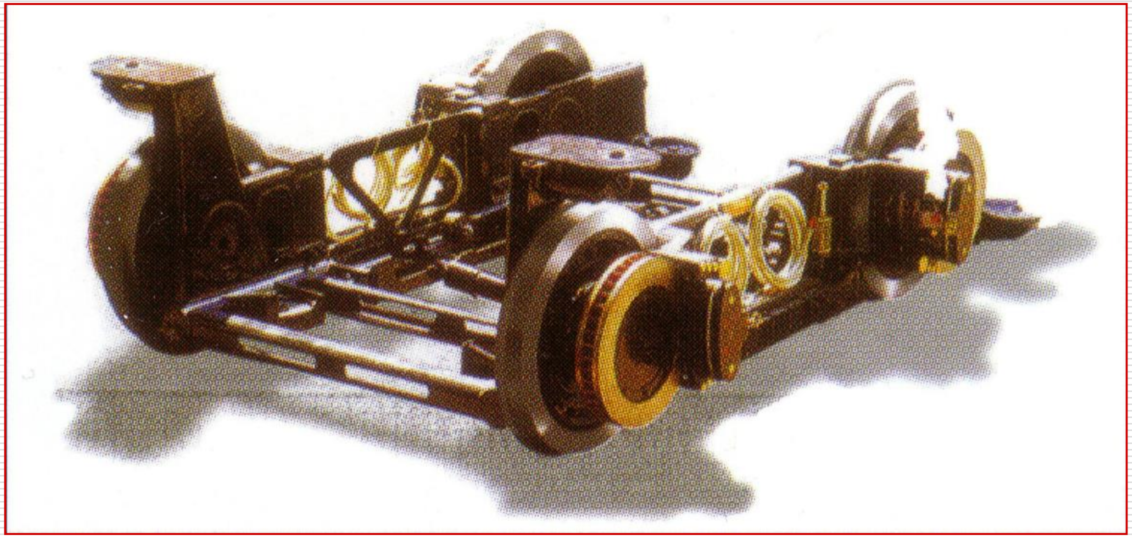
- The developed device refers to “*Cityway Roma 2”* vehicle, which has been chosen because it’s a modern full low floor tram, with *both trailer and motor bogies having independent wheels*.
- Nevertheless, this variable wheel gauge device can be fitted to *all tram vehicles of the new generation*. Moreover, this device can perform *different gauge variations* from the one present in Rome.
- In particular the developed device refers to “Cityway Roma 2” *motor bogie*, chosen because, compared to the trailer bogie, it requires more technical issues to be solved.

"Cityway Roma 2": motor and trailer bogie with independent wheels

Motor bogie (without motor set)

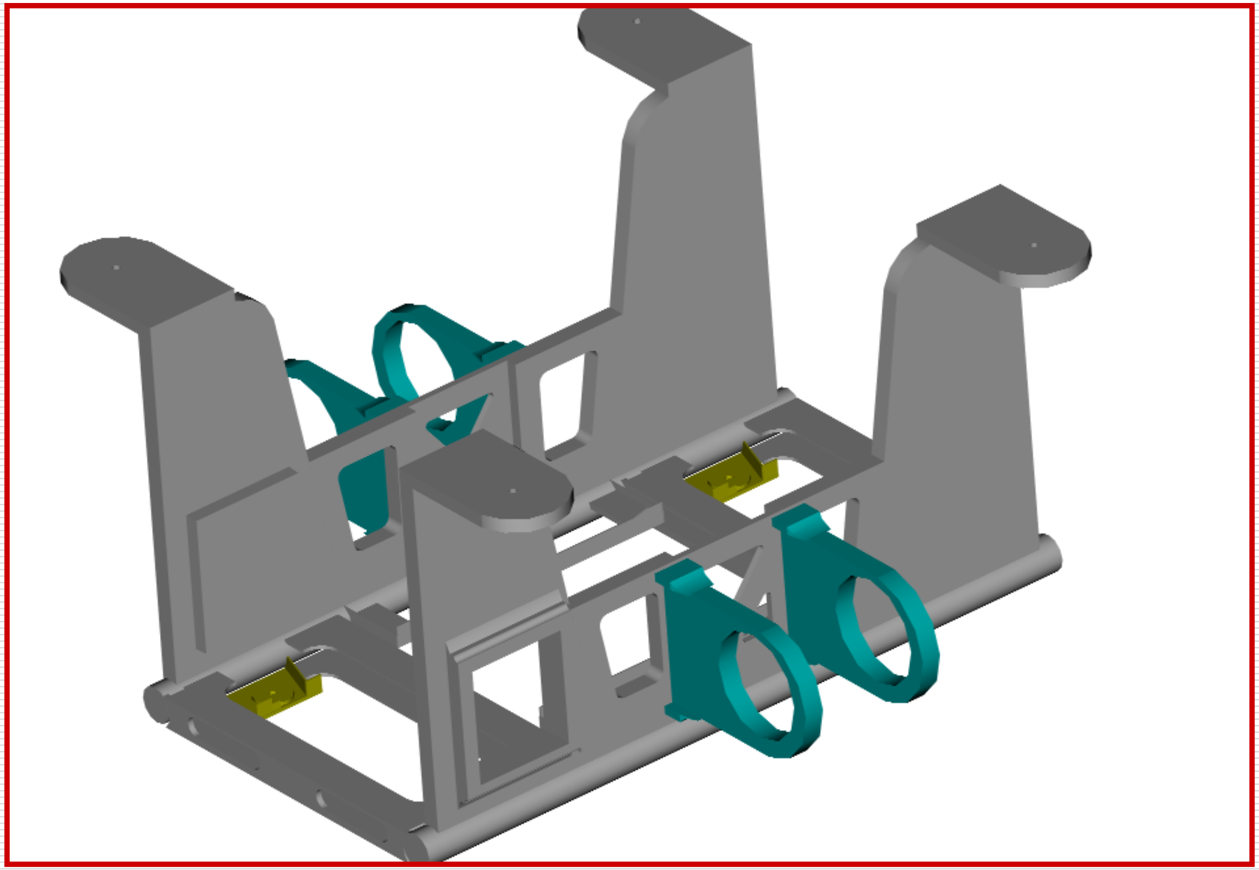


Trailer bogie



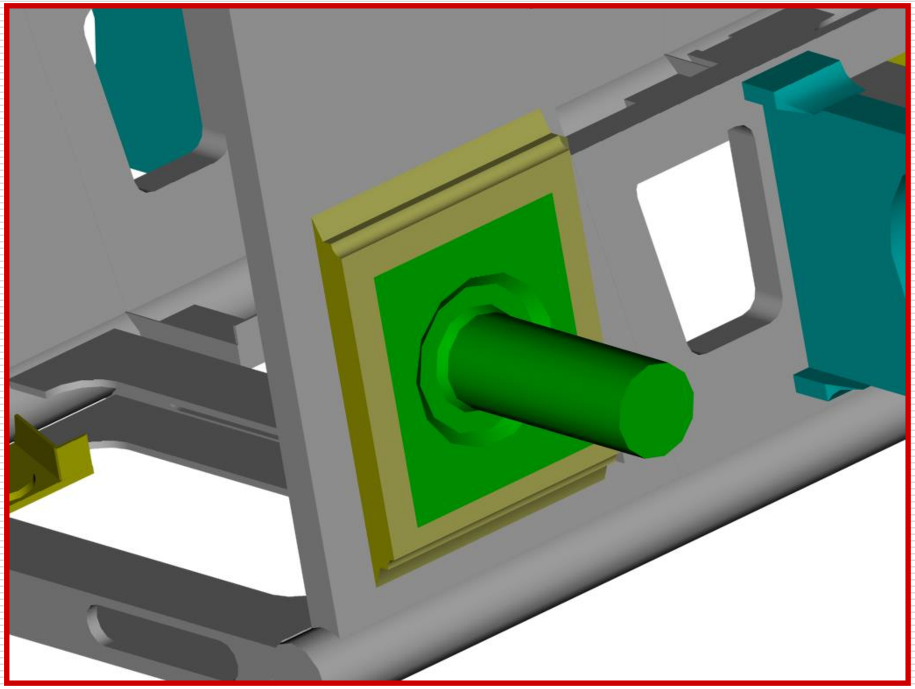
Concept of the variable wheel gauge device developed for “Cityway Roma 2” vehicle

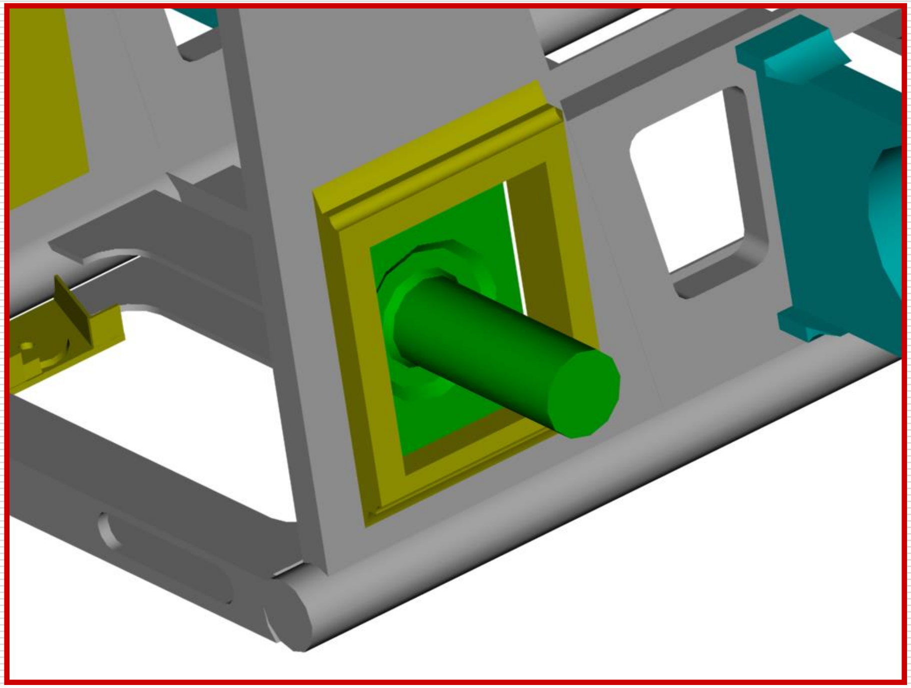
The motor bogie



Concept of the variable wheel gauge device developed for "Cityway Roma 2" vehicle

The part to be moved

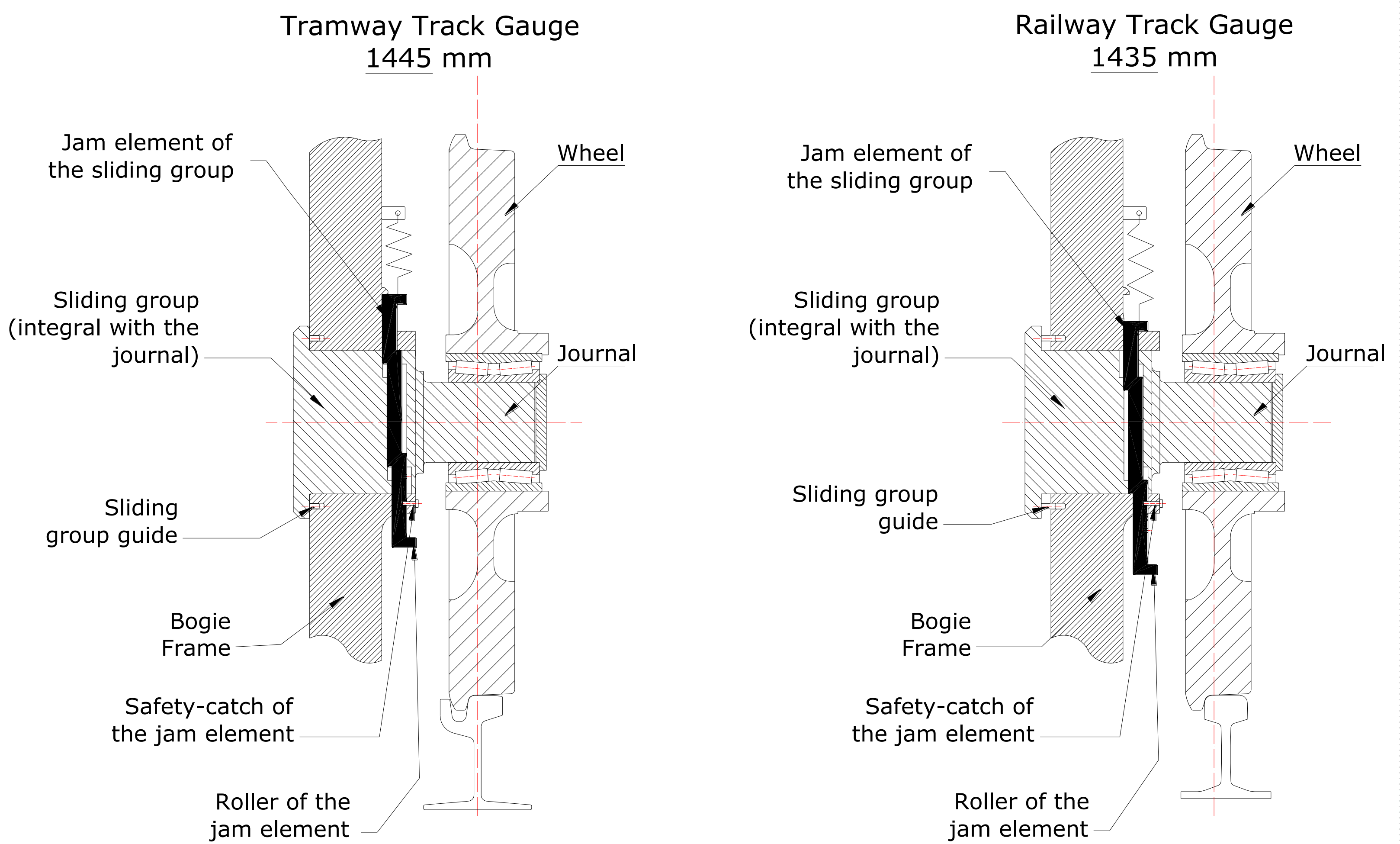




Tramway track gauge:
1445 mm

Railway track gauge:
1435 mm

Concept of the variable gauge device at tramway and railway gauge position

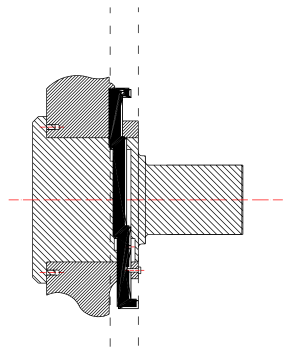


Track gauge: 1445 mm

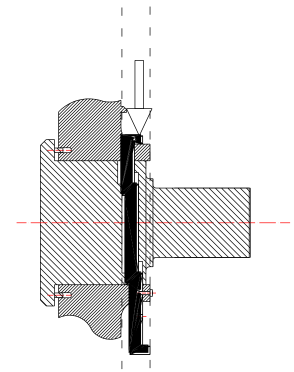
Track gauge: 1435 mm

Jam element positions during the reduction of track gauge from 1445 mm to 1435 mm

Stage 1:
Tramway Track
Gauge (1445 mm)



Stage 5+6:
jam element
pulled down for
the 2° time
+
insertion of the
safety-catch



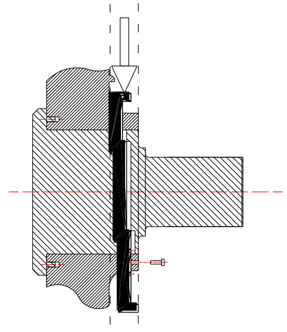
Bogie frame

Sliding group

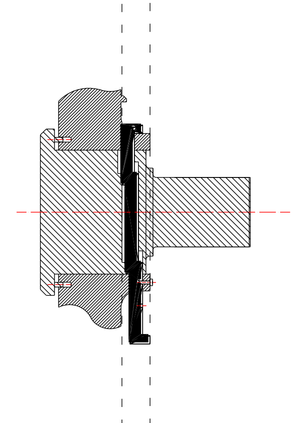
Jam element

Empty spaces

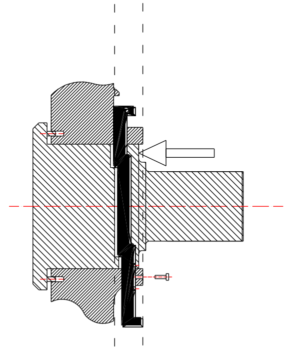
Stages 2+3:
release of the
safety-catch
+
jam element
pulled down for
the 1° time



Stage 7:
Railway Track
Gauge (1435 mm)

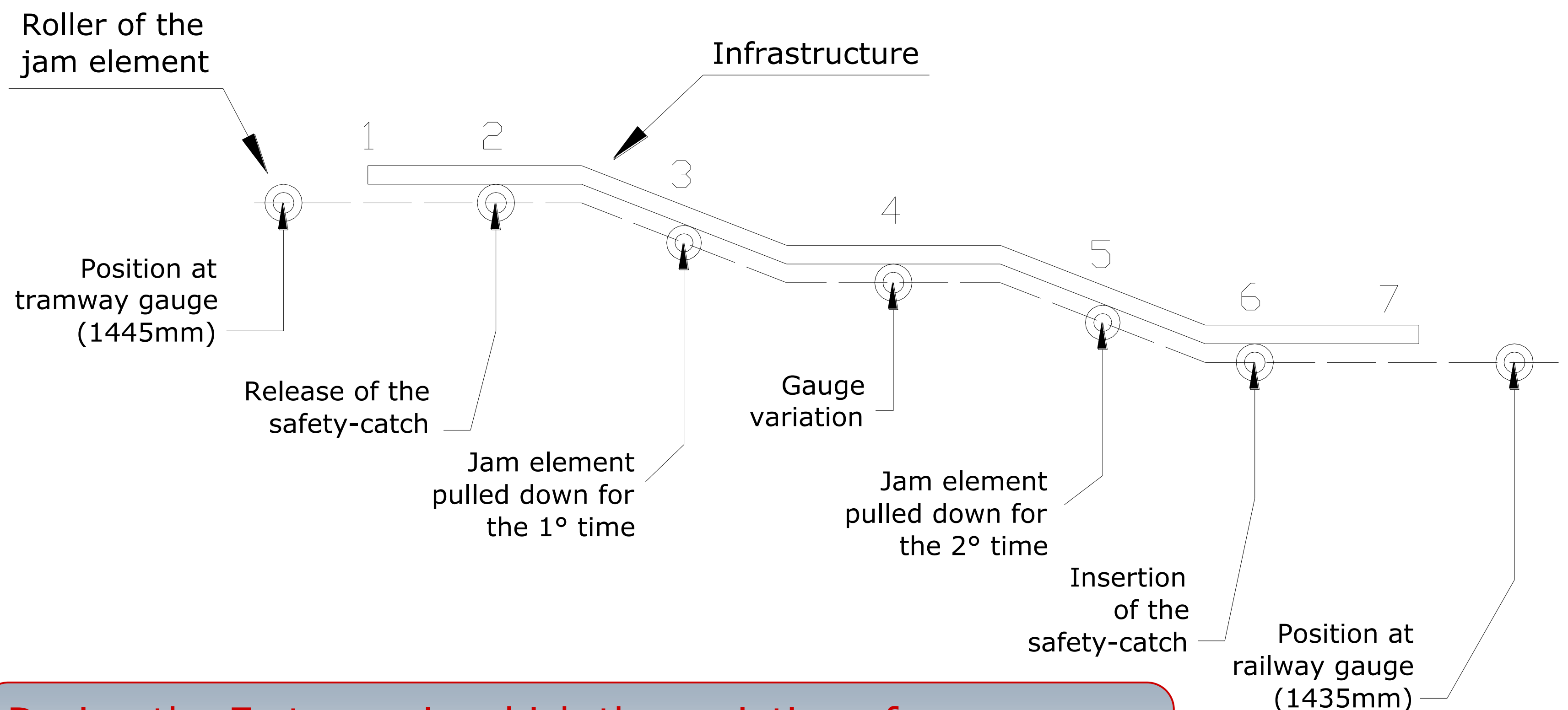


Stage 4:
sliding group
translation (gauge
variation)



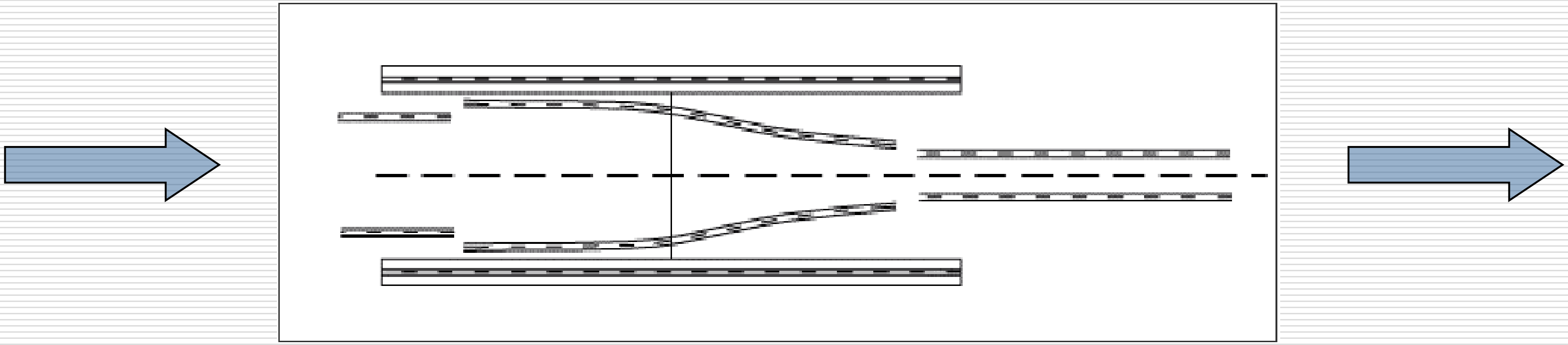
Positions of the jam element during the translation of the sliding group that carries out the variation of gauge.

Side view of the jam element fitting the variable gauge infrastructure by means of its roller element



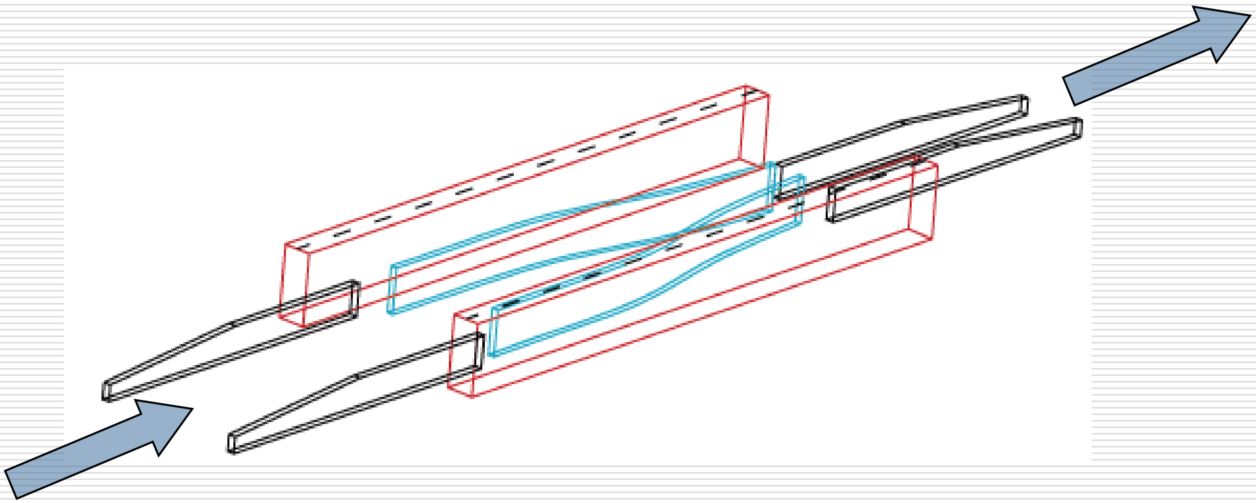
During the 7 stages, in which the variation of gauge can be divided, the infrastructure carries out the vertical translation of the jam element and, moving sideways the sliding group and the wheels, temporary unloaded from the vehicle’s weight, realizes the variation of gauge.

A possible concept of the variable gauge infrastructure

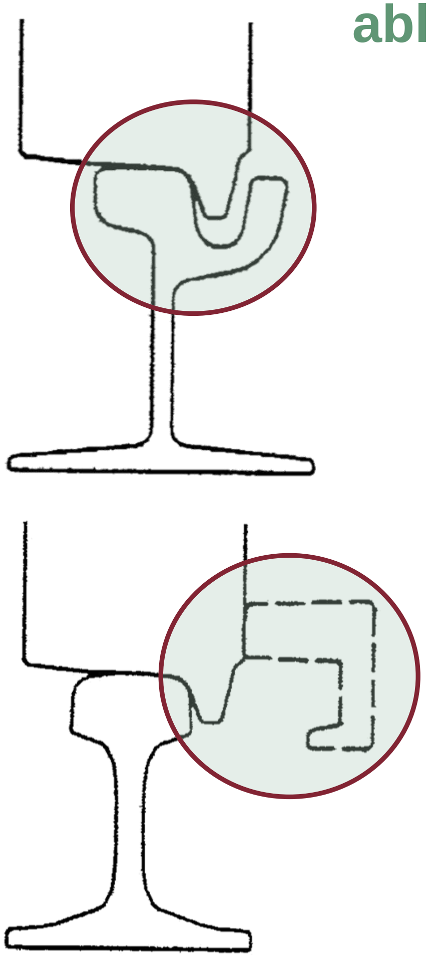


Track gauge: 1445 mm

Track gauge: 1435 mm



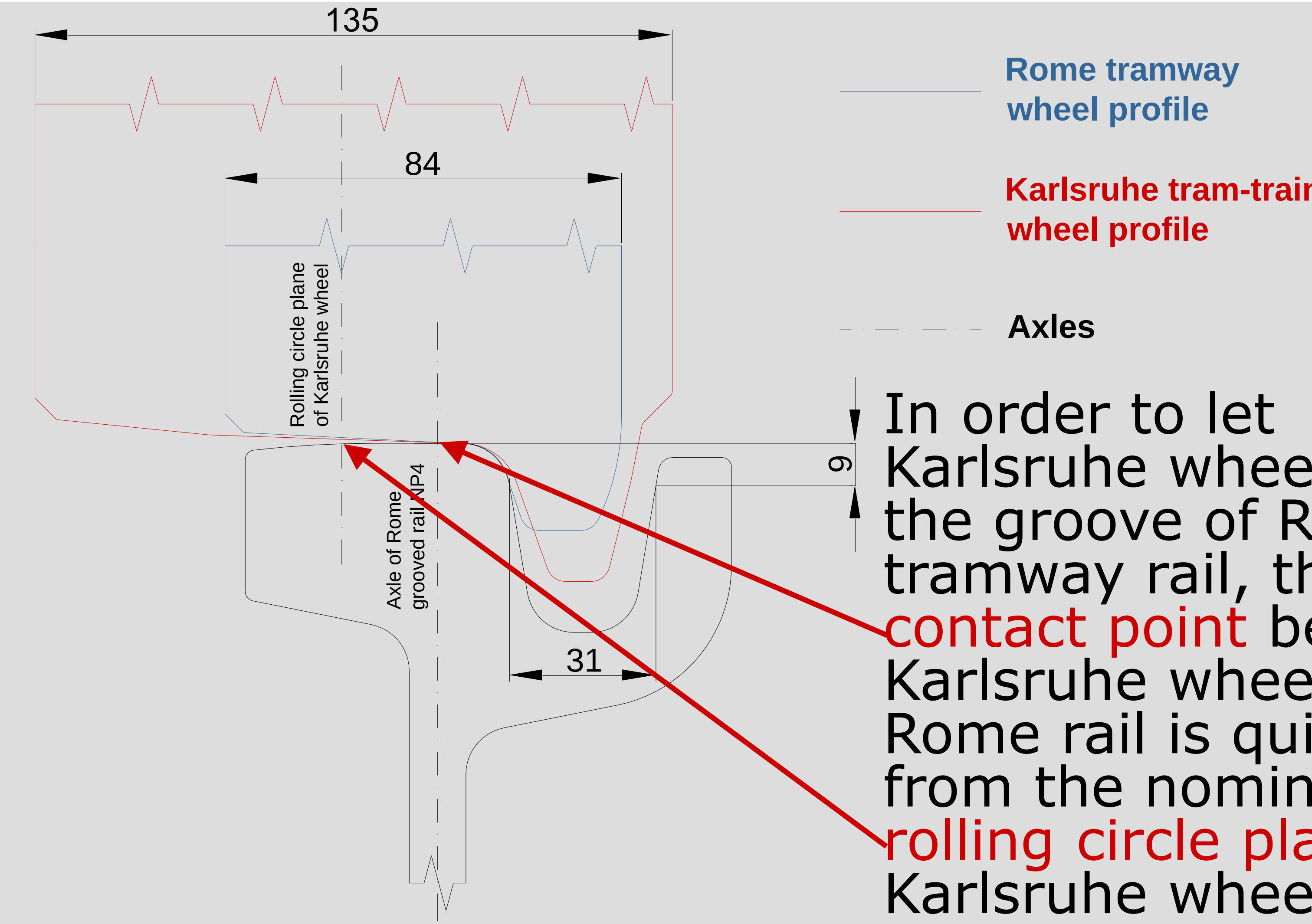
6. Different wheel-rail interaction between tramway and railway



***Possible solution*: development of a special wheel profile able to fit both grooved and flat-bottomed rails**

- Issues arising from the different rail sections used in tramway and railway tracks must be faced by introducing in tram-train vehicles special wheel profiles (hereafter tram-train wheel profiles) able to fit both grooved and flat-bottomed rails.
- For instance, in the city of Karlsruhe, a special wheel profile has been developed, having a narrow wheel flange, in order to fit grooved rails, and a wide tyre profile of 135 mm, in order to let the contact between the inside edge of the wheel, higher than street surface, and the railway check rails (that had to be raised).
- However, “tram-train” wheel profiles, due to their particular shapes coming from tram wheels could cause, in general, a different dynamic behaviour of the vehicle in comparison with the one induced by a conventional railway wheel profile.

Wheel–rail geometrical interaction between Rome grooved rail NP4 and both Rome tramway wheel and Karlsruhe tram–train wheel



In order to let Karlsruhe wheel fit the groove of Rome tramway rail, the contact point between Karlsruhe wheel and Rome rail is quite far from the nominal rolling circle plane of Karlsruhe wheel.

Aim and tool of the study

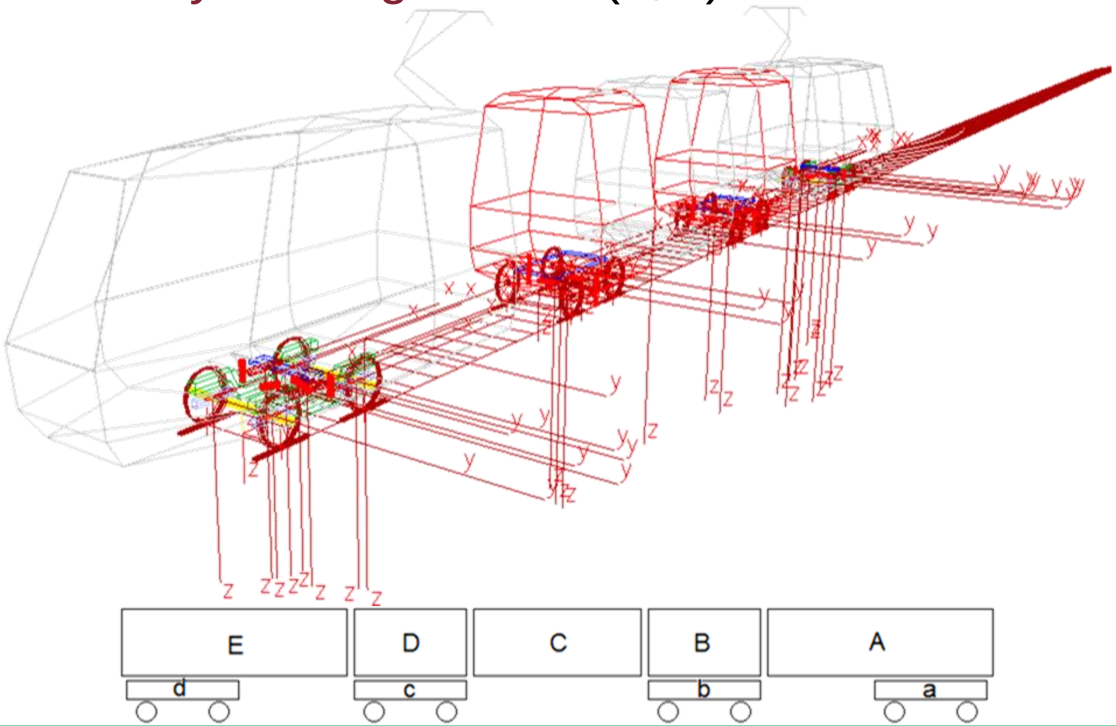
- Aim: the analysis of a special wheel profile (tram-train wheel profile) able to fit both grooved and flat-bottomed rails in order to evaluate:
  - its geometrical interaction with rail sections used in conventional railway tracks;
  - its influence on the dynamic behaviour of a tram-train vehicle moving on railway track

  in comparison with a conventional railway wheel profile.
- Tool: modelling of a Light Rail Vehicle, provided with the two types of wheel profiles, and simulation of its dynamic behaviour on railway tracks by applying the multi-body system software SIMPACK®. The vehicle model is not intended to represent an actual vehicle, although it is based partly on existing vehicles.

The vehicle model: architecture

- In order to investigate wheel-rail interaction the benchmark vehicle has been carefully chosen to represent a typical light rail vehicle with characteristic similar to the modern “tram-train” vehicles. In particular the vehicle modelled with SIMPACK® adopts a mixed solution:
  - traditional motor bogies having a pair of solid–axle wheel–sets (a, d);
  - trailer bogies having independently rotating wheels (b, c).

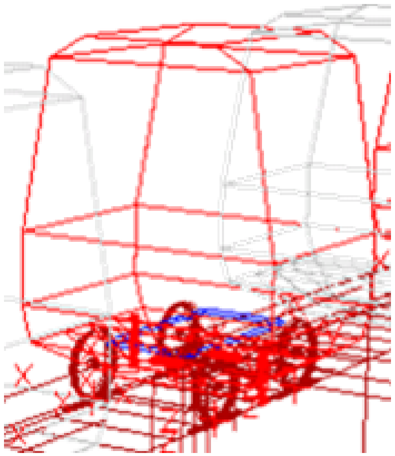
- The whole vehicle is made by five articulated body sections (two head bodies A and E, one intermediate body C and two linking platforms joined to the two trailer bogies B and D) and four bogies (two outer motor bogies and two inner trailer bogies).



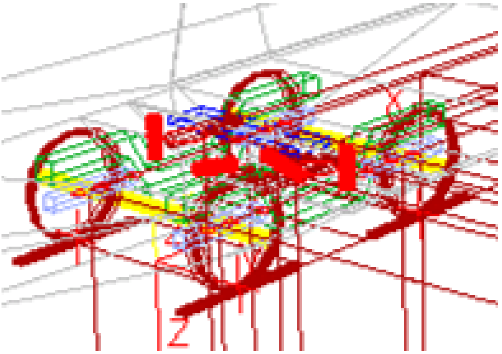
The vehicle model: main characteristics

Main characteristics of the vehicle	
Wheels arrangement	Bo-2-2-Bo
Track gauge	1.435 mm
Total length	31.250 mm
Width	2.400 mm
Height without trolley	3.560 mm
Tare weight	40 t
Height of low floor area	350 mm (75%)
Height of high floor area	880 mm
Boogie wheelbase	1.750 mm
Wheel diameter, new	740 mm

Detail of the linking platform and trailer bogie

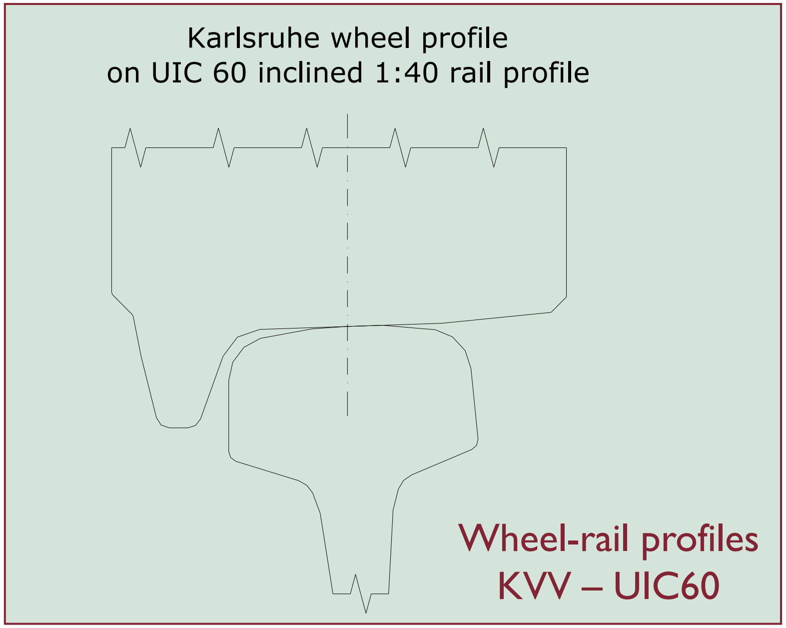


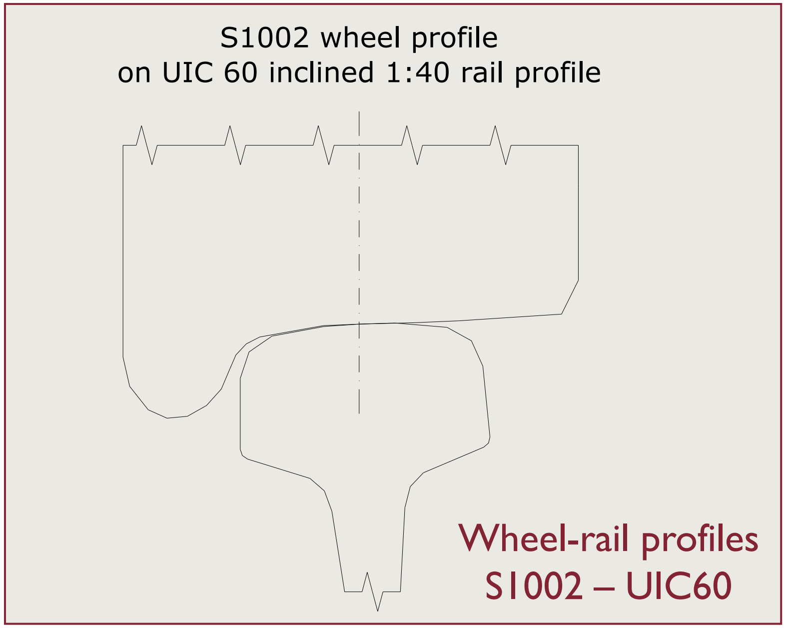
Detail of the motor bogie



Wheel-rail contact model: profiles

- The tram-train wheel profile chosen has been similar to the one used for Karlsruhe tram-train vehicles (GT8–100C/2S GT8–100D/2S–M series), afterwards called KVV profile.
- It has been compared to the nominal ORE S1002 wheel profile, widely adopted by European railway administrations, on UIC 60 rail profile with inclination of 1/40.





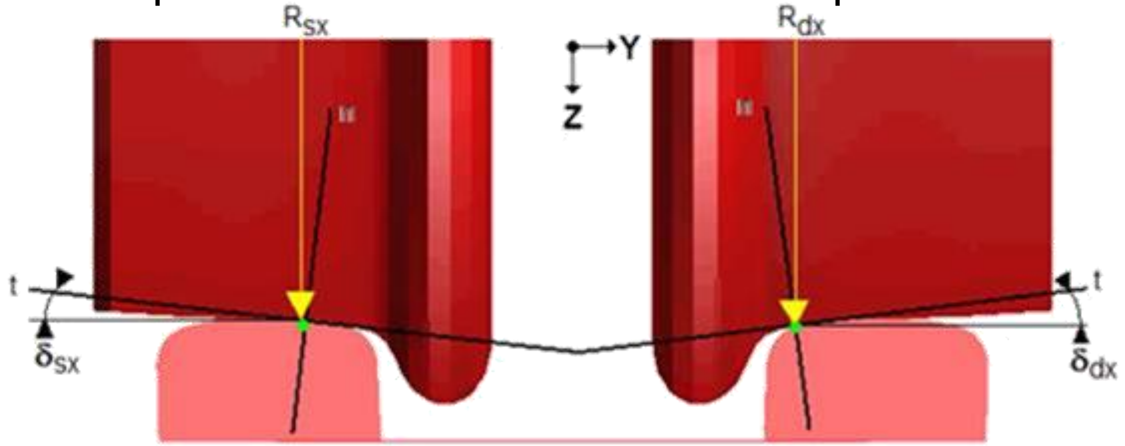
Wheel-rail contact model: main geometrical differences between wheel profiles

Characteristics \ Wheel profile	KVV	S1002
Wheel profile width [mm]	135	135÷140
Distance between inside faces of wheel profiles in correspondence of upper rail surface [mm]	1374 (*)	1360
Distance between inside faces of wheel profiles at 10 mm under the nominal rolling circle [mm]	1378	1360
Distance between outside faces of wheel flanges [mm]	1426	1425
Wheel flange height [mm]	28	30

(*) The standard European value of 1360 mm is assumed in KVV profile at 9,5 mm above the nominal rolling circle

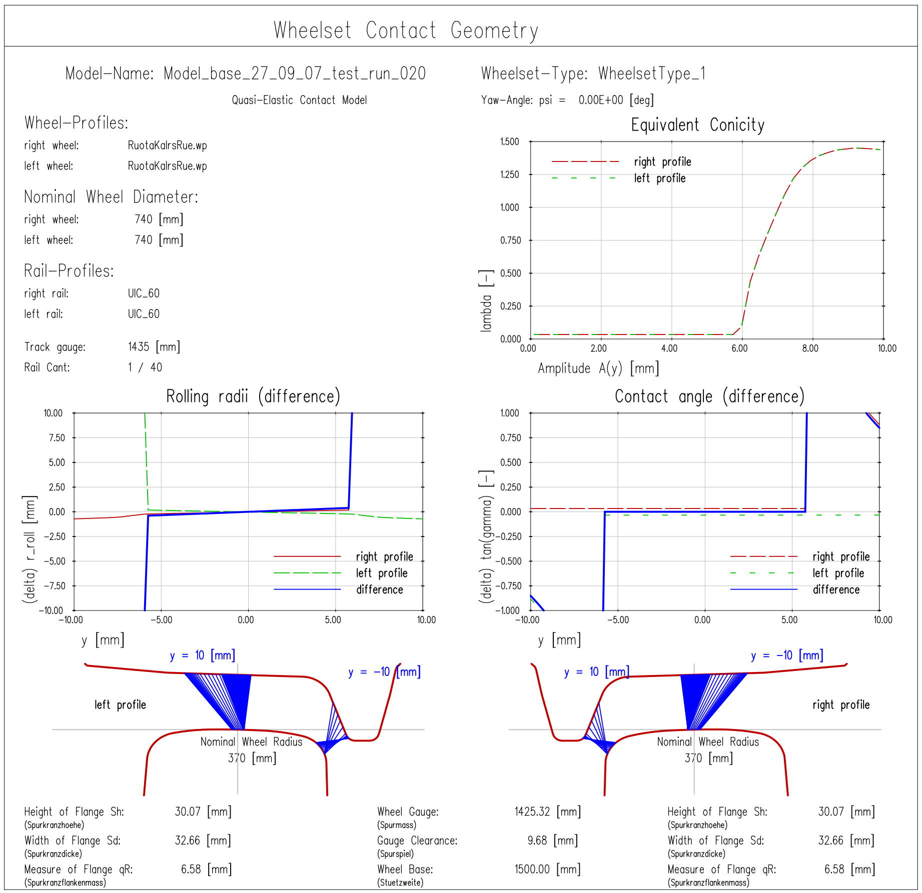
Wheel-rail contact model: parameters for geometrical analysis

- The geometrical analysis of wheel-rail interaction, carried out in simulation environment, has been considered the following characteristics of interaction between the two wheel profiles (KVV and S1002) and the UIC 60 rail profile with an inclination of 1/40:
  - wheels rolling radii (difference R_{sx}-R_{dx} between right and left wheel) as a function of the relative lateral position y of the wheelset with respect to the track;
  - wheels contact angles (difference δ_{sx}-δ_{dx} between right and left wheel) as a function of the relative lateral position of the wheelset with respect to the track;
  - equivalent conicity $\gamma = [R_{sx}-R_{dx}]/2y$
  - the distribution of contact points

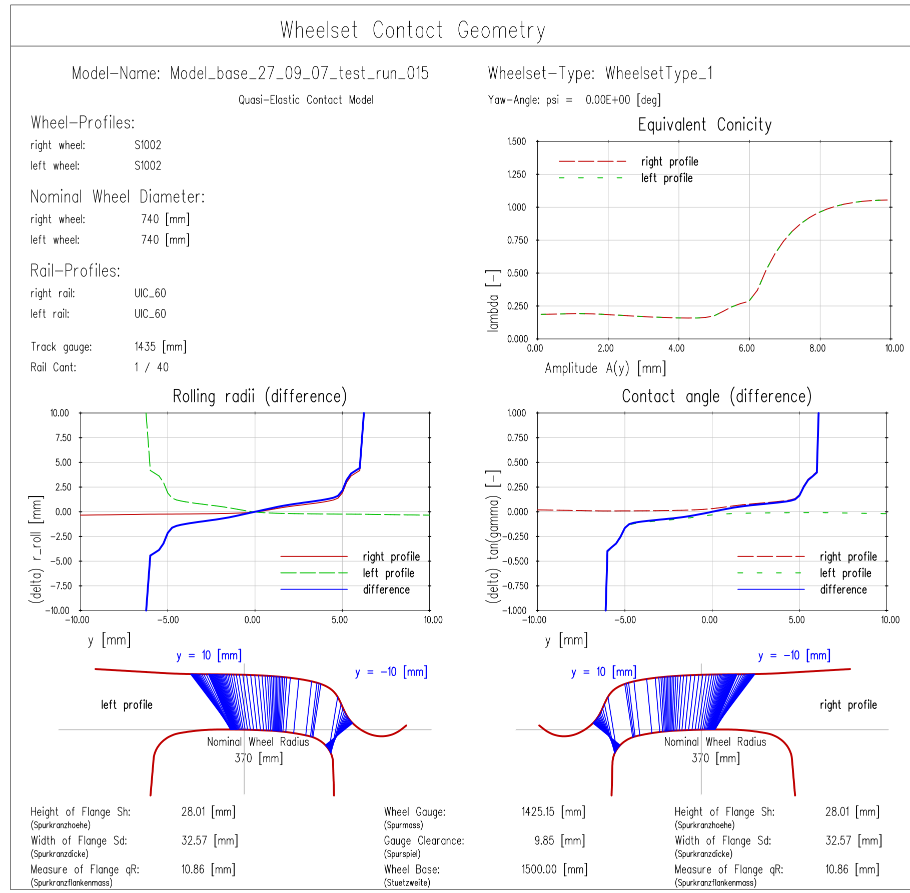


Wheel-rail contact model: geometrical analysis

Wheel rail interaction: KVV – UIC60



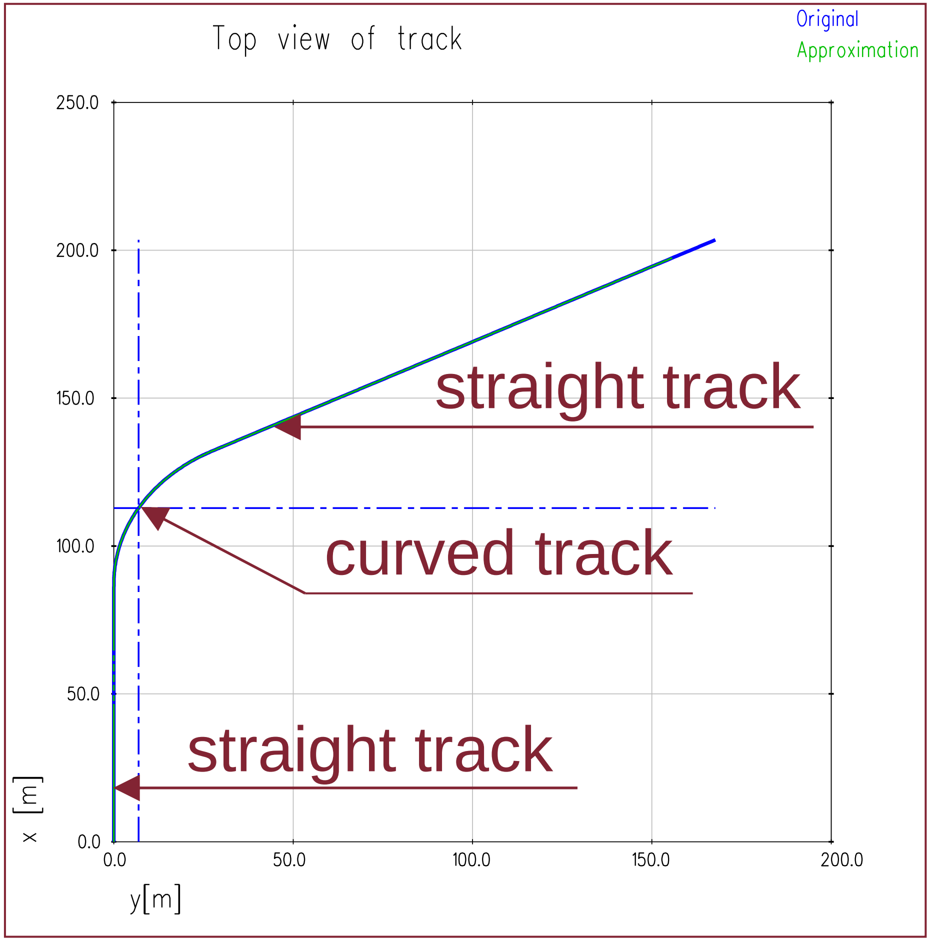
Wheel rail interaction: S1002 – UIC60



Wheel-rail contact model: results of geometrical analysis

- For KVV wheel profile (like for a conic profile) diagrams of rolling radii and contact angles differences in function of wheelset lateral displacement are linear.
- For S1002 "distributed wear" profile, which is a variable conicity profile, the variation of the parameters in function of wheelset lateral displacement is not linear.
- At last, regarding the distribution of contact points, graphics for KVV wheel profile show two zones with high contact points density: the first zone around the nominal rolling circle (lateral displacement of wheelset between ±1 mm) and the second in the contact zone between rail and wheel flange (lateral displacement between ±5 and ±6 mm). Contrary to what happens for S1002, these high concentrations of contact points for KVV profile can cause severe localized wear on the rolling circle and on the inside face of wheel flange.

Dynamic analysis: the railway track model



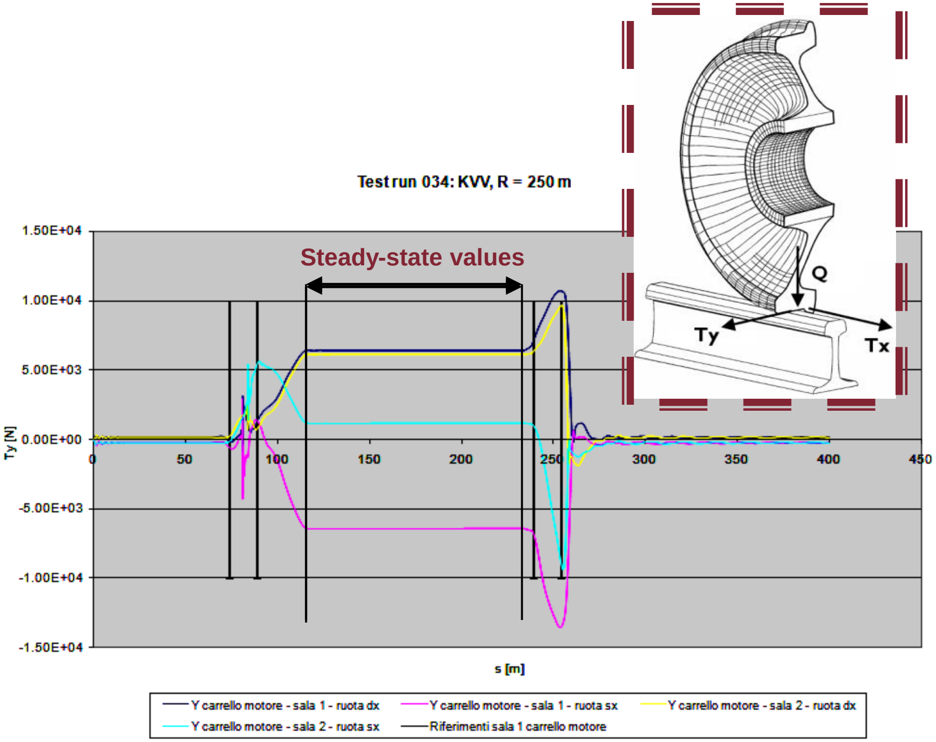
The main characteristics of the track chosen for run dynamic tests are the following:

- curve radius at the end of initial transition length
  R = 20, 50, 100, 150, 200, 250, 400, 600, 800, 1000 m;
- cant deficiency
  s = 0,16 m;
- friction coefficient
  μ = 0,15.

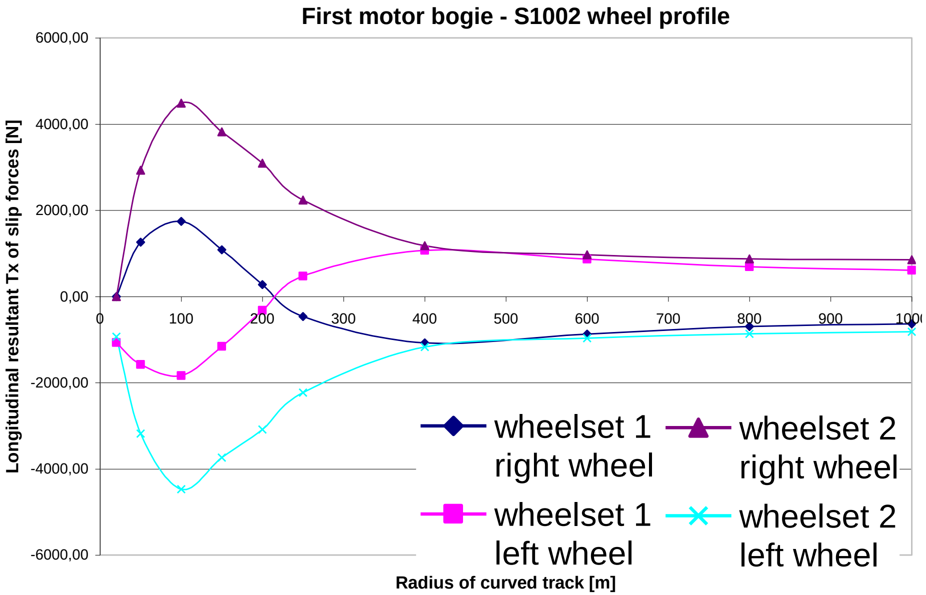
Dynamic analysis: analysed parameters

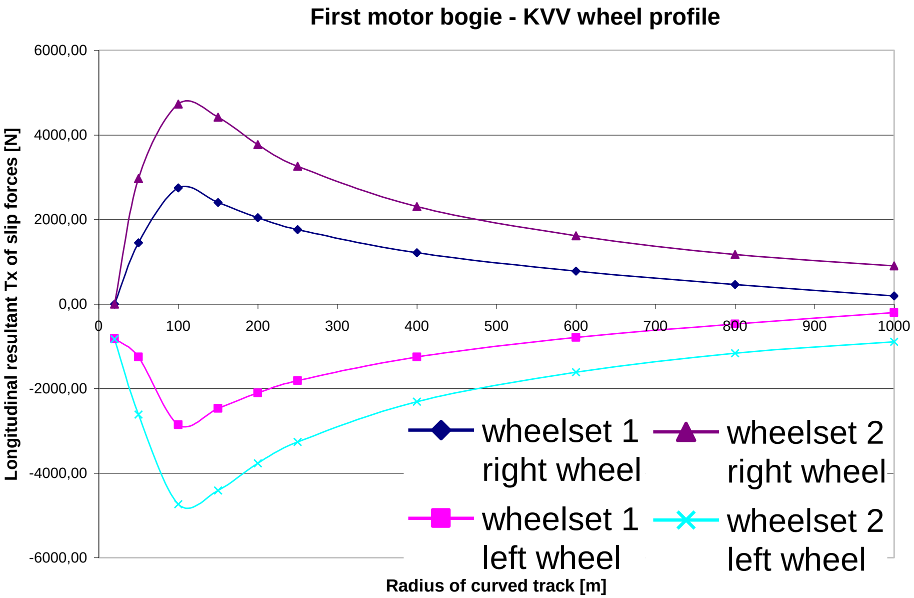
- Dynamic analysis has been carried out only for the steady-state behaviour while the vehicle's curving (v = 10 m/s): in each run, have been selected only the maximum values in full curve for the analysed parameters, which are:
  - longitudinal resultant Tx of slip forces (between wheel and rail);
  - transversal resultant Ty of slip forces (between wheel and rail);
  - lateral displacements of wheelsets;

  both for motor and trailer bogie.



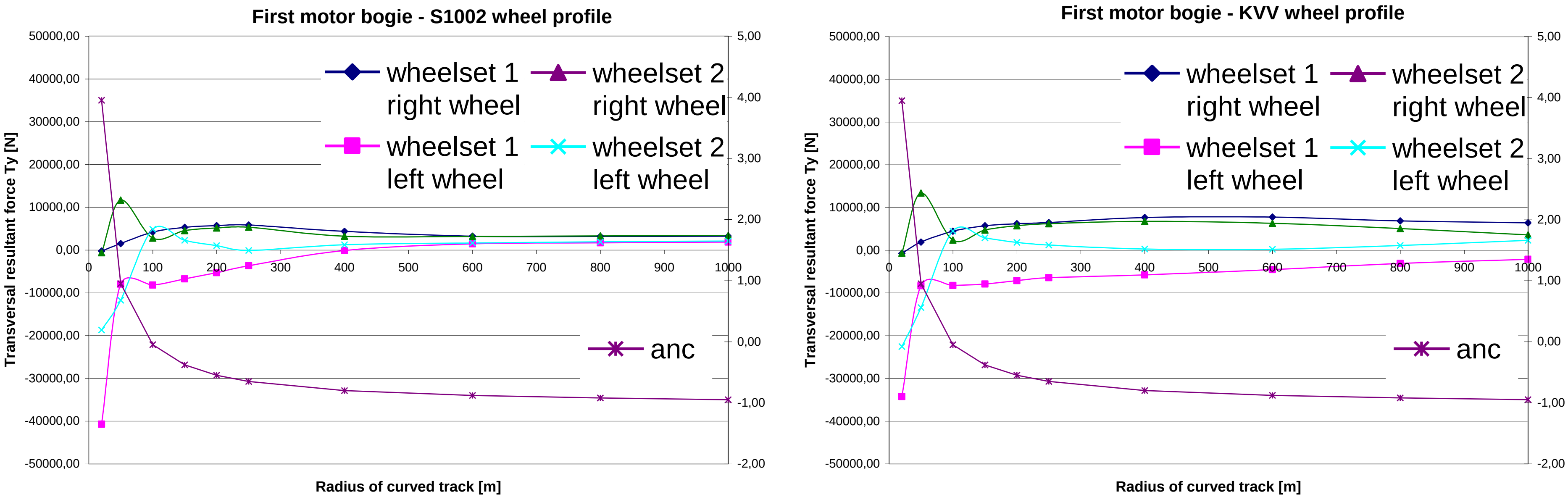
Dynamic analysis: longitudinal resultant Tx of slip forces





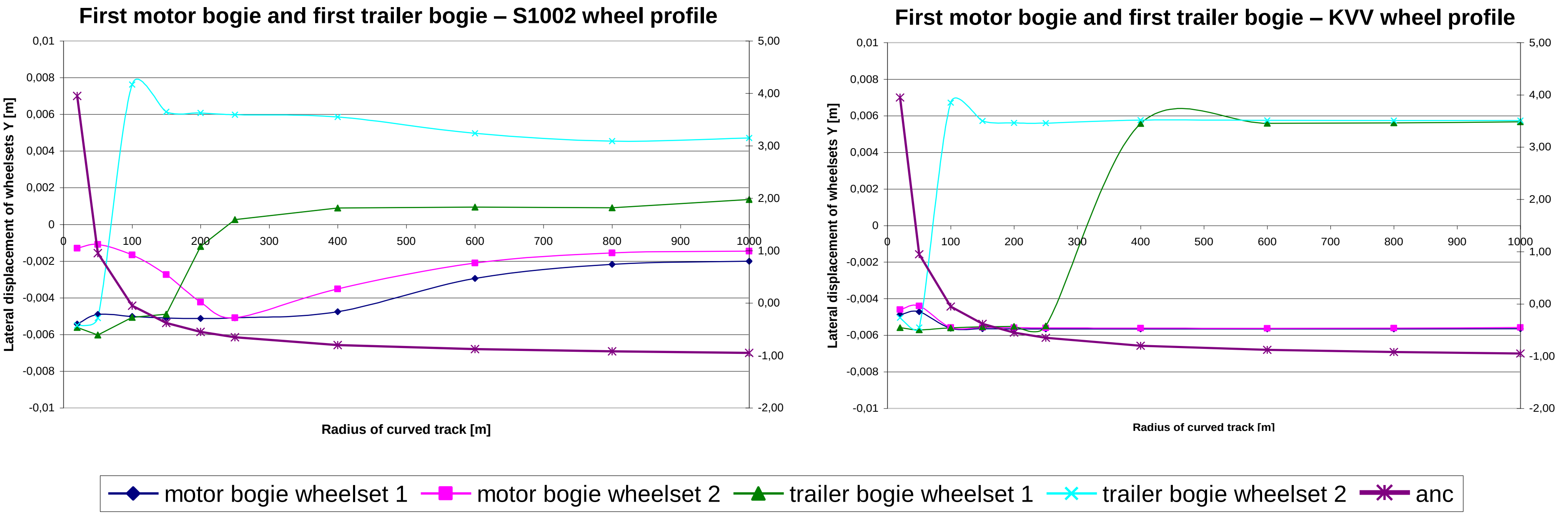
- The use of KVV profile on traditional motor bogie eliminates the presence of a turning curve radius for the value of longitudinal resultant Tx, acting on the guiding wheelset; this effect can be seen in case of S1002 profile (Tx value turning curve radius: 220 m).
- At last for trailer bogie, with independently rotating wheels, both in case of KVV profile and S1002 profile the analysis highlights the almost absence of the longitudinal resultants for the slip forces, confirming that the born of longitudinal guiding forces is a phenomenon belonging only to standard wheelsets, whatever the wheel profile is.

Dynamic analysis: transversal resultant Ty of slip forces



- Diagrams show that, both for the traditional motor bogie and for the trailer bogie with independently rotating wheels, the transversal forces reach higher values with the adoption of KVV profile with respect to S1002 profile, whereas the trend of transversal forces with the curved track radius is almost the same for the two wheel profiles, except for the force acting on the left wheel of the second wheelset which has opposite signs in the two cases (diagrams related to trailer bogie are not reported because very similar).
- In these diagrams also the variation of non compensated curving acceleration as a function of curve radius is reported.

Dynamic analysis: lateral displacement of wheelsets



- Diagrams show that at the increase of curve radius with the S1002 the motor bogie centres itself on the track, whereas with KVV profile this phenomenon doesn't occur and the bogie places itself on the outside of the curve. Trailer bogie places itself always on the inner of the curve more markedly adopting KVV profile.

Conclusions: summary

- The last part of this presentation has summarised the results of a study on the possible influence of a special “tram-train” wheel profile on the dynamic behaviour of a typical Light Rail Vehicle running on conventional railway tracks.
- The study has been carried out by modelling, in a multi-body simulation environment, a Light Rail Vehicle, provided with the tram-train wheel profile KVV, and comparing its dynamic behaviour on railway tracks with the dynamic behaviour of the same LRV provided with a heavy railway standard wheel profile ORE S1002.

Conclusions: geometrical wheel-rail interaction

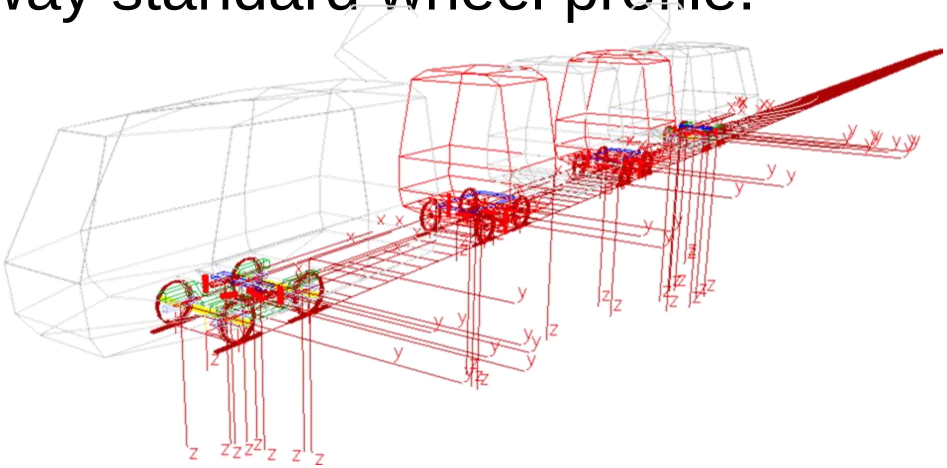
- About geometrical wheel–rail interaction, contrary to what happens for S1002, tram-train wheel profile KVV presents high concentrations of contact points, which can cause severe localized wear in correspondence of the rolling circle and of the inside face of wheel flange.
- Therefore providing independently rotating wheels with KVV, which is a profile with a very low difference between rolling radii near the nominal rolling circle, it is no possible to obtain any force towards the centre of the track due to the gravitational stiffness and hence it is no possible to realize the self-centring action on straight track.
- This fact implies that independently rotating wheels provided with KVV profile cause an increase of rail wear compared to traditional wheelsets.

Conclusions: dynamic analysis

- About dynamic analysis the study of a Light Rail Vehicle curving on conventional railway track has highlighted that the use of a tram-train wheel profile changes the dynamic behaviour of both bogies with traditional wheelsets and with independently rotating wheels in comparison with the same bogies provided with the standard wheel profile ORE S1002.

Further developments

- At last, a possible development of the research is the analysis of the influence of “tram-train” wheel profiles on the dynamic behaviour of Light Rail Vehicle running on singular points of the track, like conventional railway turnouts, in correspondence of which “tram-train” wheel profiles, due to their narrow flange, could cause remarkable differences compared to a conventional railway standard wheel profile.



Thanks for your attention

Luca Rizzetto

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IV.9 UNIROMA1 - Post-Master course in “Railway Infrastructure and Systems Engineering”

Master universitario di II livello in

Ingegneria delle Infrastrutture e dei Sistemi Ferroviari

Innovazione per la mobilità integrata

A.A. 2023/2024

Fondamenti di tecnica ed economia ferroviaria

Matteo Primizia (RFI - Gruppo Ferrovie dello Stato Italiane)

Luca Rizzetto (Sapienza Università di Roma)

Corso promosso da

Incontro inaugurale del 26 febbraio 2024

Obiettivi

Fornire ai discenti

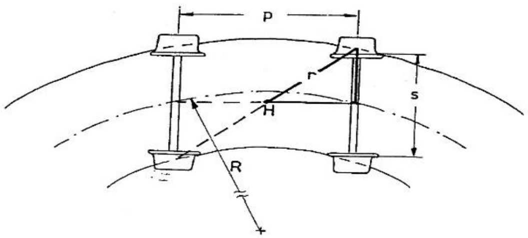
- gli elementi di base propedeutici ad affrontare in modo efficace lo studio delle infrastrutture e dei sistemi ferroviari

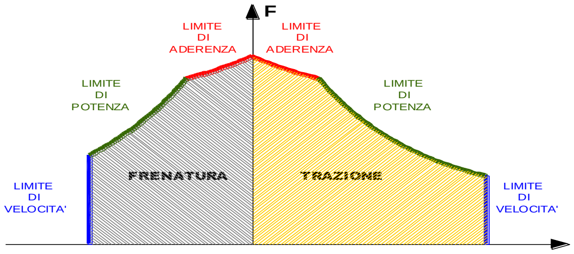
- le peculiarità tecniche ed economiche e le dinamiche di funzionamento (interazione fra componenti) del trasporto ferroviario

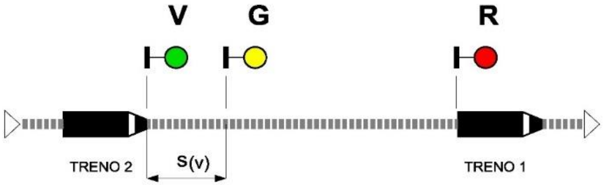
Argomenti delle lezioni ed esercitazioni

Tecnica Ferroviaria (a cura di Luca Rizzetto)

- Elementi di base: glossario, grandezze fondamentali e unità di misura; classificazione, consistenza numerica e utilizzazione di infrastrutture, veicoli e servizi
- Sostentazione e locomozione dei veicoli ferroviari
- Architettura, sistemi di trazione e motori elettrici dei veicoli
- Diagramma elementare del moto e prestazioni del veicolo isolato
- Deflusso negli impianti lineari e puntuali
- Schematizzazione dell'offerta e della domanda di trasporto







Argomenti delle lezioni e delle visite

Economia Ferroviaria (a cura di Valerio Giovine, Matteo Primizia)

- L’evoluzione delle ferrovie
- La rete, i veicoli e il personale ferroviario
- Visita *a distanza* di un impianto ferroviario
- L’organizzazione del sistema ferroviario
- Il mercato ferroviario e le sue regole
- La ferrovia nel contesto internazionale

SAPIENZA
UNIVERSITÀ DI ROMA

Master universitario di II livello in

Ingegneria delle Infrastrutture e dei Sistemi Ferroviari

Innovazione per la mobilità integrata

A.A. 2023/2024

Via e impianti fissi

Donatella Fochesato (RFI - Gruppo Ferrovie dello Stato Italiane)

Alessandro Ruvio (Sapienza Università di Roma)

Paolo Tamburrini (Alstom)

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EUROPEAN RAIL SKILLS ALLIANCE

Incontro inaugurale del 26 febbraio 2024

Contenuti del Modulo (1)

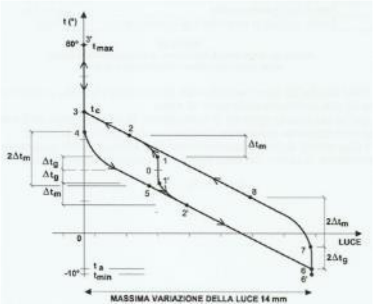
- Via ferrata ed elementi costitutivi del binario: tipologie e geometria del binario corrente e degli apparecchi di comunicazione (Stefano Ricci)

- Posa e rinnovo del binario (Marco Antognoli)

Contenuti del Modulo (2)

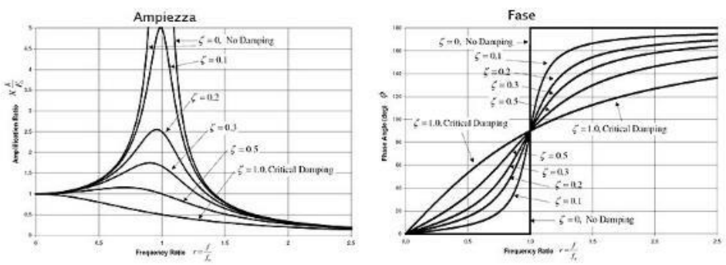
- Controllo e manutenzione del binario (Stefano Rossi)

- Termica del binario (Stefano Ricci)

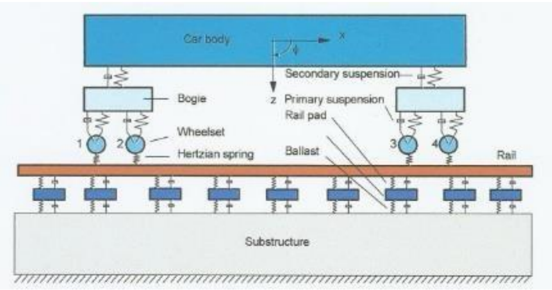


Contenuti del Modulo (3)

- Modellazione del comportamento statico e dinamico del binario (Massimiliano Bruner)



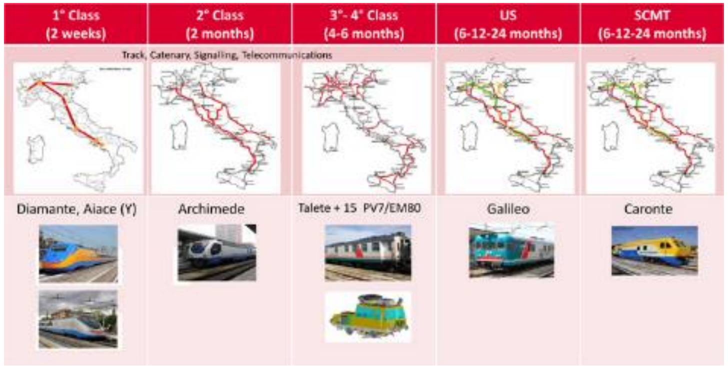
- *Esercitazione di gruppo*: analisi del comportamento statico e dinamico di diverse tipologie di armamento (Massimiliano Bruner)



Contenuti del Modulo (4)

- Principi di gestione di una infrastruttura ferroviaria (Donatella Fochesato)

- Diagnostica mobile dell’infrastruttura ferroviaria: visita (RFI)



Contenuti del Modulo (5)

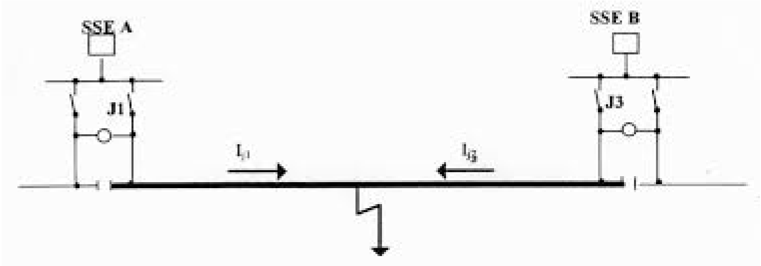
- Impianti fissi per il segnalamento e le telecomunicazioni (Attilio Gaeta)

- Impianti fissi per gli attraversamenti stradali a raso (Attilio Gaeta)

Contenuti del Modulo (6)

- Impianti fissi per la trazione elettrica (Alessandro Ruvio)

- *Esercitazione di gruppo*: Cadute di tensione nelle linee di contatto in linea (Alessandro Ruvio)



Contenuti del Modulo (7)

- Progettazione degli impianti fissi per la trazione elettrica (Paolo Tamburrini)

- Sottostazioni elettriche: visita (Fabrizio Massaroni)

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Innovazione per la mobilità integrata

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Sistemi di trazione e dinamica dei veicoli

Alberto Caviglia (Alstom)

Riccardo Licciardello (Sapienza Università di Roma)

Paolo Masini (Trenitalia – Gruppo Ferrovie dello Stato Italiane)

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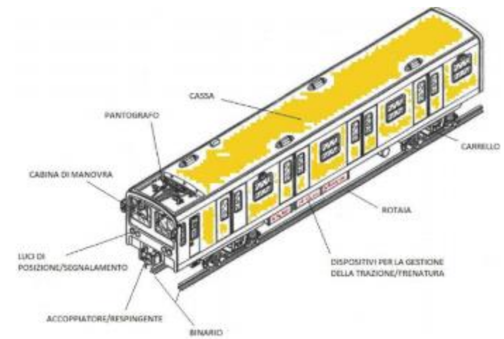
EUROPEAN RAIL SKILLS ALLIANCE

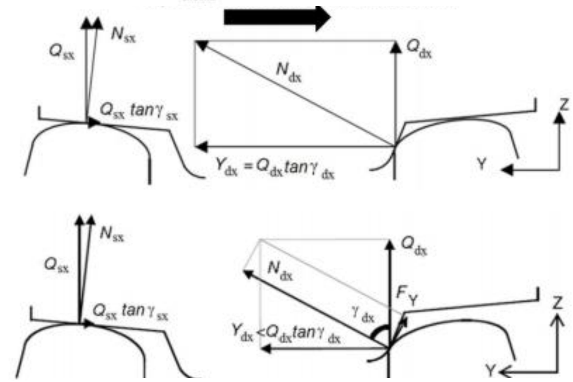
Incontro inaugurale del 26 febbraio 2024

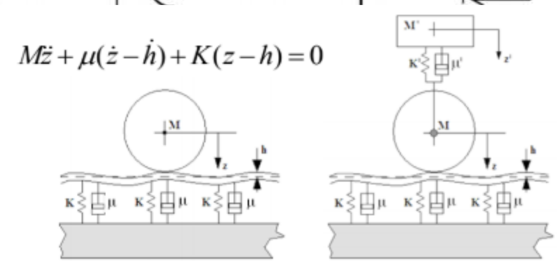
Contenuto Lezioni (coord. prof. R. Licciardello)

☐ Veicoli ferroviari: componenti e modelli teorici

- ➢ Evoluzione del pensiero scientifico sulla trazione ferroviaria.
- ➢ Modelli cinematici e dinamici per l'analisi della marcia del veicolo ferroviario.
- ➢ Caratteristica meccanica di trazione: aderenza, sforzo di trazione, applicazioni numeriche, regimi termici.
- ➢ Teoria della manutenzione dei rotabili ferroviari.
- ➢ Dinamica di marcia dei veicoli ad assetto variabile e sistema «tilting».



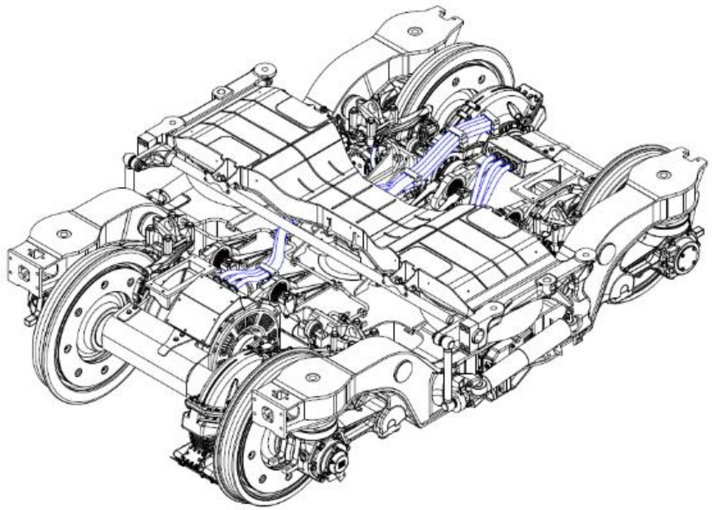




Contenuto Lezioni (coord. ing. A. Caviglia)

☐ Carrello ferroviario: architettura e validazione

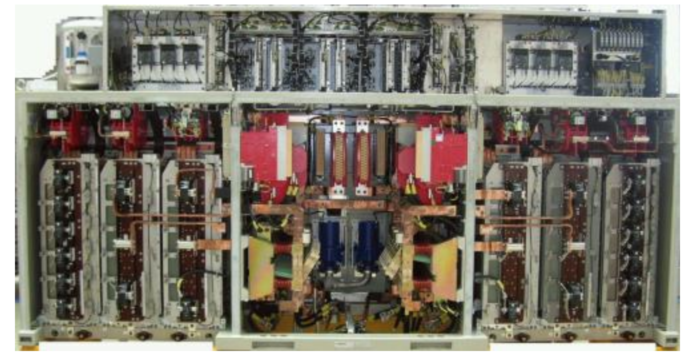
- Storia ed architettura del carrello ferroviario.
- Progettazione del carrello ferroviario (norme di riferimento, metodologie di dimensionamento e di prova).
- La trasmissione del moto.
- L’impianto freno.
- Dinamica di marcia del veicolo ferroviario.
- Validazione e «type testing» del rotabile ferroviario.

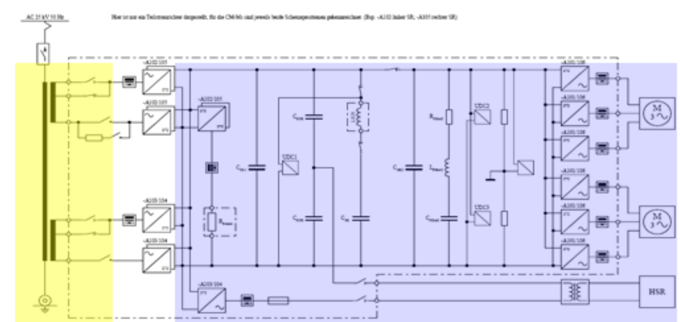


Contenuto Lezioni (coord. ing. A. Caviglia)

Trazione elettrica ferroviaria

- Storia dei prodotti ed elementi normativi.
- Elementi di dimensionamento e principali componenti.
- Principi generali di funzionamento dei vari tipi di convertitori di trazione.
- Alta Velocità in Italia dalle origini ad oggi.
- Alta Velocità: potenza concentrata o distribuita. Sviluppi futuri nella trazione elettrica.
- Validazione del sistema di trazione: esempi con prodotti specifici.

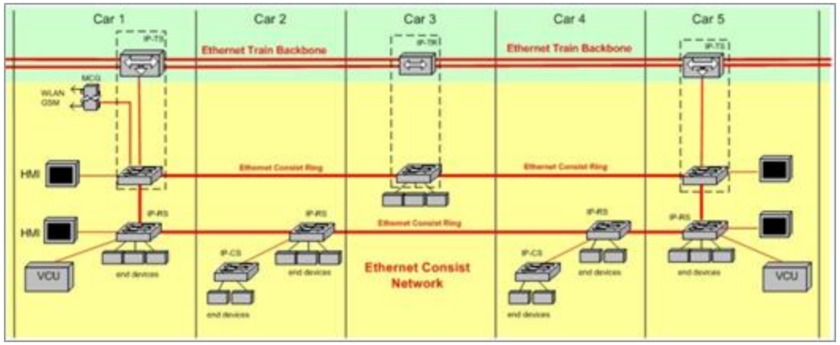


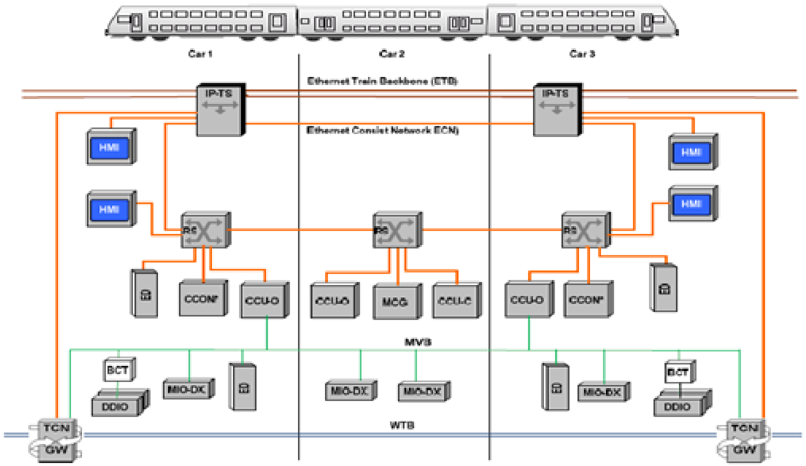


Contenuto Lezioni (coord. ing. A. Caviglia)

Train Control Management System (TCMS)

- Sistema di Controllo del treno ed il TCMS. Storia ed evoluzione del sistema.
- Principali componenti del TCMS – l’architettura. Interfacce. Le unità programmabili. Bus di comunicazione.
- Architettura software del TCMS.
- Validazione con type testing e «Soft train»
- Telediagnostica.





Contenuto Lezioni (coord. ing. P. Masini)

Trenitalia: le flotte e la manutenzione ferroviaria

- Flotte di Trenitalia: treni regionali, materiale ad alta velocità e nuovo ETR1000
- Quadro normativo e Entity in Charge of Maintenance.
- Organizzazione della ingegneria e della manutenzione in Trenitalia.

- Piani di manutenzione, la trama manutentiva, 1° e 2° livello di manutenzione.
- Manutenzione a moduli. Condition based maintenance.
- Manutenzione basata su indicatori. Telediagnostica.
- Visita Impianto di Manutenzione Rotabili

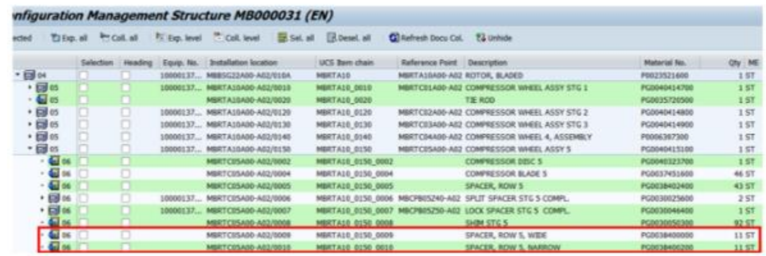
Contenuto Lezioni (coord. ing. P. Masini)

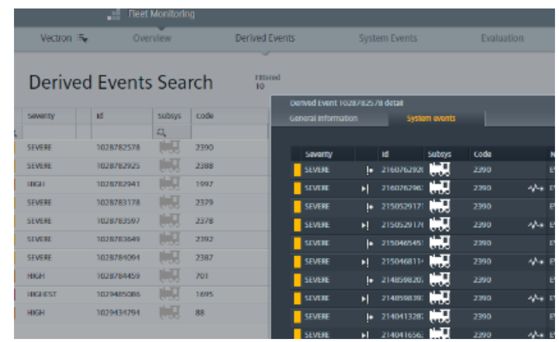
- Sistemi di test e di diagnosi avanzati per la meccanica ferroviaria
  - Cenni su indicatori di vita e salute componenti meccanici.
  - Monitoraggio accelerometrico per la definizione dei livelli di stress di un sottoassieme telaio-carrello di una flotta AV al fine di quantificarne stato di salute e vita.
  - Monitoraggio della evoluzione dei piani di rotolamento delle ruote ai fini della programmazione degli interventi di riprofilatura e sostituzione ruote.
  - Monitoraggio accelerometrico per la definizione della salute dei cuscinetti boccole ai fini della loro ottimale utilizzazione.

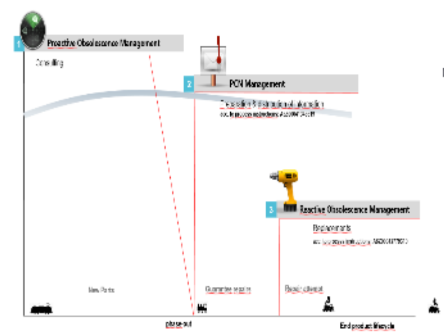
Contenuto Lezioni (coord. ing. P. Masini)

☐ LCC e Asset Management

- Modello e diagramma funzionale di un veicolo.
- Principi di analisi del guasto, metodi FMEA, FMECA.
- Ritorni di esperienza e analisi FRACAS.
- Obsolescenza dei componenti e asset management.



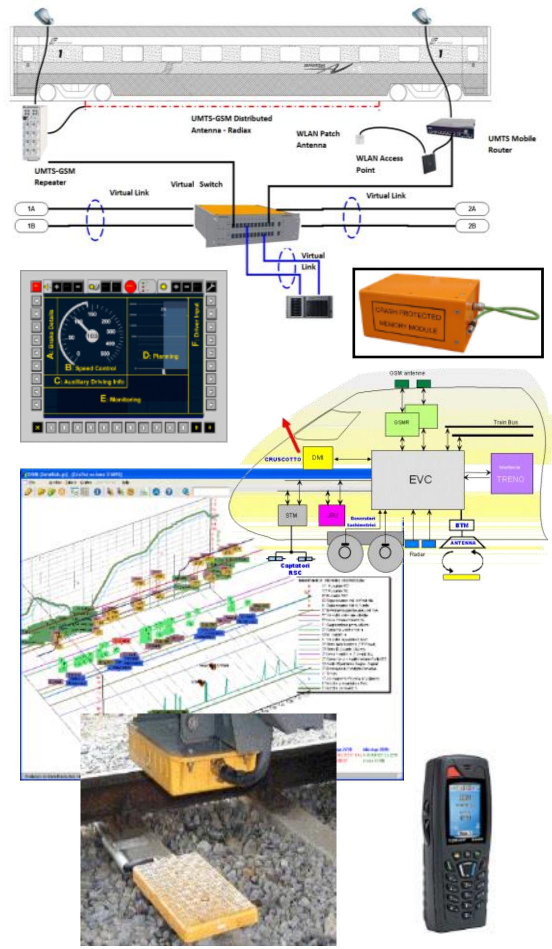




Contenuto Lezioni (coord. ing. P. Masini)

- Sistemi di segnalamento, di telecomunicazione e d'informazione ai passeggeri

  - Sistemi di segnalamento: SCMT, SSC, ETCS.
  - Vigilanza del Personale di Condotta e rilevamento parametri biometrici.
  - Sistemi di registrazione giuridica degli eventi di marcia: DIS, JRU; esempi di lettura di dati reali.
  - Apparati Radio di Bordo GSM-R: Cab Radio e apparati palmari.
  - Sistemi di informazione ai passeggeri
  - Reti e collegamento terra-bordo: il bus MVB, dorsali ethernet di bordo, comunicazioni 3G – LTE, sistemi di ripetizione del segnale radio.



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Progettazione dell'infrastruttura

Giuseppe Loprencipe (Sapienza Università di Roma)

Dario Tiberti (Italferr - Gruppo Ferrovie dello Stato Italiane)

Corso promosso da

STAFFER

EUROPEAN RAIL SKILLS ALLIANCE

Incontro inaugurale del 26 febbraio 2024

DATA	ORARIO	ARGOMENTO	DOCENTE
Mercoledì 20.03.2024	14-16	Il progetto dell'infrastruttura ferroviaria.	Tiberti *(Italferr)*
	16-18	Introduzione. Definizioni tracciato. Le curve ferroviarie	Loprencipe *(Sapienza)*
Giovedì 21.03.2024	14-16	Richiami cartografia. Rilievo geometria del binario.	Iannucci (Italferr)
	16-18	La progettazione del tracciato ferroviario.	Loprencipe *(Sapienza)*
Venerdì 22.03.2024	14-16	Aspetti progettuali e costruttivi dei ponti ferroviari di grande luce.	Petrangeli *(Sapienza a r.)*
	16-18	Opere d'arte ferroviarie: normativa ed esempi progettuali.	Evangelista *(Italferr)*
Lunedì 25.03.2024	14-16	Il tracciamento e la correzione del tracciato ferroviario.	Petrucci *(Salcef Group)*
	16-18	Opere in terra ed esempi di interazione idraulica con l'infrastruttura.	Berardi / Cabas *(Italferr)*
Martedì 26.03.2024	14-16	Il monitoraggio geotecnico.	Napoleoni *(Sapienza)*
	16-18	Gallerie ferroviarie.	Sciotti *(Italferr)*
Mercoledì 27.03.2024	14-16	La progettazione del tracciato ferroviario. La normativa sulla geometria dei tracciati ferroviari.	Loprencipe *(Sapienza)*
	16-18	Applicazione di gruppo	Loprencipe *(Sapienza)*
Giovedì 28.03.2024	14-16	BIM & Information Management nella Progettazione Ferroviaria	Aprea *(Italferr)*
	16-18	Applicazione di gruppo.	Loprencipe *(Sapienza)*
Mercoledì 03.04.2024	08-18	Visita didattica ad un cantiere della linea Napoli - Bari	Loprencipe / Tiberti
Giovedì 04.04.2024	14-16	Verifica e controllo delle opere d'arte.	Iacobini *(RFI)*
	16-18	Cantierizzazione.	Maccari *(Italferr)*

SAPIENZA UNIVERSITA' DI ROMA

Proff. Loprencipe, Napoleoni, Petrangeli

Programma Modulo 4 : Progettazione dell'infrastruttura (PIN)

Giuseppe Loprencipe *(Sapienza)*, Dario Tiberti *(Italferr)*

DATA	ORARIO	ARGOMENTO	DOCENTE
Mercoledì 20.03.2024	14-16	Il progetto dell'infrastruttura ferroviaria.	Tiberti *(Italferr)*
	16-18	Introduzione. Definizioni tracciato. Le curve ferroviarie	Loprencipe *(Sapienza)*
Giovedì 21.03.2024	14-16	Richiami cartografia. Rilievo geometria del binario.	Iannucci (Italferr)
	16-18	La progettazione del tracciato ferroviario.	Loprencipe *(Sapienza)*
Venerdì 22.03.2024	14-16	Aspetti progettuali e costruttivi dei ponti ferroviari di grande luce.	Petrangeli *(Sapienza a r.)*
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Lunedì 25.03.2024	14-16	Il tracciamento e la correzione del tracciato ferroviario.	Petrucci *(Salcef Group)*
	16-18	Opere in terra ed esempi di interazione idraulica con l'infrastruttura.	Berardi / Cabas *(Italferr)*
Martedì 26.03.2024	14-16	Il monitoraggio geotecnico.	Napoleoni *(Sapienza)*
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Mercoledì 27.03.2024	14-16	La progettazione del tracciato ferroviario. La normativa sulla geometria dei tracciati ferroviari.	Loprencipe *(Sapienza)*
	16-18	Applicazione di gruppo	Loprencipe *(Sapienza)*
Giovedì 28.03.2024	14-16	BIM & Information Management nella Progettazione Ferroviaria	Aprea *(Italferr)*
	16-18	Applicazione di gruppo.	Loprencipe *(Sapienza)*
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Giovedì 04.04.2024	14-16	Verifica e controllo delle opere d'arte.	Iacobini *(RFI)*
	16-18	Cantierizzazione.	Maccari *(Italferr)*

ITALFERR. SpA

Società di ingegnera del Gruppo FS

Ingg. Aprea,Evangelista, Iannucci, Maccari, Sciotti,Cabas, Berardi Tiberti

Programma Modulo 4 : Progettazione dell'infrastruttura (PIN)

Giuseppe Loprencipe *(Sapienza)*, Dario Tiberti *(Italferr)*

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SALCEF GROUP

player internazionale specializzato nella costruzione e nella manutenzione di infrastrutture ferroviarie e metropolitane

Ing. Petrucci

RFI SpA

Gestore infrastruttura ferroviaria nazionale

Ing. Iacobini

PROGETTAZIONE DELL'INFRASTRUTTURA

- IL PROCESSO PER LA REALIZZAZIONE DELL’INFRASTRUTTURA FERROVIARIA

- LE PECULIARITA' DELLA PROGETTAZIONE DELL'INFRASTRUTTURA FERROVIARIA
  - OPERA A RETE
  - SISTEMA COMPLESSO
  - OPERA PUBBLICA

- ELEMENTI CARATTERIZZANTI I PRIMI LIVELLI PROGETTUALI
- ASPETTI DI MERITO SU COMPONENTI RILEVANTI DELL’INFRASTRUTTURA
- VERIFICA E CONTROLLO OPERE D’ARTE
- VISITE DIDATTICHE

IL PROCESSO PER LA REALIZZAZIONE DELL'INFRASTRUTTURA FERROVIARIA

LA PROGETTAZIONE

01 ESIGENZA DELLA COMMITTENZA

02 STUDIO DI TRASPORTO, STUDIO DELLE ALTERNATIVE E INDIVIDUAZIONE DELLA SOLUZIONE PROGETTUALE

03 PROGETTO PER ITER APPROVATIVO

04 SVILUPPO PROGETTO PER GARA E RECEPIMENTO PRESCRIZIONI ITER

05 ATTIVITÀ NEGOZIALI

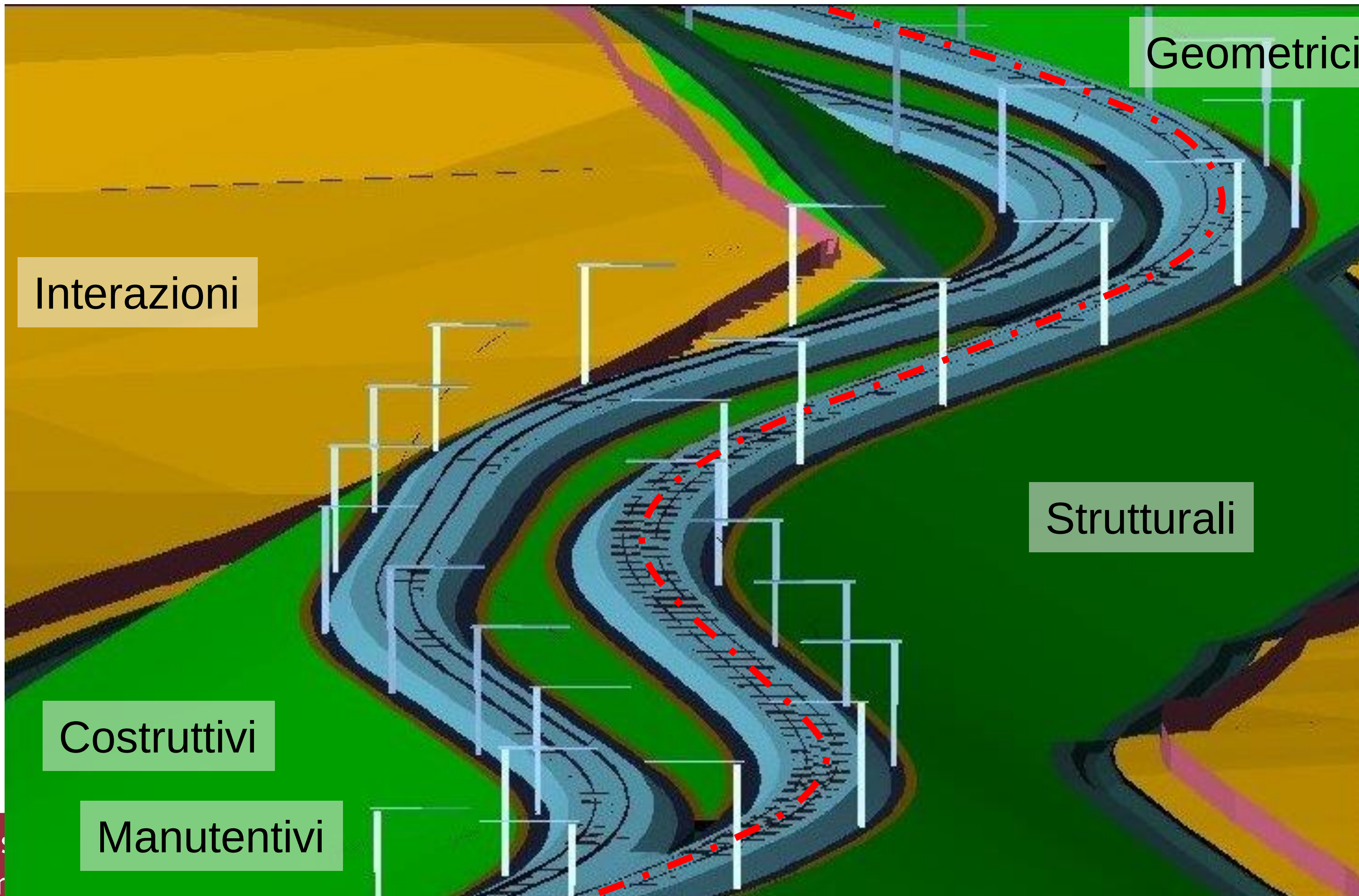
PROGETTAZIONE ESECUTIVA
ESECUZIONE DELLE O
PRESIDIO DELLA FASE REALIZZATIVA

07 FASE DI ATTIVAZIONE (VERIFICA, COLLAUDO, CERTIFICAZIONE E PRE-ESERCIZIO)

08 GESTIONE DELLA INFRASTRUTTURA

PROGETTO DELL’INFRASTRUTTURA

LE PECULIARITA’: OPERE A RETE



LE PECULIARITA': SISTEMA COMPLESSO

Molteplicità di competenze

Integrazione

e approccio sistemico

LE PECULIARITA': OPERA PUBBLICA

IL CODICE DEI CONTRATTI

L. 109/1994 – Legge quadro in materia di LLPP

DPR 554/1999 – Regolamento di attuazione L. 109/1994

L. 443/2001 – Delega al Governo in materia di infrastrutture ed insediamenti produttivi strategici ed altri interventi per il rilancio delle attività produttive

D.Lgs 163/2006 – Codice dei contratti pubblici relativi a lavori, servizi e forniture in attuazione delle direttive 2004/17/CE e 2004/18/CE

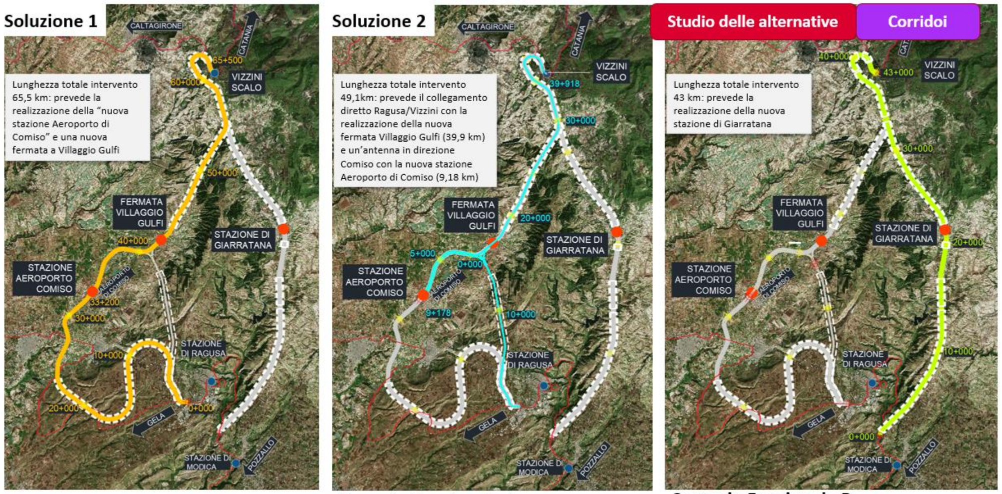
DPR 207/2010 – DPR 207/2010 Regolamento di esecuzione ed attuazione del D.Lgs 163/2006

D.Lgs 50/2016 – Codice dei contratti pubblici

Linee guida CSLLPP (progetto di fattibilità tecnica PNRR – PFTE)

D.Lgs 36/2023 – Codice dei contratti pubblici

DOCFAP



Scenario Funzionale A
Corridoio 1

Scenario Funzionale A
Corridoio 2

Scenario Funzionale B
Corridoio 3

Linee esistente; Nuove stazioni; Stazioni esistenti; Gallerie

zione cesura centro urbano;
• Liberazione del centro abitato di Augusta dalla ferrovia ed annessi PL;
• Riduzione dell'impatto della linea sulle aree protette (saline).

Principali caratteristiche dell'opera

2,8 km di tracciato in sostituzione degli oltre 7 km di linea storica.

Nuova stazione passeggeri modulo 250 m.

Opera	Sviluppo opera [m]
Trincee	445
Rilevati	875
Galleria artificiale	68
Viadotto su Scatolare	274
Viadotto ferroviario	977
Nuove Viabilità	1948

PFTE

TERRITORIO : RAPPRESENTAZIONE

- Sistemi di coordinate
- Riprese aerofotogrammetriche e LiDAR
- Cartografia Numerica
  - Dati esistenti e relativo utilizzo
  - Processi produttivi per la redazione di cartografia
- Rilievo Topografico
  - Tecnologie di Rilievo diretto
  - Tecnologie di Rilievo indiretto
- Rilievi Lidar, termici e multispettrali da drone
- Misurazione del Binario e Attrezzaggio su Base Assoluta

TERRITORIO : CARATTERIZZAZIONE GEOLOGICA E GEOTECNICA

- Prove e metodi di indagine
- Caratterizzazione geologica e geotecnica dei terreni
- Problematiche ricorrenti e particolari in campo ferroviario

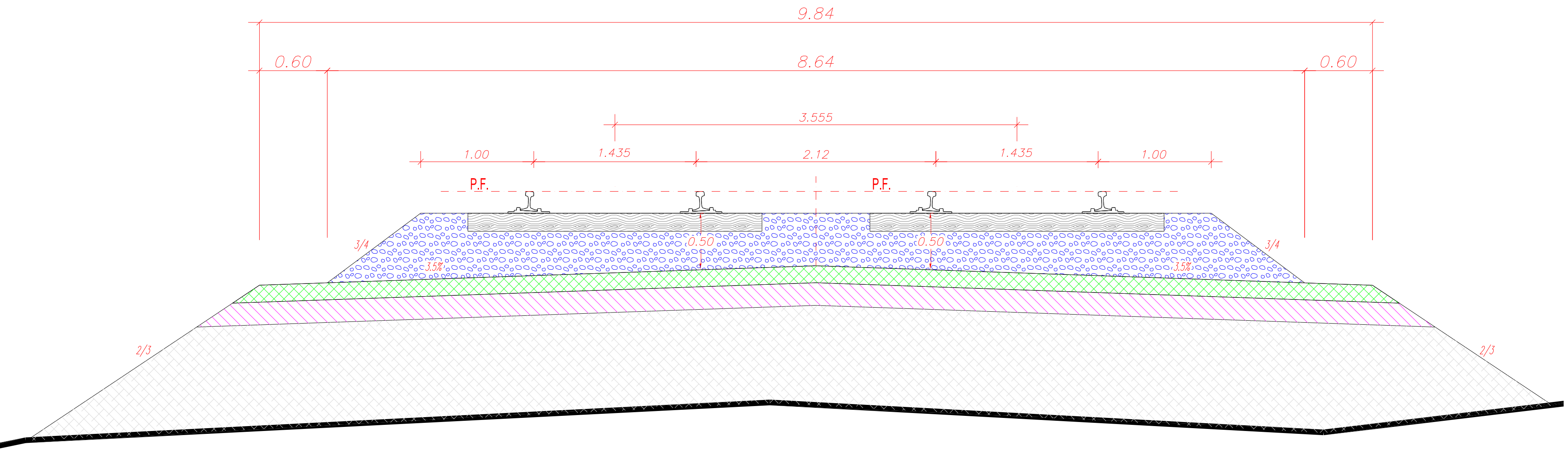
PROGETTO DEL TRACCIATO FERROVIARIO

- Nomenclatura, definizioni generali e richiami di geometria delle curve
- Tracciato ferroviario: progettazione planimetrica e altimetrica
- Criteri di progetto geometrici, cinematici e dinamici
- Condizioni geometriche per la circolazione in curva: intervia e interasse
- Normativa di riferimento
- Esempi e applicazioni
- Fasi progettuali
- Iter di progetto

- Introduzione e criteri generali di progettazione al calcolatore
- La gestione della cartografia digitale
- La modellazione geometrica tridimensionale al calcolatore
- Presentazione di alcuni strumenti per la progettazione ferroviaria al calcolatore
- La frontiera della progettazione in BIM

CORPO STRADALE – OPERE D'ARTE

RILEVATI FERROVIARI, OPERE IN TERRA E GRANDI OPERE INTERRATE



- Rilevati ferroviari: gli standard, la progettazione, le tecniche costruttive
- Infrastrutture ferroviarie realizzate in corrispondenza di pendii in frana
- La modellazione fisica nella progettazione degli attraversamenti fluviali

- Aspetti normativi e progettuali:
  - Le azioni da traffico ferroviario
  - Distribuzioni longitudinali e trasversali
  - Incrementi dinamici
  - Interazione statica e dinamica TBS
  - Azioni longitudinali
  - Azioni accidentali ed effetti aerodinamici
  - Criteri di verifica
  - Impostazione progettuale e ulteriori requisiti tecnici
- Interazione dinamica treno - struttura
- Esempi progettuali e applicativi: Il ponte sul Po

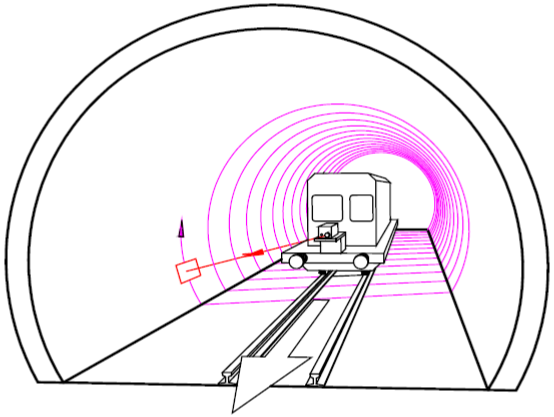
GALLERIE FERROVIARIE

- Definizioni e caratteristiche generali
- Le scelte progettuali e costruttive nella realizzazione delle gallerie ferroviarie
- Dalla galleria del Frejus alle gallerie dell’Alta Velocità Roma-Napoli e Bologna-Firenze
- Metodi di scavo
  - Lo scavo tradizionale
  - Lo scavo meccanizzato

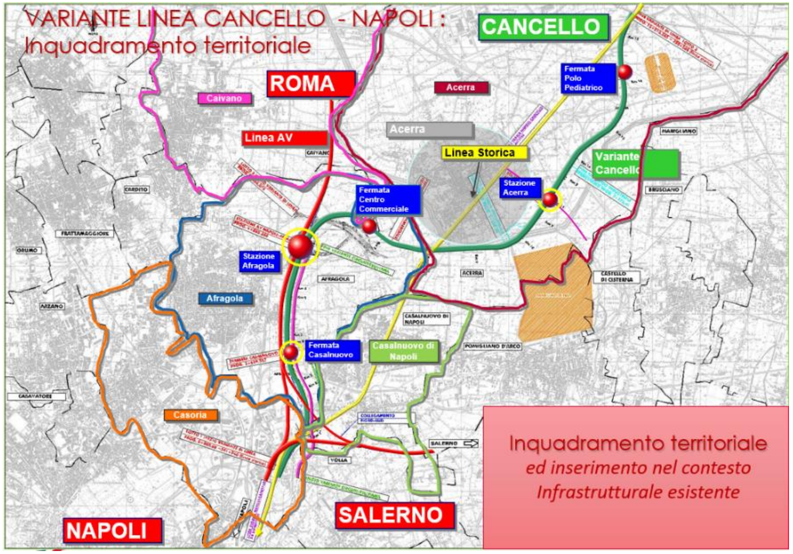
CANTIERIZZAZIONE

- La cantierizzazione per un’infrastruttura ferroviaria.
- WBS di un opera
- Il Programma Lavori
- La curva ad “S” di produzione

VERIFICA E CONTROLLO DELLE OPERE D'ARTE



Visita didattica cantiere Napoli - Bari - Variante Cancello (03 apr 2024)



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Innovazione per la mobilità integrata

A.A. 2023/2024

Tecnica della circolazione

Gabriele Malavasi (Sapienza Università di Roma)

Paolo Farinelli (Hitachi Rail STS)

Carlo Domenico Ronzino (Rete Ferroviaria Italiana)

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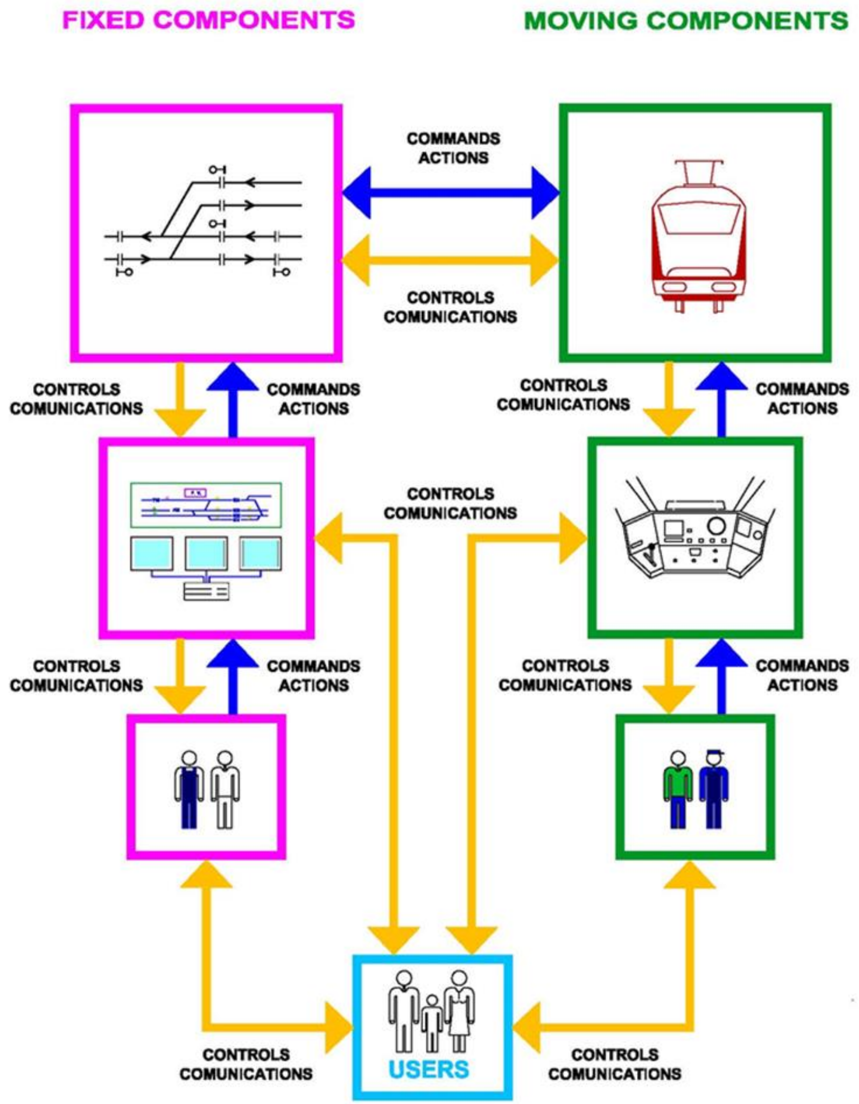
Incontro inaugurale del 26 febbraio 2024

Componenti del sistema circolazione



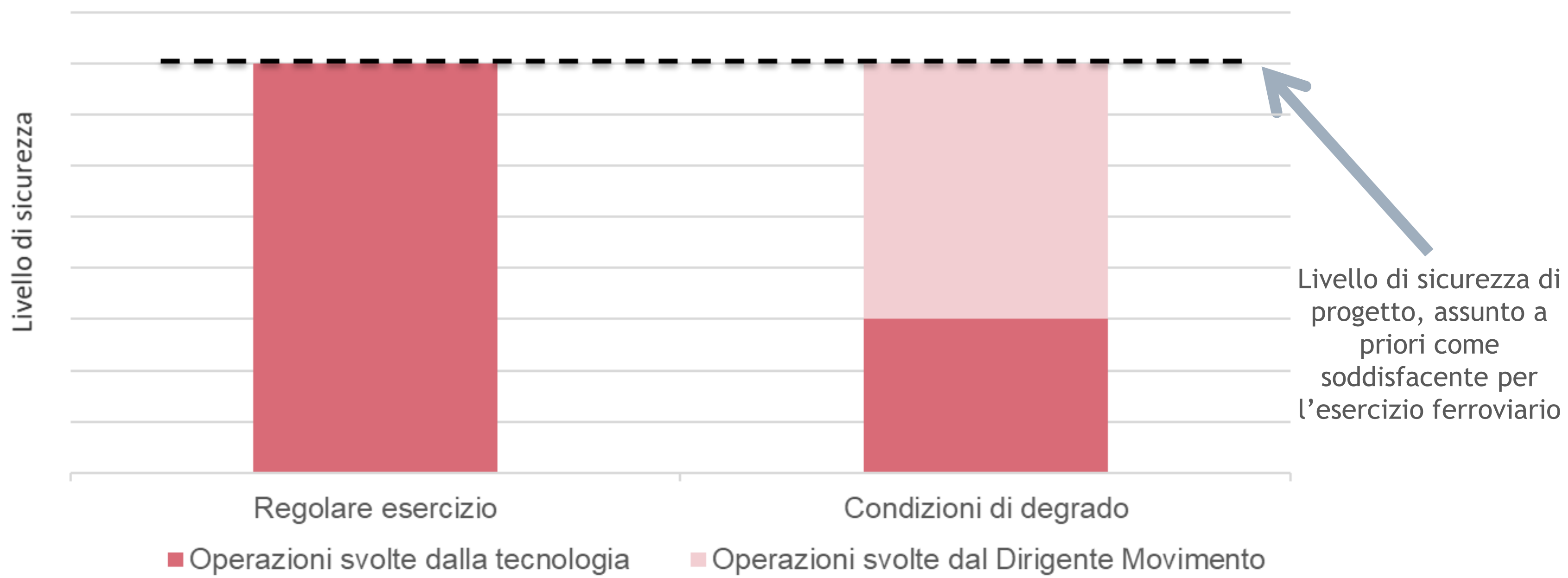
Livello di sicurezza da garantire

In **condizioni di regolare esercizio**

La tecnologia assicura che siano verificate le condizioni per la circolazione dei treni in sicurezza.

In **condizioni di degrado**

Parte delle operazioni di sicurezza effettuate normalmente dalla tecnologia, devono essere svolte dagli operatori di terra o di bordo.



Programma del modulo (1/3)

Tema	Argomento *Aspetti funzionali*
1. Circolazione in stazione	☐ Sistema circolazione: circolazione in stazione. Itinerari di ingresso e di uscita. ☐ Verifica di capacità dei nodi semplici.
2. Distanziamento dei treni	☐ Distanziamento dei treni. Sistemi di blocco. Segnali. Capacità di linea.
3. Apparati centrali di stazione	☐ Funzioni, tempi operativi. ☐ Esercitazione di gruppo: Affidabilità degli apparati centrali.
4. Apparati centrali di stazione	☐ Tipologie tecnologiche. ☐ Esercitazione di gruppo: Logica di manovra di un deviatoio.

Programma del modulo (2/3)

Tema	Argomento *Aspetti tecnologici*
5. Apparati centrali di stazione	☐ Apparati centrali a calcolatore.
6. Impianti di segnalamento	☐ Sistemi e tecnologie ERTMS L1, L2, L3 moving block. Aspetti funzionali e tecnologici.
7. Impianti di segnalamento	☐ Sistemi SCMT, SSC: aspetti funzionali e tecnologici. Applicazioni ERTMS in RFI.
8. Sistemi di sicurezza e controllo nelle metropolitane a guida automatica	☐ Il segnalamento secondo lo standard CBTC (Communication-Based Train Control).

Programma del modulo (3/3)

Tema	Argomento *Aspetti gestionali*
9. Criteri di sicurezze del software	☐ Criteri di sicurezza del software dei sistemi di comando e controllo.
10. Train Management System	☐ Architettura del train management system di rete
11. Regolamento di esercizio ferroviario	☐ RCF: principi, esercizio ordinario, esercizio degradato.
12. Visita	☐ ACC di Roma Termini
Orario:	dal lunedì al venerdì ore 9.00-13.00
Periodo lezioni e seminari:	Dal 15 al 30 aprile 2024
Data esame:	6 maggio 2024

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Gestione della sicurezza ferroviaria

Mara Lombardi (Sapienza Università di Roma)

Nicola Meini (Hitachi Rail)

Gian Fabrizio Ghiglia (RFI - Gruppo Ferrovie dello Stato Italiane)

Linda Cardinali (Trenitalia - Gruppo Ferrovie dello Stato Italiane)

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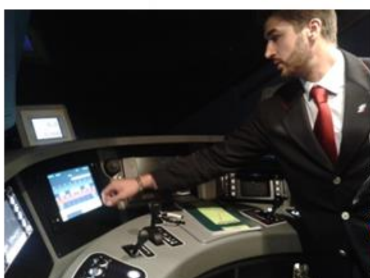
Gestione della Sicurezza Ferroviaria

SICUREZZA REQUISITO «A PRIORI» PER L'ESERCIZIO FERROVIARIO ⇨ **(SGS)**

GESTIONE DEL RISCHIO

IMMISSIONE IN ESERCIZIO VEICOLI

Monitoraggio infrastrutture



FATTORE UMANO

Affidabilità, sostenibilità e resilienza

TECNOLOGIA

Gestione della Sicurezza Ferroviaria

- La Sicurezza dell'Esercizio (Safety) non solo come vincolo cogente ma anche come opportunità di business;
- Il monitoraggio dell'infrastruttura finalizzato alla valutazione del rischio e alla gestione della sicurezza ferroviaria (affidabilità, sostenibilità e resilienza);
- L'Agenzia Europea e l'Autorità Nazionale per la Sicurezza delle Ferrovie;
- Il Quarto Pacchetto ferroviario;
- I Sistemi di Gestione della Sicurezza del Gestore Infrastruttura e delle Imprese Ferroviarie;
- Metodi di valutazione e gestione del rischio;
- Le interazioni tra quadro normativo di riferimento, tecnologie di sicurezza di terra e di bordo e fattore umano;
- I Requisiti progettuali per la sicurezza dei veicoli ferroviari;
- L'autorizzazione alla messa in servizio;
- L'interoperabilità sulle Reti ferroviarie europee.

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Terminali passeggeri e merci

Stefano Ricci (Sapienza Università di Roma)

Antonello Martino (RFI - Gruppo Ferrovie dello Stato Italiane)

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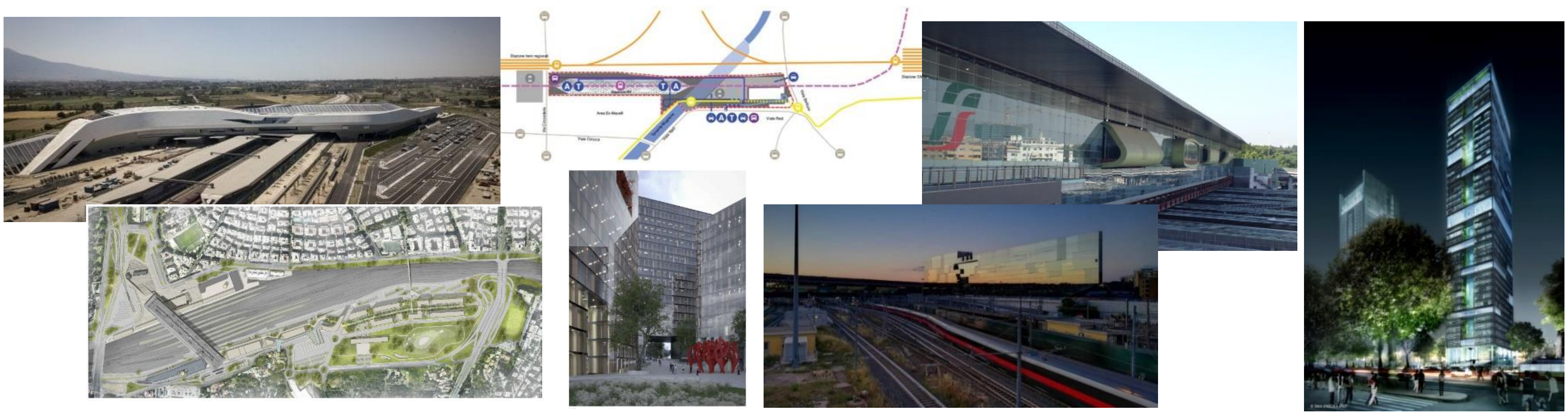
Incontro inaugurale del 26 febbraio 2024

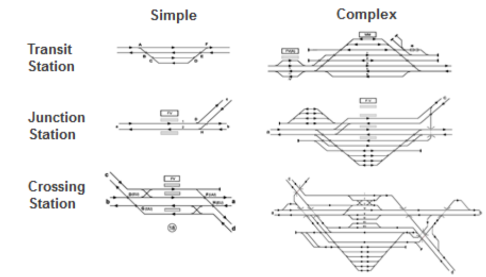
Contenuti del Modulo TPM: criteri e progetti

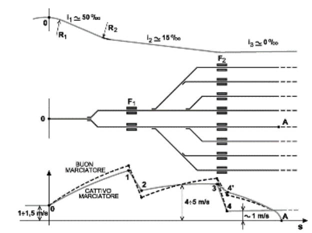
- La rinnovata centralità delle Stazioni nella strategia di Rete Ferroviaria Italiana (RFI).
- Il processo degli investimenti.
- Lo stakeholder engagement.
- Approcci data-driven per lo sviluppo delle stazioni.
- L'accessibilità nelle stazioni.
- Progettazione e sviluppo dell'infrastruttura.
- Hub di riconnessione urbana: alcuni progetti strategici.
- Gestione delle stazioni.
- Visita alle stazioni di Roma Tiburtina e Roma San Pietro.

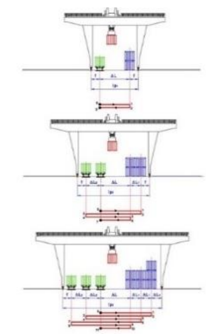


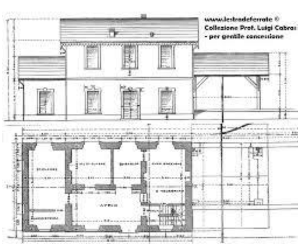
Contenuti del Modulo TPM: metodi e strumenti

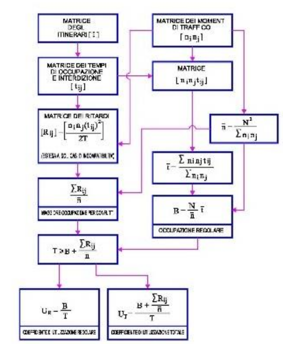
- Capacità di sosta e dimensionamento. Funzioni e schemi di base degli impianti di transito e di bivio
- Funzioni e schemi di base degli impianti di scambio e di testa
- Stazioni di smistamento. Impianti per il trasbordo dei container e dei semirimorchi
- Verifica di fattibilità dei terminali intermodali
- Esercizio dei nodi complessi. Potenzialità degli impianti (Stefano Ricci)
- Fabbricati viaggiatori: aspetti funzionali e progettuali
- *Lavoro di gruppo*: dimensionamento di un fascio di binari











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Innovazione per la mobilità integrata

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Trasporto merci e logistica

Francesco Filippi (Sapienza Università di Roma)

Aldo Maietta (Mercitalia Logistics - Gruppo Ferrovie dello Stato Italiane)

Chiara Catani (Trenitalia - Gruppo Ferrovie dello Stato Italiane)

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Incontro inaugurale del 26 febbraio 2024

Argomenti del modulo (1/2)

1. Il Polo Mercitalia: il ruolo della Holding della logistica nel Gruppo Ferrovie dello Stato Italiane *(Mercitalia)*
2. Il contesto regolatorio nazionale ed internazionale e le opportunità di finanziamento per il settore ferroviario *(Mercitalia)*
3. La strategia internazionale: il Polo Mercitalia in Europa e la sfida della sostenibilità *(Mercitalia)*
4. Le sfide del mercato della logistica *(Mercitalia)*
5. Mercitalia Rail e il servizio di trazione ferroviaria in Italia *(Mercitalia)*
6. La digitalizzazione, l'innovazione, le sfide tecnologiche nella logistica *(Mercitalia)*
7. La pianificazione e la programmazione dell'offerta commerciale *(Mercitalia)*
8. La produzione, la manutenzione e la gestione dell'asset rotabile *(Mercitalia)*
9. L'evoluzione delle competenze professionali nel settore della logistica *(Mercitalia)*
10. I concetti principali della logistica. Sistemi logistici. I principali trend. *(Sapienza)*
11. Supply Chain in Trenitalia al servizio delle attività manutentive dei rotabili *(Trenitalia)*
12. Caso di studio: Gli effetti della epidemia sui sistemi logistici *(Sapienza)*

Argomenti del modulo (2/2)

13. Supply Chain in Trenitalia al servizio delle attività manutentive dei rotabili (Case study) *(Trenitalia)*
14. Modi, nodi di trasporto e aree di mercato in Europa *(Sapienza)*
15. Caso di studio: Il trasporto Barcellona – Civitavecchia *(Sapienza)*
16. Comunicare la Logistica: messaggi, strumenti e stakeholder *(Mercitalia)*
17. Progetti di digitalizzazione della flotta e dei processi per il superamento dei vincoli operativi *(Mercitalia)*
18. Prospettive e criticità del trasporto ferroviario merci *(Sapienza)*
19. Caso di studio: Ottimizzare il sistema logistico della moda *(Sapienza)*
20. Logistica urbana *(Sapienza)*
21. Caso di studio: Hotel logistique a Parigi *(Sapienza)*
22. Mercitalia Intermodal: lo sviluppo del trasporto combinato delle merci *(Mercitalia)*
23. Mercitalia Shunting & Terminal: l'importanza dell'ultimo miglio – Visita al terminal di Pomezia *(Mercitalia)*

Orario:	dal lunedì al venerdì ore 14.00-18.00
Periodo lezioni e seminari:	Dall’8 al 21 maggio 2024
Periodo esami:	29 maggio 2024

Argomenti dei moduli Sapienza

- Concetti principali della logistica delle attività produttive.
  - Sistemi logistici, progettazione delle catene logistiche e strategie.
  - Trasporti e reti di distribuzione (outbound).
  - I principali trend che interessano la logistica.
  - L’integrazione del cicli nell’azienda. Lo stock strategico.
  - Il Logistics Network Design. Le analisi per lo sviluppo delle strategie logistiche.
- Studio di un caso ed esercizi
  - Gli effetti della epidemia sui sistemi logistici globali e la ricerca della resilienza con ridondanze, diversificazione e gestione dei rischi.
  - La risposta del sistema stradale e ferroviario in US.

Argomenti dei moduli Sapienza

- Modi, nodi di trasporto e aree di mercato in Europa.
  - La competizione e integrazione dei modi di trasporto.
  - I sistemi portuali del nord e del sud Europa.
  - Le aree logistiche a servizio delle zone produttive e dei mercati europei.
- Studio di un caso ed esercizi
  - Il trasporto Barcellona – Civitavecchia.
  - Confronto tra tre possibili percorsi: ferroviario, stradale e marittimo.
- Prospettive e criticità del trasporto ferroviario merci in Europa.
  - Obiettivi di traffico, capacità della rete, affidabilità, e ritardi.
- Studio di un caso ed esercizi
  - Ottimizzare il sistema logistico della moda.
  - Le esigenze logistiche del settore e l'analisi delle reti logistiche tra la Turchia e l'Olanda.

Argomenti dei moduli Sapienza

- Logistica urbana.
  - Impatti nella penetrazione urbana delle merci.
  - La ricerca di un ruolo alla ferrovia per la sostenibilità.
  - La transizione ecologica gli accordi internazionali e il PNRR
- Studio di un caso ed esercizi
  - Hotel logistique a Parigi.
  - Un terminal ferroviario a pochi metri dai binari della Gare du Nord, per trasformare la distribuzione urbana delle merci.

Argomenti dei moduli Mercitalia

- Il Polo Mercitalia: il ruolo della Holding della logistica nel Gruppo Ferrovie dello Stato Italiane.
  - Le società del Polo, il ruolo di Mercitalia Logistics, logistica integrata, le sinergie nel Polo della Logistica.
- Il contesto regolatorio nazionale ed internazionale e le opportunità di finanziamento per il settore ferroviario
  - Vincoli e opportunità derivanti dalla regolazione, rapporti con le autorità e meccanismi di funzionamento dei principali programmi di contribuzione pubblica al settore.
- La strategia internazionale: il Polo Mercitalia in Europa e la sfida della sostenibilità
  - Il posizionamento europeo del Polo Logistica, i trend e le sfide internazionali.
- Le sfide del mercato della logistica.
  - Tipologie ed esigenze dei principali clienti: l'organizzazione di una struttura orientata al mercato.
- Mercitalia Rail e il servizio di trazione ferroviaria in Italia.
  - Mercitalia Rail: Ruolo, assetto, core business.

Argomenti dei moduli Mercitalia

- La digitalizzazione, l'innovazione, le sfide tecnologiche nella logistica
  - Design thinking e change management a supporto della trasformazione digitale volta all'innovazione dei paradigmi industriali e dei processi operativi.
- La pianificazione e la programmazione dell'offerta commerciale
  - La pianificazione dell'offerta, la programmazione ordinaria e straordinaria, la progettazione oraria e la relativa revisione sulla base della riprogrammazione.
- La produzione, la manutenzione e la gestione dell'asset rotabile.
  - I fattori della produzione e il reticolo degli impianti, le competenze professionali, l'organizzazione della produzione, il modello operativo, il ruolo della manutenzione.
- L'evoluzione delle competenze professionali nel settore della logistica
  - Competenze tecniche distintive, trasversali e di sistema, digital skills in risposta ai nuovi modi di comunicare, collaborare e interpretare i dati.

Argomenti dei moduli Mercitalia

- Comunicare la Logistica: messaggi, strumenti e stakeholder.
  - Strumenti e strategie per individuare e coinvolgere gli stakeholder, costruire messaggi efficaci per media, istituzioni e clienti.
- Progetti di digitalizzazione della flotta e dei processi.
  - I progetti del Polo della Logistica per la digitalizzazione della flotta e dei processi operativi al fine di superare vincoli operativi e rigidità normative
- Mercitalia Intermodal: lo sviluppo del trasporto combinato delle merci.
  - Il ruolo dell'intermodale Nazionale e Internazionale, Network logistico, il ruolo della flotta interoperabile.
- Mercitalia Shunting & Terminal: l'importanza dell'ultimo miglio - **Visita all'impianto di Pomezia.**
  - Il ruolo della manovra ferroviaria, gli asset e la gestione degli impianti.

Argomenti dei moduli Mercitalia

Visita tecnica: *Visita al terminal di Pomezia*

Visita e illustrazione dell'interporto e aree intermodali, operazioni di carico/scarico treni, esempi di materiale rotabile, unità di carico e attrezzature per la logistica integrata, sella di lancio, officina di manutenzione.

Argomenti dei moduli Trenitalia

- Supply Chain in Trenitalia al servizio delle attività manutentive dei rotabili.
  - il contesto della logistica in Trenitalia, determinazione fabbisogni, dimensionamento scorte (scorta di sicurezza e scorta di ciclo), schedulazione ordini, distribuzione e ottimizzazione flussi logistici, nuove prospettive (Stampa 3d e Virtual Warehouse)

- Supply Chain in Trenitalia al servizio delle attività manutentive dei rotabili (Case study)
  - esercitazione (caso pratico in cui simulare il ciclo logistico di un materiale in diversi scenari - standard, ritardo fornitore, consumi maggiori dei fabbisogni espressi, etc.)

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A.A. 2023/2024

Pianificazione e qualità del servizio

Ruggero Gianfaldoni (Trenitalia - Gruppo Ferrovie dello Stato Italiane)

Antonio Musso (Sapienza Università di Roma)

Matteo Primizia (RFI - Gruppo Ferrovie dello Stato Italiane)

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EUROPEAN RAIL SKILLS ALLIANCE

Incontro inaugurale del 26 febbraio 2024

Obiettivi

Fornire ai discenti

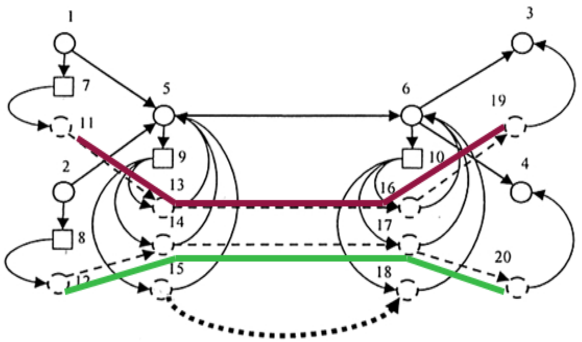
- i modelli della pianificazione dei trasporti e la loro applicazione nell’ambito ferroviario
- la capacità di infrastruttura e la sua allocazione
- L’orario ferroviario: modelli, progettazione, ottimizzazione e sua pubblicizzazione
- la programmazione dei mezzi e degli equipaggi
- la gestione operativa della circolazione e i controlli operativi dei servizi di trasporto
- i sistemi di gestione della qualità e sugli indicatori di qualità e di soddisfazione dei clienti
- sistemi innovativi e sostenibilità del trasporto urbano

$$P_j^{oish} = \frac{\exp(V_j^{oish}/\theta)}{\sum_{k=0}^{FM} \exp(V_k^{oish}/\theta)}$$

Argomenti delle lezioni

Tecniche di pianificazione, sistemi di qualità, sostenibilità (a cura di Antonio Musso)

- Il processo di pianificazione dei trasporti
- I modelli della domanda di trasporto
- Le logiche della Qualità
- I sistemi di gestione della Qualità
- Gli indicatori di qualità
- La soddisfazione del cliente
- La valutazione dei costi nel trasporto per ferrovia
- Intelligent Transport Systems per la mobilità integrata
- Sostenibilità e innovazione nel trasporto urbano



Argomenti delle lezioni

Pianificazione, programmazione e gestione della infrastruttura ferroviaria (a cura di Matteo Primizia)

- L'allocazione della capacità di infrastruttura: tracce, lavori, puntualità
- La pianificazione degli interventi di manutenzione e potenziamento
- Le regole per l'allocazione della capacità: il PIR
- La costruzione dell'orario ferroviario: dai modelli al progetto orario
- La gestione operativa ed i Servizi alla clientela
- Visita a distanza della Sala Circolazione RFI di Roma

Argomenti delle lezioni

Programmazione, gestione e controllo del trasporto ferroviario viaggiatori (a cura di Ruggero Gianfaldoni)

- La progettazione di un orario ferroviario da parte delle imprese di trasporto
- La commercializzazione e pubblicizzazione dell’orario ferroviario
- La pianificazione di flotte ed equipaggi
- Il controllo operativo (visita a distanza alle Sale operative di Trenitalia)

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Programmazione e legislazione delle opere ferroviarie

Agostino Cappelli (già IUAV di Venezia – MERCATORUM University)

Gino Taglieri (RFI S.p.A. - Vice Direzione Generale Operation)

Amedeo Gargiulo (già Agenzia Nazionale per la Sicurezza delle Ferrovie)



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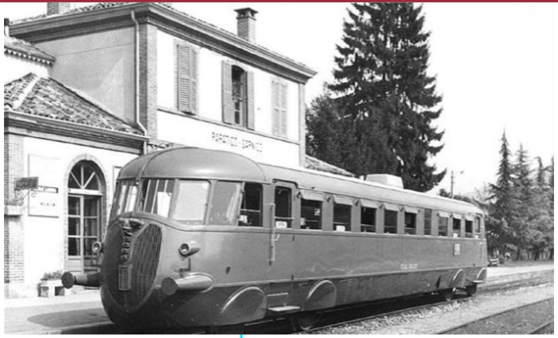
Argomenti del modulo

1. La programmazione delle opere ferroviarie e dei trasporti in Italia dal dopoguerra ad oggi



1. La programmazione delle ferrovie urbane e metropolitane: L. 910 e L. 211

2. Le fonti di finanziamento

Argomenti del modulo

4. Dalla programmazione alla progettazione ed all'affidamento dei lavori: le norme sugli appalti pubblici

5. Il progetto di fattibilità tecnica – economica

6. Il progetto definitivo

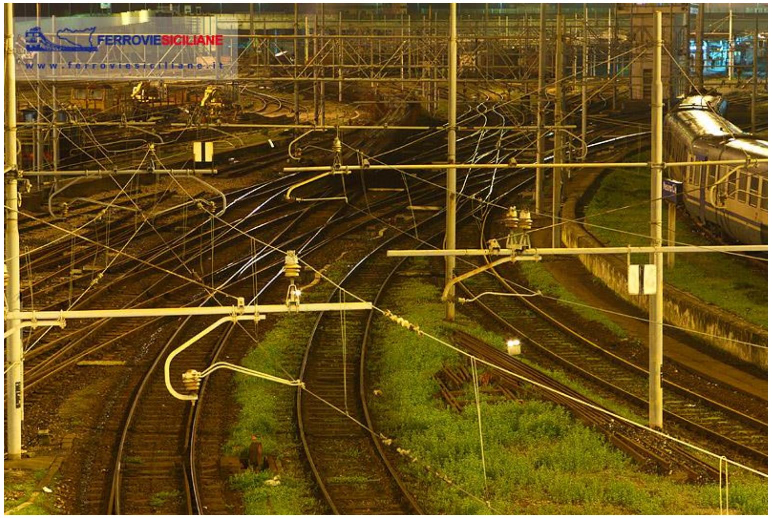
7. Il consenso sulla realizzazione delle opere: dal progetto alle conferenze dei servizi

Argomenti del modulo

8. Il codice dei contratti pubblici per l'affidamento di servizi e lavori.

9. Fasi di pianificazione, programmazione e progettazione gare d'appalto

10. I sistemi di realizzazione delle opere pubbliche- Tipologie d'appalto



Argomenti del modulo

11. La direzione lavori, il collaudo, la sicurezza nei cantieri.

12. Il Project management

13. La sicurezza nei trasporti ferroviari

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Innovazione per la mobilità integrata

A.A. 2023/2024

Valutazione degli interventi e impatto ambientale

Cinzia Giangrande (RFI - Gruppo Ferrovie dello Stato Italiane)

Stefano Ricci (Sapienza Università di Roma)



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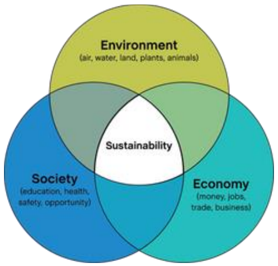
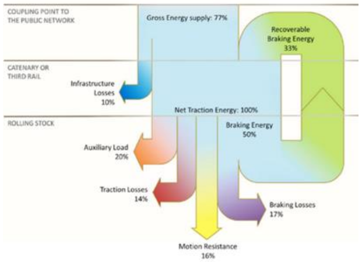
Incontro inaugurale del 26 febbraio 2024

Contenuti del modulo (1)

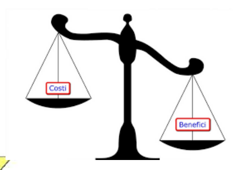
- Introduzione alla valutazione degli interventi - Equilibrio del sistema ambiente ed esternalità - Impatto ambientale: VIA e SIA (Stefano Ricci)

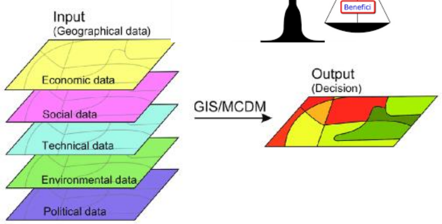


- Consumi energetici ed emissioni nell’esercizio ferroviario (Cristiana Piccioni)



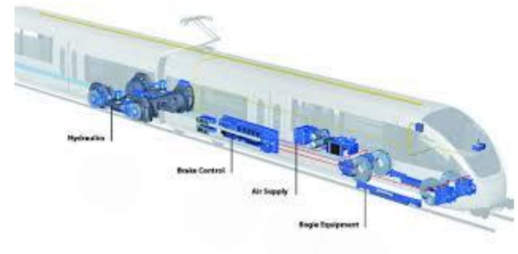
- La valutazione operativa della sostenibilità ambientale degli investimenti ferroviari (Agostino Nuzzolo)





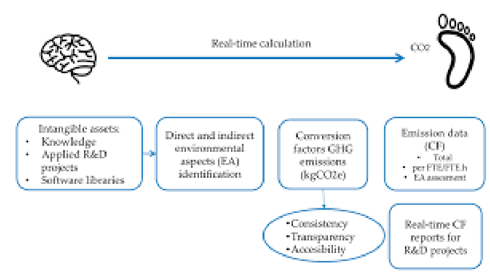
Contenuti del modulo (2)

- Linee guida per una progettazione ecosostenibile dei veicoli ferroviari: criteri di *eco-design* (Davide Bonaffini)



- Ciclo di vita e capacità ambientale dei sistemi di trasporto ferroviari (Stefano Ricci)

- Sistemi ferroviari e impronta ecologica. *Carbon footprint simulation* (Maria Eugenia Lopez Lambas)

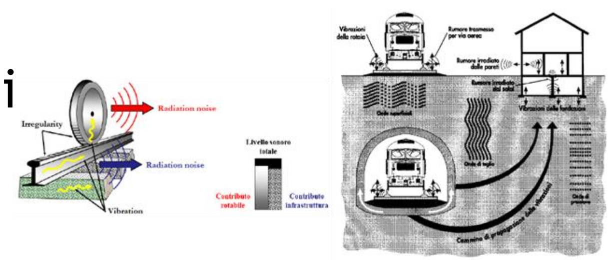


Contenuti del modulo (3)

- Normativa ambientale e sostenibilità. La Gestione delle terre e rocce da scavo nei progetti di RFI (Cinzia Giangrande, Francesca Cantù, Marco Fantozzi)

- Rumore prodotto dalle infrastrutture di trasporto: Quadro normativo nazionale e comunitario. Piano di Risanamento Acustico Nazionale di RFI e Piano d’azione ai sensi della direttiva europea (Cinzia Giangrande)

- Criteri per la redazione degli studi acustici e la progettazione degli interventi di mitigazione. Vibrazioni prodotte dal traffico ferroviario (Simone Relandini)



Master universitario di II livello in

Ingegneria delle Infrastrutture e dei Sistemi Ferroviari

Innovazione per la mobilità integrata

A.A. 2023/2024

Economics e soft skills

Luca Rizzetto (Sapienza Università di Roma)

Felice Santoli (Alstom)

Simonetta Serafini (Ferrovie dello Stato Italiane)

Corso promosso da

STAFFER

EUROPEAN RAIL SKILLS ALLIANCE

Incontro inaugurale del 26 febbraio 2024

Contenuti del modulo (1)

- Analisi Benefici Costi. Analisi multicriteria (Marco Antognoli)

Contenuti del modulo (2)

- Strumenti per la valutazione della sostenibilità economica: dal planning industriale al planning finanziario nelle infrastrutture ferroviarie (Matteo Agliocchi)

- Strumenti per la valutazione della sostenibilità economica : un caso applicativo per la gestione di un progetto di infrastruttura ferroviaria (Giulio Quojani)

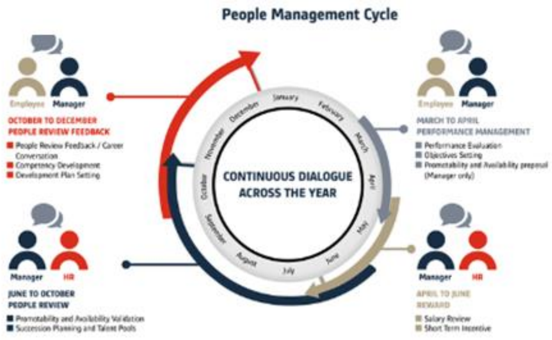
Contenuti del modulo (3)

- Lavorare in azienda. *Mind setting* (Simonetta Serafini)

- Le *top skills* richieste dalle aziende (Simonetta Serafini)

Contenti del modulo (4)

- Dagli Economics al Performance Management: un esempio applicativo (Felice Santoli)



- AIR value model: applicazione in una multinazionale del trasporto (Felice Santoli)

IV.10STAFFER - Summer school on “The European Railway System”

STAFFER

Summer School on “The European railway system”

Course Introduction

Luca Rizzetto

Università degli Studi di Roma "La Sapienza"

Rome, 10 July 2024

SAPIENZA UNIVERSITÀ DI ROMA

STAFFER EUROPEAN RAIL SKILLS ALLIANCE

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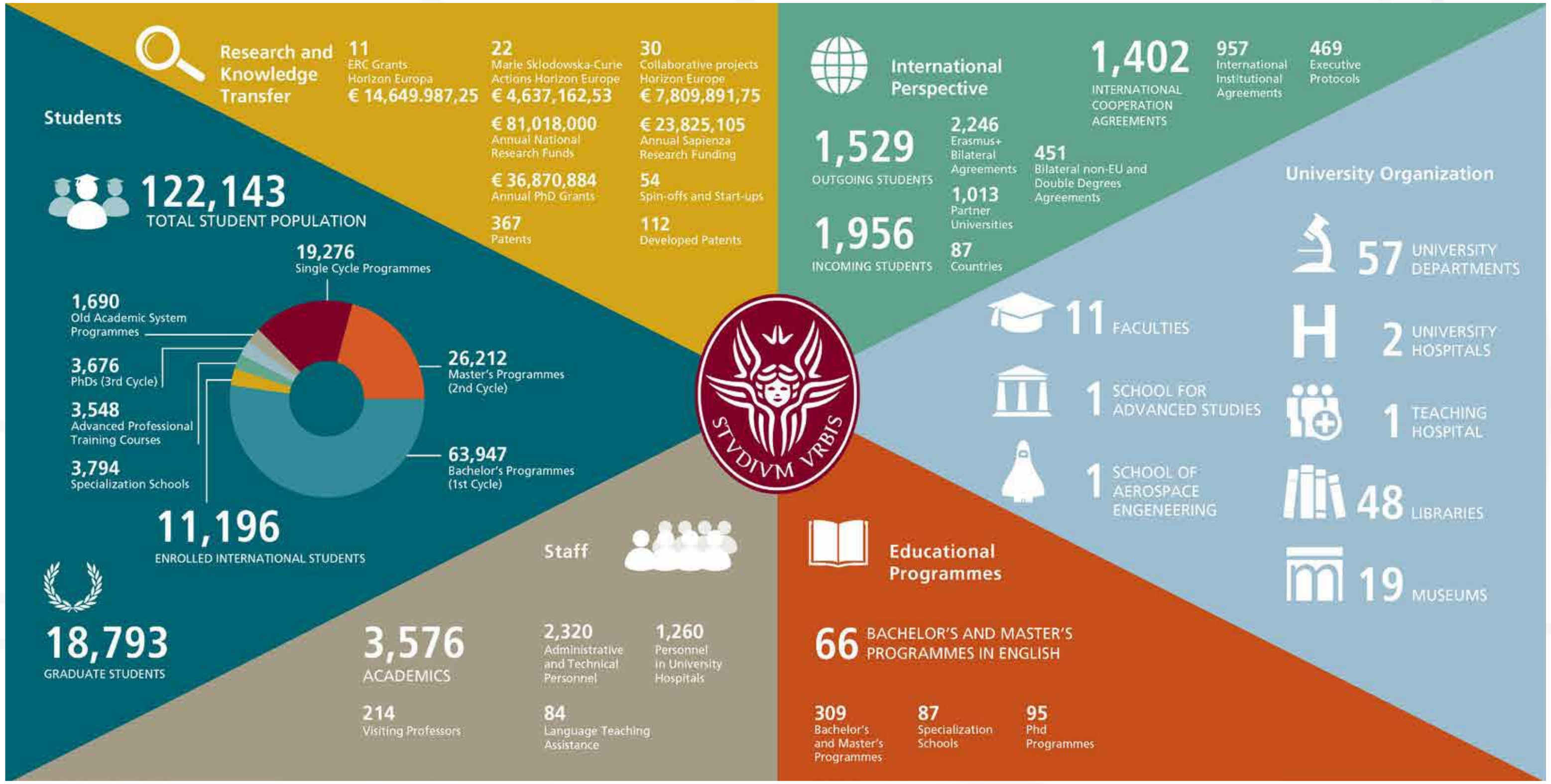
Sapienza University of Rome

- **Founded in 1303** by Pope Boniface VIII, Sapienza is the **oldest university in Rome** and **the largest in Europe.** Its mission is to contribute to the development of a knowledge society through research, excellence, quality education and international cooperation.
- Main facts and figures:
  - 721 years of history
  - 11 faculties
  - 57 departments
  - 122,143 students
  - 3,576 academics
  - 2,320 employees, technicians and librarians
  - 1,260 administrative staff in university hospitals



Co-funded by the Erasmus+ Programme of the European Union

Sapienza University of Rome

Faculty of Civil and Industrial Engineering

- Founded in 1817 by Pope Pius VII (www.ing.uniroma1.it/en)
- 6 Departments:
  - Astronautics, Electric and Energy Engineering
  - Chemical, Materials, Environment Engineering
  - **Civil, Building and Environmental Engineering**
  - Fundamental and Applied Sciences for Engineering
  - Mechanical and Aeronautics Engineering
  - Structural and Geotechnics Engineering
- 13 Bachelors (2 taught in English) - about 5500 students
- 17 Masters (14 taught in English) - about 3900 students
- 14 Post-Master Specialist Courses (3 taught in English) - about 200 students
- 4 PhD Courses – about 300 students

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Dept of Civil, Building and Environmental Engineering

(https://www.dicea.uniroma1.it/en)

- **14 Scientific-Disciplinary Areas:**
  Applied Geology and Hydrogeology - Applied Geophysics - Architectonic and Urban Composition - General and Applied Hygiene - Geodesy and Geomatics - Geo-technics - Hydraulic Constructions - Hydraulics - History of Architecture - Roads - Sanitary - Environmental Engineering -Technical Architecture - **Transport** - Urban Technics and Planning

- **4 Bachelor programmes:**
  Civil Engineering - Civil and Industrial Engineering (Latina Campus) - Environmental and Land-use Engineering-Sustainable Building Engineering (Rieti Campus) (taught in English)

- **6 Master programmes:**
  Building-Architectural Engineering - Civil Engineering - Environmental and Sustainable Development Engineering (Latina Campus) (taught in English) -Environmental and Land-use Engineering (taught in English) –Environmental and Sustainable Building Engineering (Rieti Campus) (taught in English) - **Transport Systems Engineering (taught in English)**

- **4 Post-Master Courses:**
  Construction and Management of Airport Infrastructures - Green BIM and Architectural Engineering - **Railway Infrastructures and Systems Engineering** - Sustainable Management of Integrated Hydric Services

- **3 PhD Courses:**
  Engineering Architecture and Urban Planning - Environmental and Hydraulic Engineering - **Infrastructures and Transport**

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EUROPEAN RAIL SKILLS ALLIANCE

Master Programme in Transport Systems Engineering

(https://web.uniroma1.it/cdaingtrasporti/)

- **Teaching Language:**
  English
- **Deployment:**
  2014-2024
- **Duration:**
  2 years (4 semesters), 120 ETCS
- **Compulsory modules:**
  Railway Engineering - Safety and Risk Analysis - Sustainable Transport Planning -Traffic Engineering and ITS -Transport Modeling and Planning - Urban and Regional Policy
- **Elective modules:**
  Air Transport -Freight Transport and Logistics -Geolocation and Navigation - Maritime Constructions - Maritime Transport -Programming for Transport Systems - **Public Transport Management** - Road Safety - Transport Infrastructures -Transport Policies - Transport Systems Design

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of the European Union

Post-Master Specialist Course in Railway Infrastructures and Systems Engineering

(https://web.uniroma1.it/masteriisf/)

- **Teaching Language:**
  Italian
- **Deployment:**
  2004-2024
- **Duration:**
  1 year, 60 ETCS
- **Multidisciplinary modules:**
  Basics of Rail Technics & Economy - Superstructure & Plants - Traction Systems & Vehicle Dynamics - Infrastructure Design -Traffic management - Safety Management - Service Planning & Quality - Planning & Legislation of works - Passengers & Freight Terminals - Projects Assessment & Environmental Impact - Economics & Soft Skills - Exchange of internship experiences
- **Partner Companies support:**
  Participation to candidate selection, teaching and hosting internships

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EUROPEAN RAIL SKILLS ALLIANCE

Summer School on "The European railway system"

Schedule – 1st week

<table>
<tr><th>Day</th><th>Time</th><th>Activities</th></tr>
<tr><td rowspan="3">Wednesday 10/07/2024</td><td>15-16.30</td><td>Room 1 - Welcome event
• Introductory speeches by:
o Francesco Napolitano (Sapienza University of Rome)
o Angela Di Febbraro (University of Genoa and STAFFER Coordinator)
o Italian STAFFER partner companies: Vito Pagliarisi (Ferrovie dello Stato Italiane), Pietro Marmo (Hitachi Rail), Marco Barale (Alstom)
• Reciprocal presentations by students and teachers</td></tr>
<tr><td>16.30-18.30</td><td>Room 1 - "A sustainable, safe European transport system without frontiers" – Anna Gigantino (ERA - European Agency for Railways)</td></tr>
<tr><td>19-20.30</td><td>Faculty Cloister - Social dinner</td></tr>
<tr><td rowspan="2">Thursday 11/07/2024</td><td>9-13</td><td>Room 15 - "Interoperability of the European railway system" – Anna Gigantino (ERA - European Agency for Railways)</td></tr>
<tr><td>15-18</td><td>Guided visit of RFI traffic control centre at Roma Termini station</td></tr>
<tr><td>Friday 12/07/2024</td><td>8-19</td><td>• Roma-Napoli transfer by high-speed train
• Seminar on historical, cultural and touristic activities of Fondazione FS with a focus on the adaptation of historic rolling stock to modern control command and signalling systems
• Guided visit of the historical-technical national railway museum in Pietrarsa
• Transfer Napoli-Roma transfer by high-speed train</td></tr>
<tr><td>Saturday 13/07/2024</td><td>-</td><td>Free time</td></tr>
<tr><td>Sunday 14/07/2024</td><td>-</td><td>Free time</td></tr>
</table>

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STAFFER
EUROPEAN RAIL SKILLS ALLIANCE

Summer School on "The European railway system"

Schedule – 2nd week

Day	Time	Activities
Monday 15/07/2024	9-13	Room 15 - "Historical evolution of railway signalling system in Italy towards ERTMS/ETCS" – Riccardo Licciardello *(Sapienza University of Rome)*
	15-18	Visit to Alstom "command, control and signalling systems" laboratory in Rome
	21-22.30	Forum of Caesar show: journey through ancient Rome
Tuesday 16/07/2024	9-12	Room 15 - "Safety management and risk assessment in European railways" – Marco Antognoli, Luca Rizzetto *(Sapienza University of Rome)*
	12-13	Room 15 - Railway Engineering Education in Europe: experiences from Erasmus+ projects, Stefano Ricci *(Sapienza University of Rome)*
	15-18	Guided visit of Trenitalia and RFI operation control rooms
Wednesday 17/07/2024	9-11	"Sustainable Powertrains and Green Mobility in Rail Transport" – Khaled Itani *(Le Cnam)*
	11-13	"Difficult choices – which alternative for which application?" – Michael Lehmann *(University of Applied Science Erfurt)*
	15-18	Guided technical visit of control centre and depot of the fully automated metro line C
Thursday 18/07/2024	9.30-17.30	Roma- Napoli Afragola transfer by high-speed train Guided visit to construction sites of the new Napoli-Bari high-speed railway line Napoli Afragola-Roma transfer by high-speed train
Friday 19/07/2024	9-13	Guided visit of Trenitalia maintenance facility and regional train dynamic driving simulator at Roma Smistamento
	14-16	Room 15 - Interactive session with individual impressions of students

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Summer School on “The European railway system”

Sapienza Team


Marco ANTOGNOLI


Peyman ASMARI


Arbra BARDHI


Massimiliano BRUNER


Mary Joan CROWLEY


Olga GOTALAY


Riccardo LICCIARDELLO


Andrea QUATTRINI


Stefano RICCI


Luca RIZZETTO

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Summer School on "The European railway system"

Teachers

Anna GIGANTINO

EUROPEAN UNION AGENCY FOR RAILWAYS

Head of Monitoring, Analysis, Research and Stakeholders Unit (MARS)

Khaled ITANI

le cnam

Technical manager of STAFFER at CNAM
Lecturer and Researcher in Electromobility

Michael LEHMANN

FHE FACHHOCHSCHULE ERFURT UNIVERSITY OF APPLIED SCIENCES

Program Director of the International Continuing Academic Education Master's in European Railway Systems (M.Sc.)

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Summer School on "The European railway system"

Students

Austria – fh st. pölten

Jakob Fujio	MÜLLER

France – le cnam

Ahcene	AIT AKLI
Nabil	ALLAL
Kévin	BLOC
Ikram	EL-ANBARI
Géraldine	FRANCOIS
Omaid	OMAR
Alexis	RABY

Germany – Technische Universität Dresden

Jacob Maximilian	KALLERT
Fabian Elias	RUDOLPH
Arthur Johannes	SUCKOW

Fachhochschule Erfurt University of Applied Sciences

Jannis	BODE
Gregor	PINKHASIK
Sören	RANG

Italy – Sapienza Università di Roma

Anahita	ABBASI ANBOUHI
Sepehr	ABDI GOUDARZI
Aneesh	BASNET
Sevket Oguz Kagan	CAPKIN
Golnoosh	GHIYAEI
Narjes	MAHBOUBIZADEH
Shahab Aldin	MANSOURI
Bahadir	SARITAS
Pradip	SUBEDI
Siva Sai Hoshitha	TANIMKI

Università degli Studi Niccolò Cusano

Tejas Singri	KRISHNAMURTHY

Serbia – University of Belgrade

Tamara	KURĆUBIĆ
Bojan	MIRKOVIC
Sergej	SREĆKOVIĆ

Croatia – Universitas Studiorum Zagrabiensis

Silvestar	GRABUŠIĆ
Franka	MEŠTROVIĆ

Slovenia – Univerza v Ljubljani

Matej	HOČEVAR
Matevž	MRZEL

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A sustainable and safe European transport system without frontiers

Summer School on the European Railway System

10.07.2024 | "La Sapienza", Rome | Anna Gigantino

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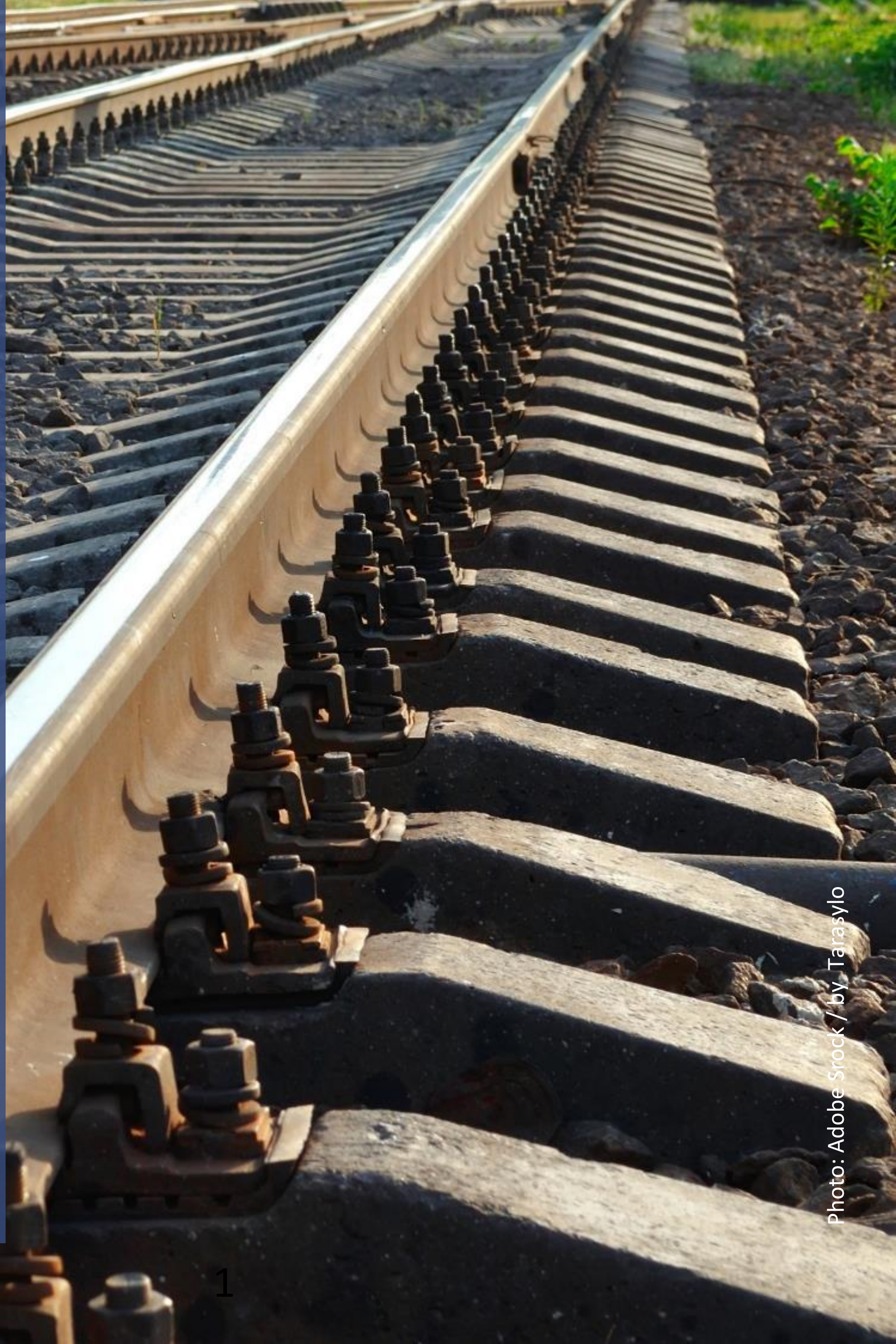

Photo: Adobe Stock / by Tarasylo

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Outline

The global geopolitical landscape

The EU institutions and transport policies

The Trans-European networks

Railway players, ERA role and mission

The target system and railway R&I

Q&A

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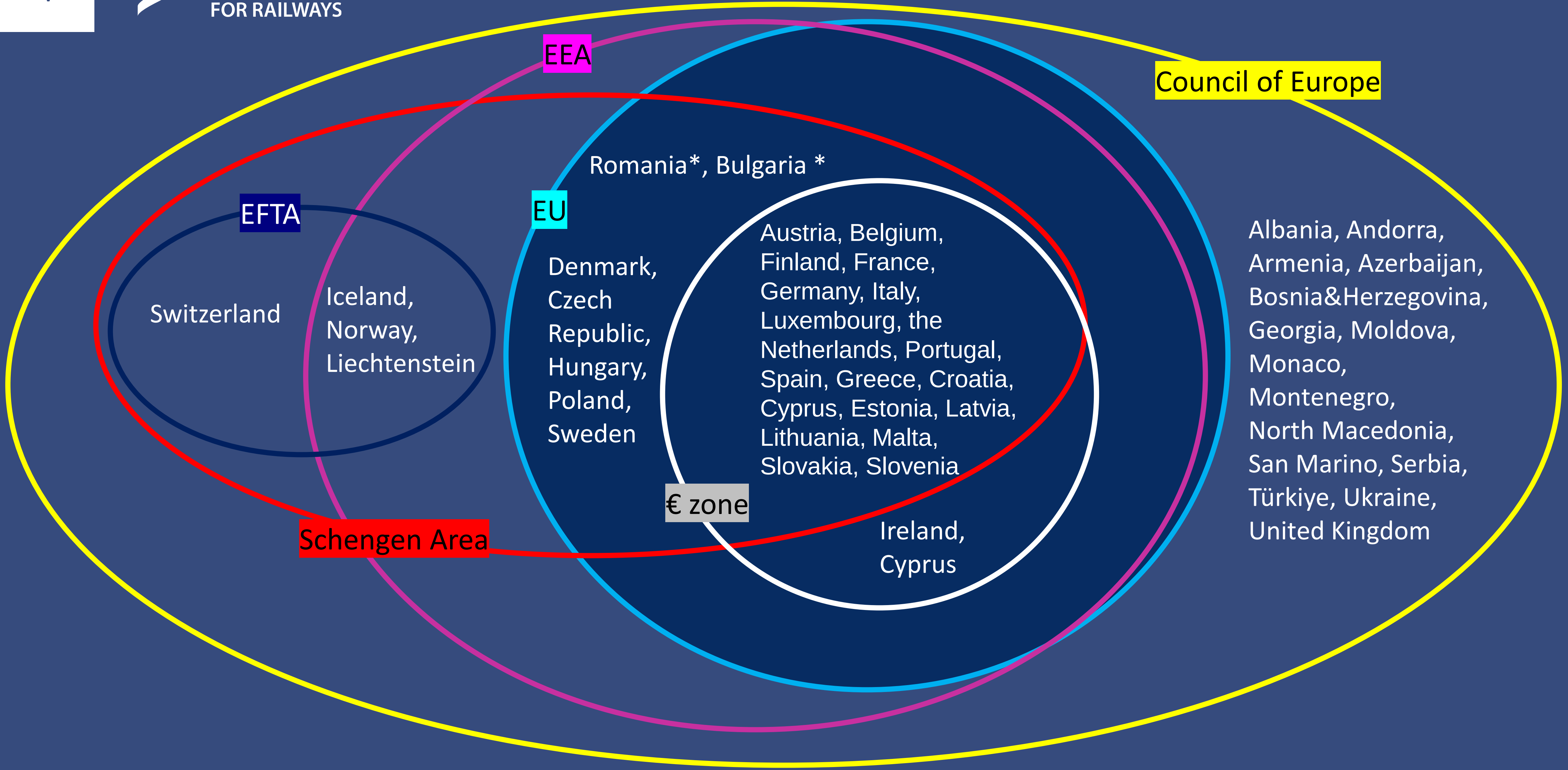
Why are we here?

EUROPEAN UNION AGENCY FOR RAILWAYS

EUROPE IS SIMPLE ☺



* Bulgaria and Romania have air and maritime borders open, with land border controls remaining in place pending agreement to lift them.

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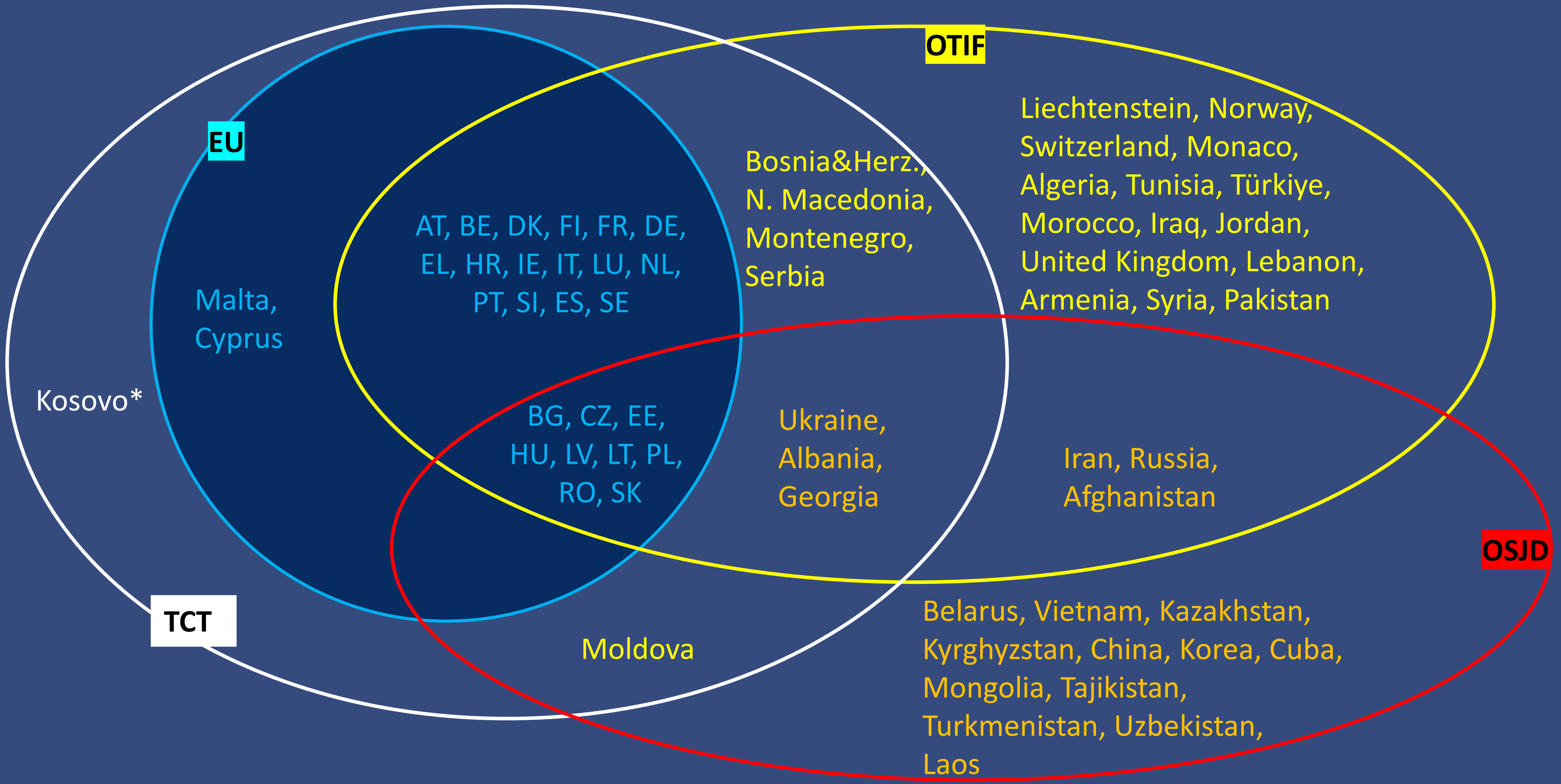
International: beyond the EU



The EU in a nutshell: timeline

- In 1951, six countries (BE, FR, DE, IT, LU, NL) founded the European Coal and Steel Community.
- In 1958, this became the European Economic Community (EEC)
- In 1993, its name was changed to the **European Union.**
- Over the years, 22 more countries joined the original 6.
- *On 1 February 2020, the United Kingdom left the EU.*

- Since 1985, the Schengen area allows people and businesses to travel and operate without border checks. It began in June 1985 with 5 countries. Today it contains most EU countries (all, except BG, CY, IE and RO) and 4 non-EU countries (Iceland, Norway, Switzerland and Liechtenstein). Schengen countries have also strengthened security at their common external border.

- The EU currently has 27 member countries and has 24 official languages.

- *More on EU history: History of the EU (europa.eu)*

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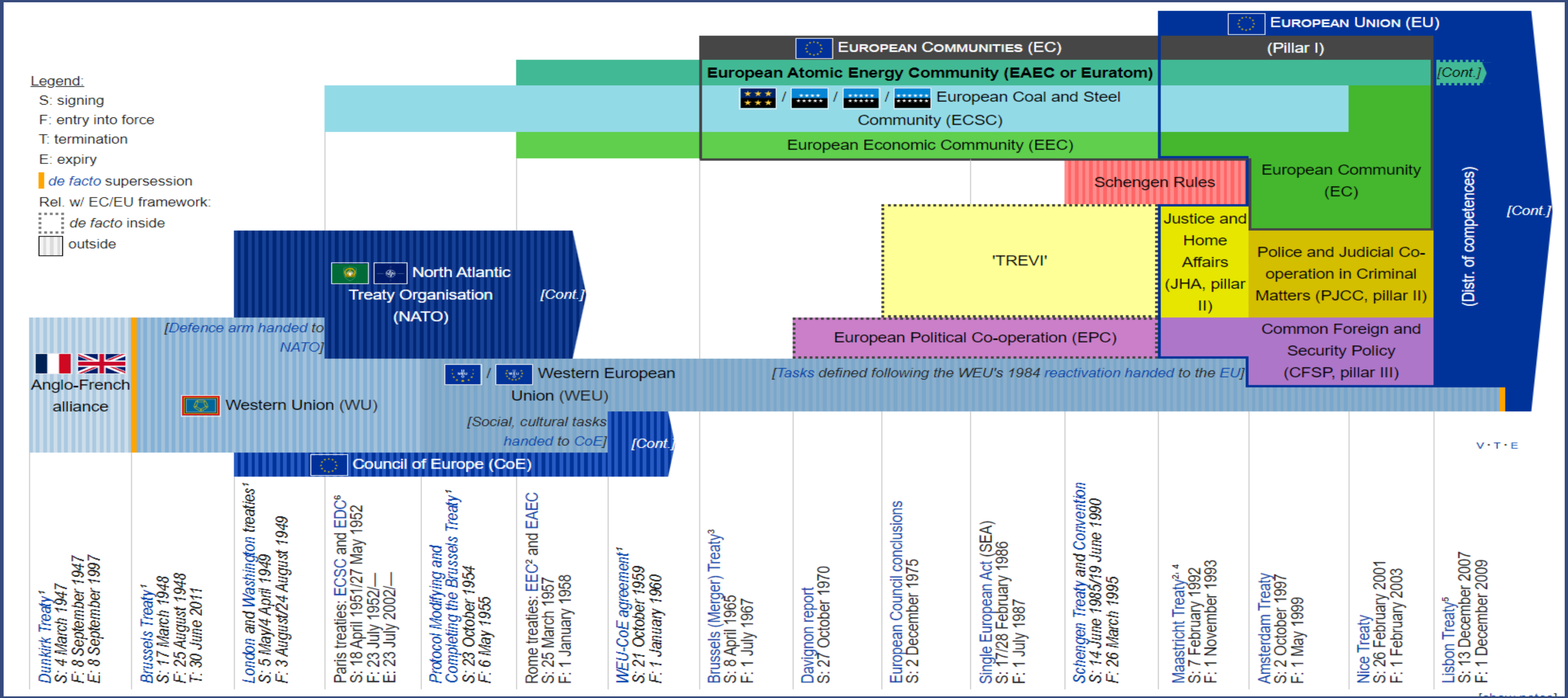
The EU in a nutshell: evolution / policies



Source: European Atomic Energy Community - Wikipedia

The 4 Freedoms of the EU

Image credits: The Financial Times

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Main EU institutions

European Council

(27 heads of State and government)

European Commission

(27 commissioners)

Council of the EU

(27 ministers)

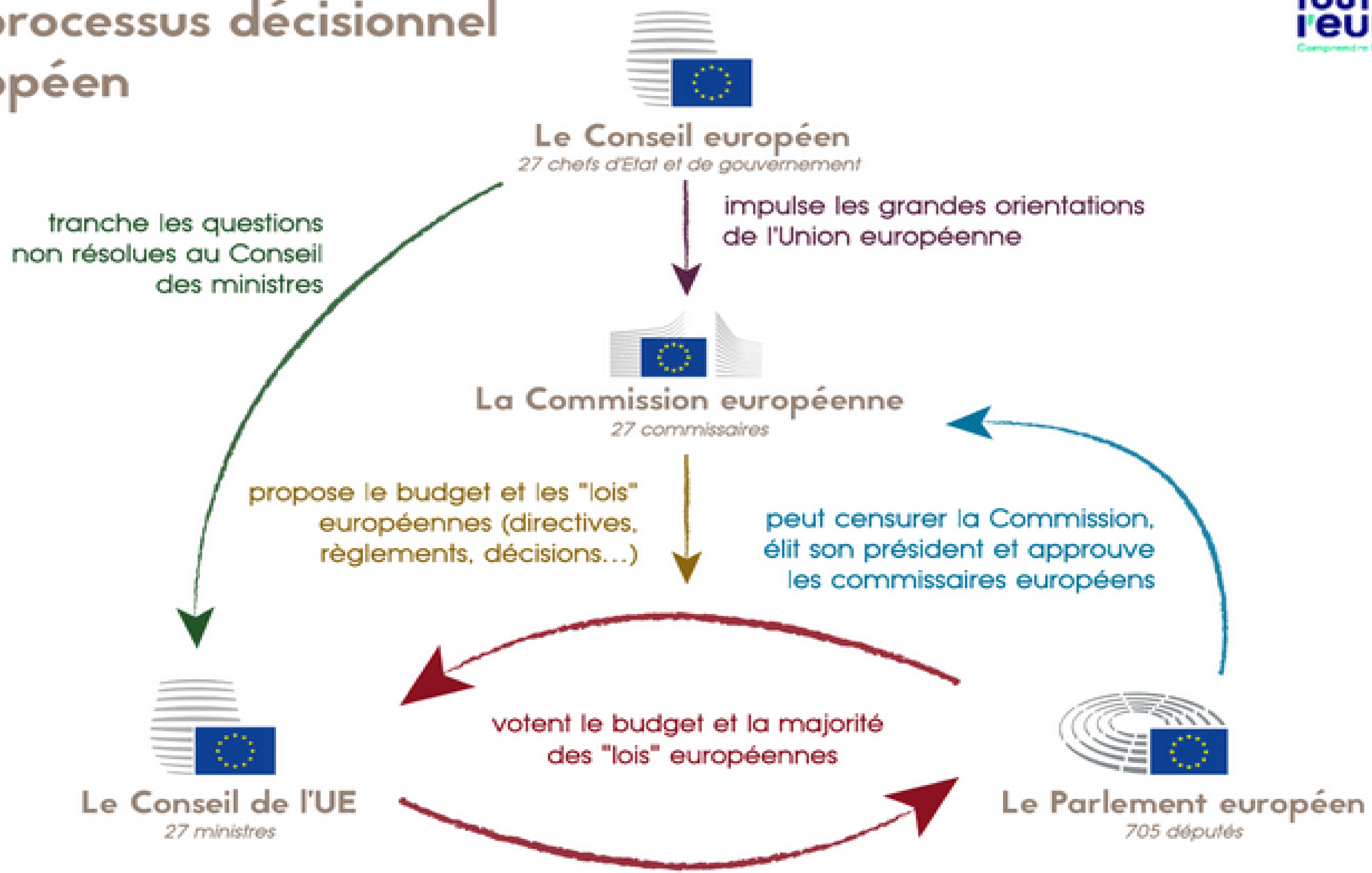
European Parliament

(705 deputies)

Decentralised Agencies

Le processus décisionnel européen

toute l'europe



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The EU in a nutshell: the Agencies

- An **agency of the European Union** is a decentralised body of the European Union (EU), which is distinct from the institutions.
- Agencies are established to accomplish specific tasks.
- Each agency has its own legal personality.
- Some develop scientific or technical know-how in certain fields, others bring together different interest groups to facilitate dialogue at European and international level.

Source: Agencies of the European Union - Wikipedia

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Trans-European Networks TENs

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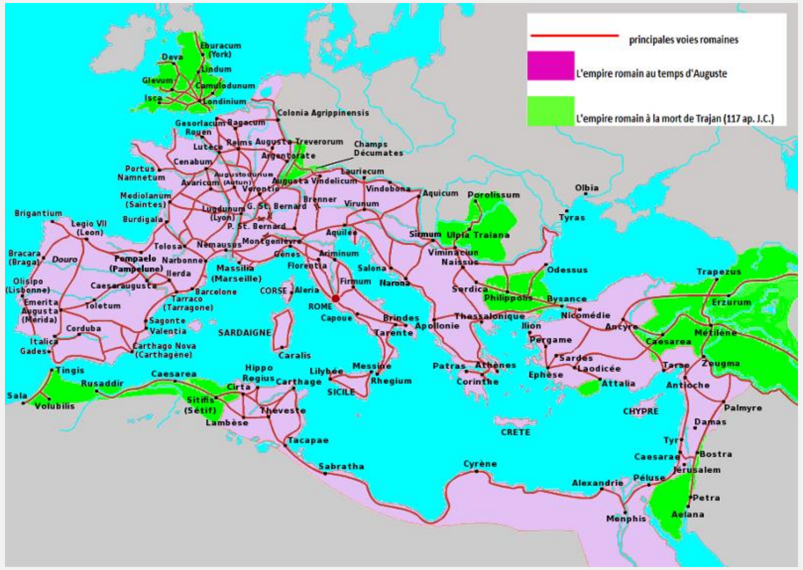
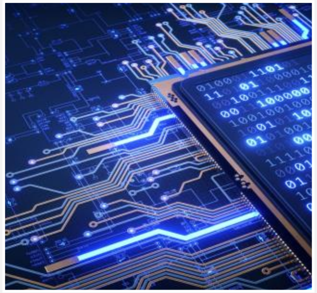


Why does EU need TENs?

Transport

Single market



Telecom

Energy

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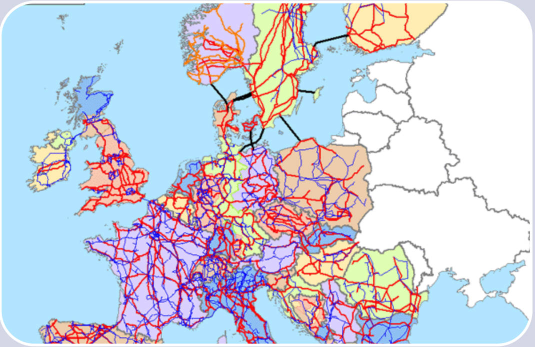
TEN Energy



Electricity

Natural gas

Oil

Single market

Security of supply

11 priority corridors

3 priority thematic areas

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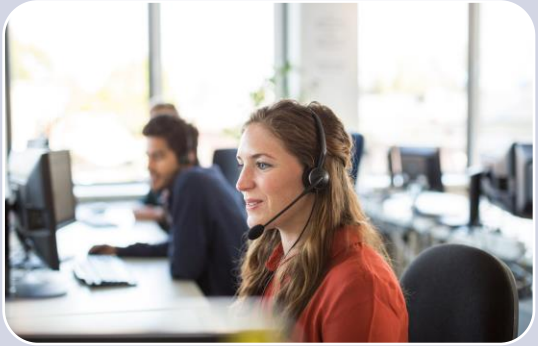
TEN Telecommunication



Deployment of TEN e-services:
e-health
e-learning
e-government

CEF Digital

Public & Private investments in digital infrastructures

Gigabit
5G network

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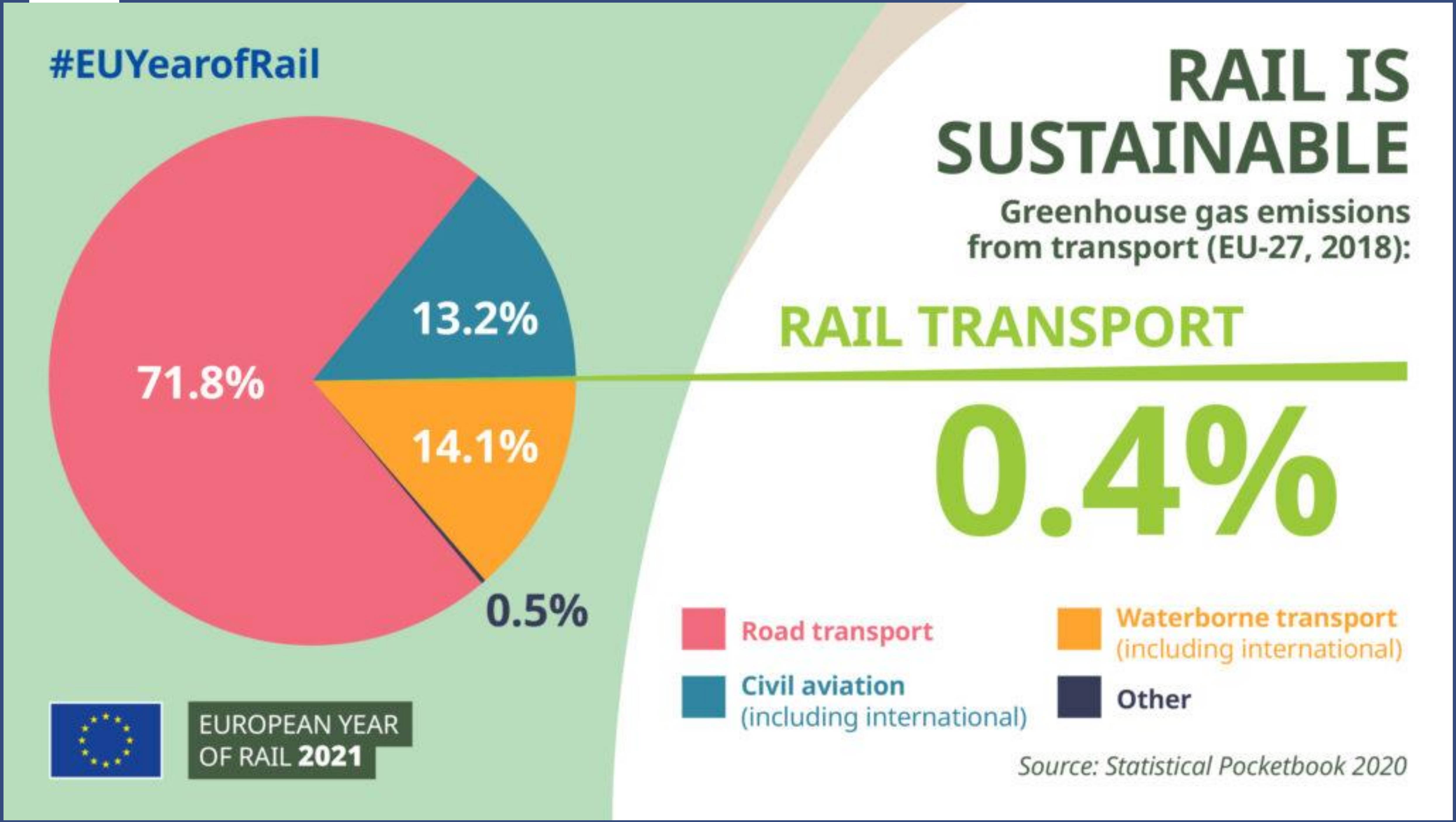
TEN Transport

9 Corridors

Inland waterways
Railways
Roads
Urban nodes
Airports
Ports
Rail-road terminals

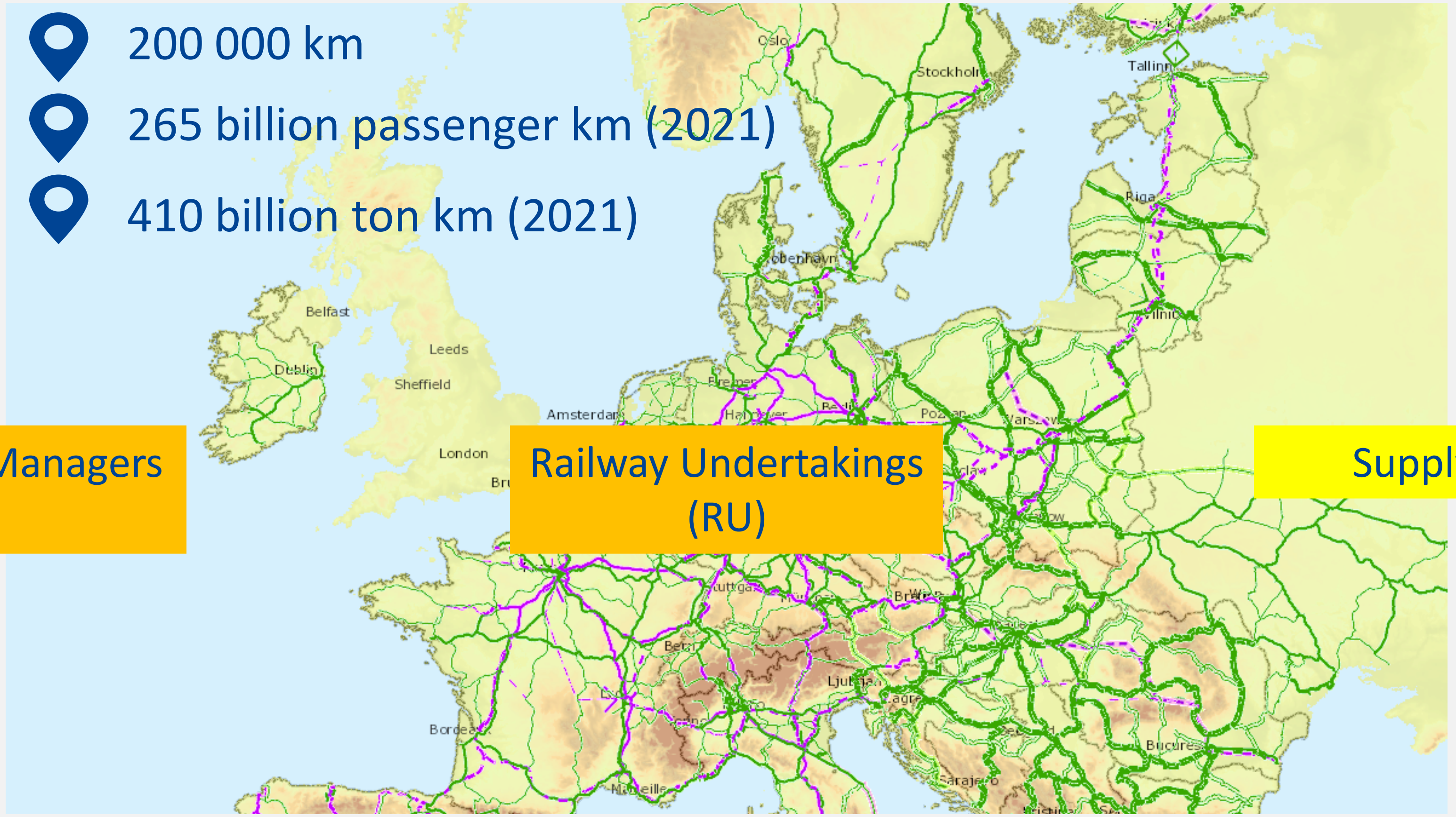
Projects
Actions


#EUYearofRail
RAIL IS SUSTAINABLE
Greenhouse gas emissions from transport (EU-27, 2018):
RAIL TRANSPORT
0.4%
71.8%
13.2%
14.1%
0.5%
Road transport
Civil aviation (including international)
Waterborne transport (including international)
Other
Source: Statistical Pocketbook 2020
EUROPEAN YEAR OF RAIL 2021

EUROPEAN UNION AGENCY FOR RAILWAYS

The Railway System of the European Union

- 200 000 km
- 265 billion passenger km (2021)
- 410 billion ton km (2021)



Infrastructure Managers (IM)

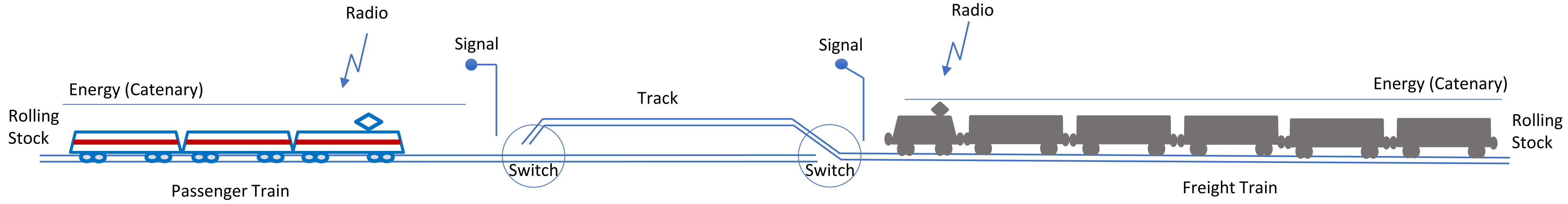
Railway Undertakings (RU)

Supply Chain

EUROPEAN UNION AGENCY FOR RAILWAYS

The Railway System

Control/Command – Signalling (CCS) System



Rolling Stock

People

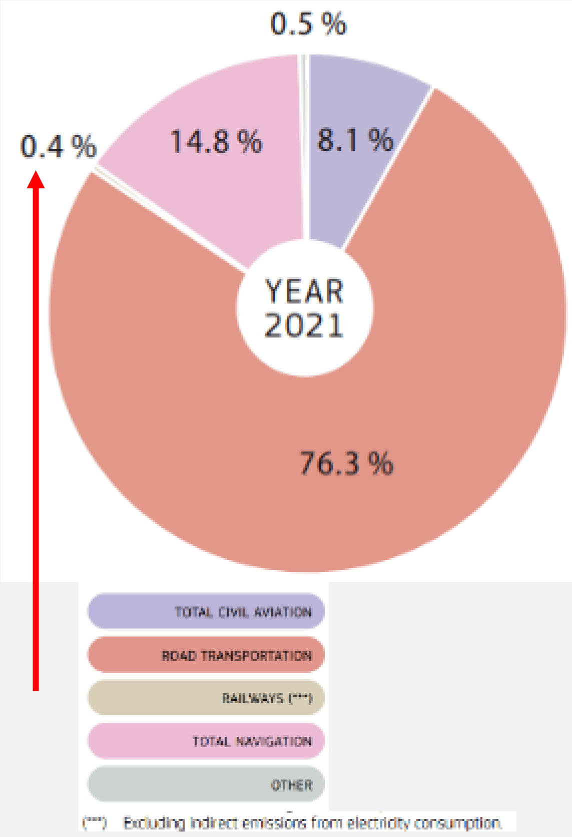
Infrastructure

Rail in the EU:

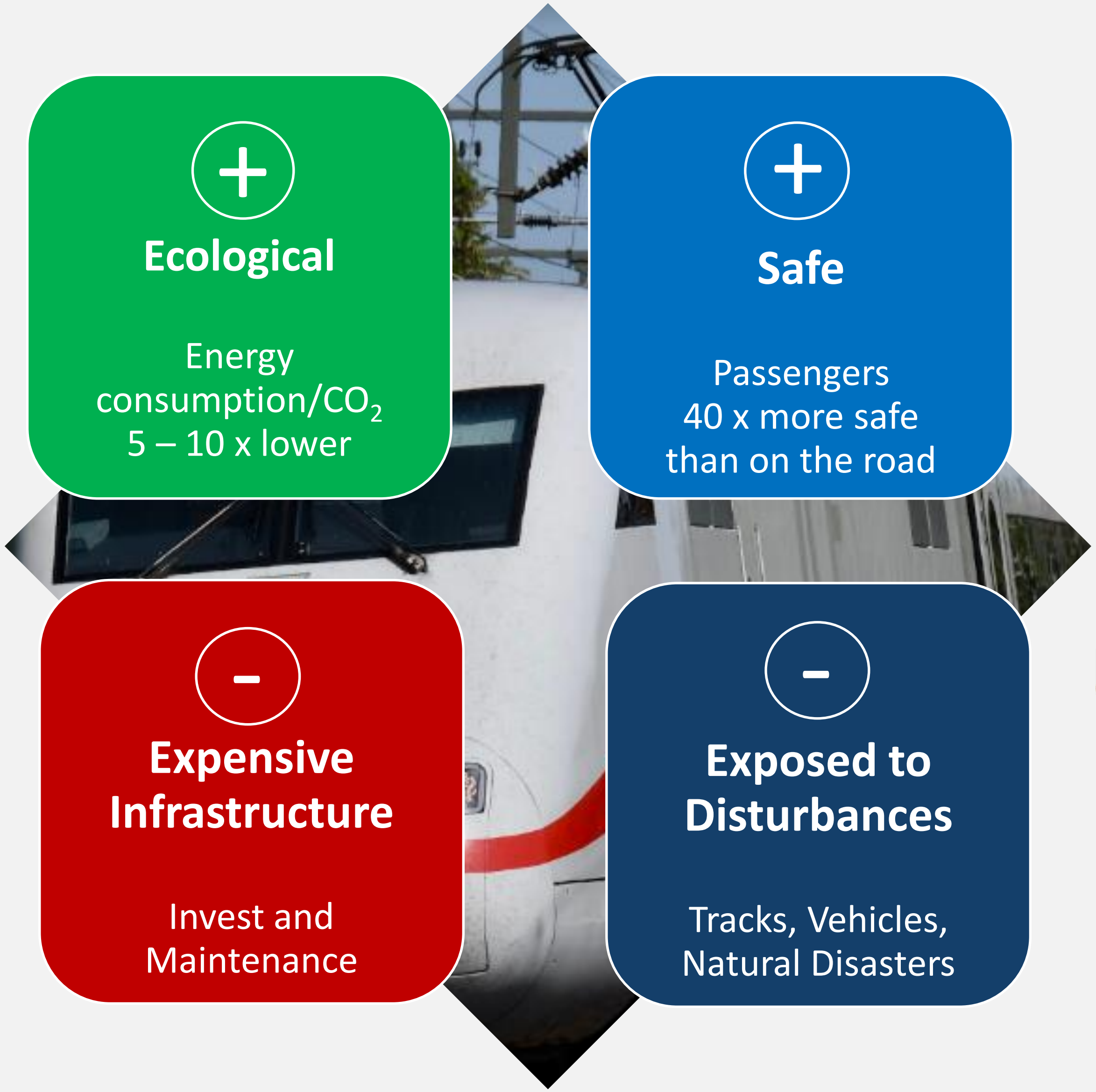
- 200 000 km
- 265 billion passenger km (2021)
- 410 billion ton km (2021)

EUROPEAN UNION AGENCY FOR RAILWAYS

The Challenge for Railways in Europe



GHG-Emissions Transport (EU-27)



+ Ecological

Energy consumption/CO_2 5 – 10 x lower

+ Safe

Passengers 40 x more safe than on the road

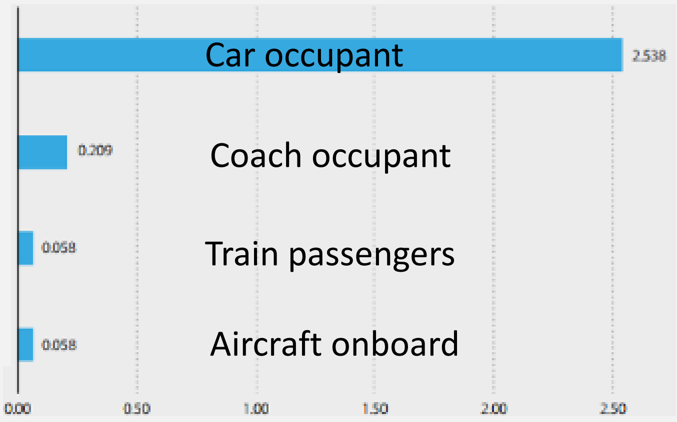
- Expensive Infrastructure

Invest and Maintenance

- Exposed to Disturbances

Tracks, Vehicles, Natural Disasters

Onboard fatalities per billion passenger km



Safety of Transport Modes (EU-27, 2015 - 2019)

Source: EU Transport in Figures, Statistical Pocketbook 2023

Source: Report on Railway Safety and Interoperability in the EU, ERA, 2022

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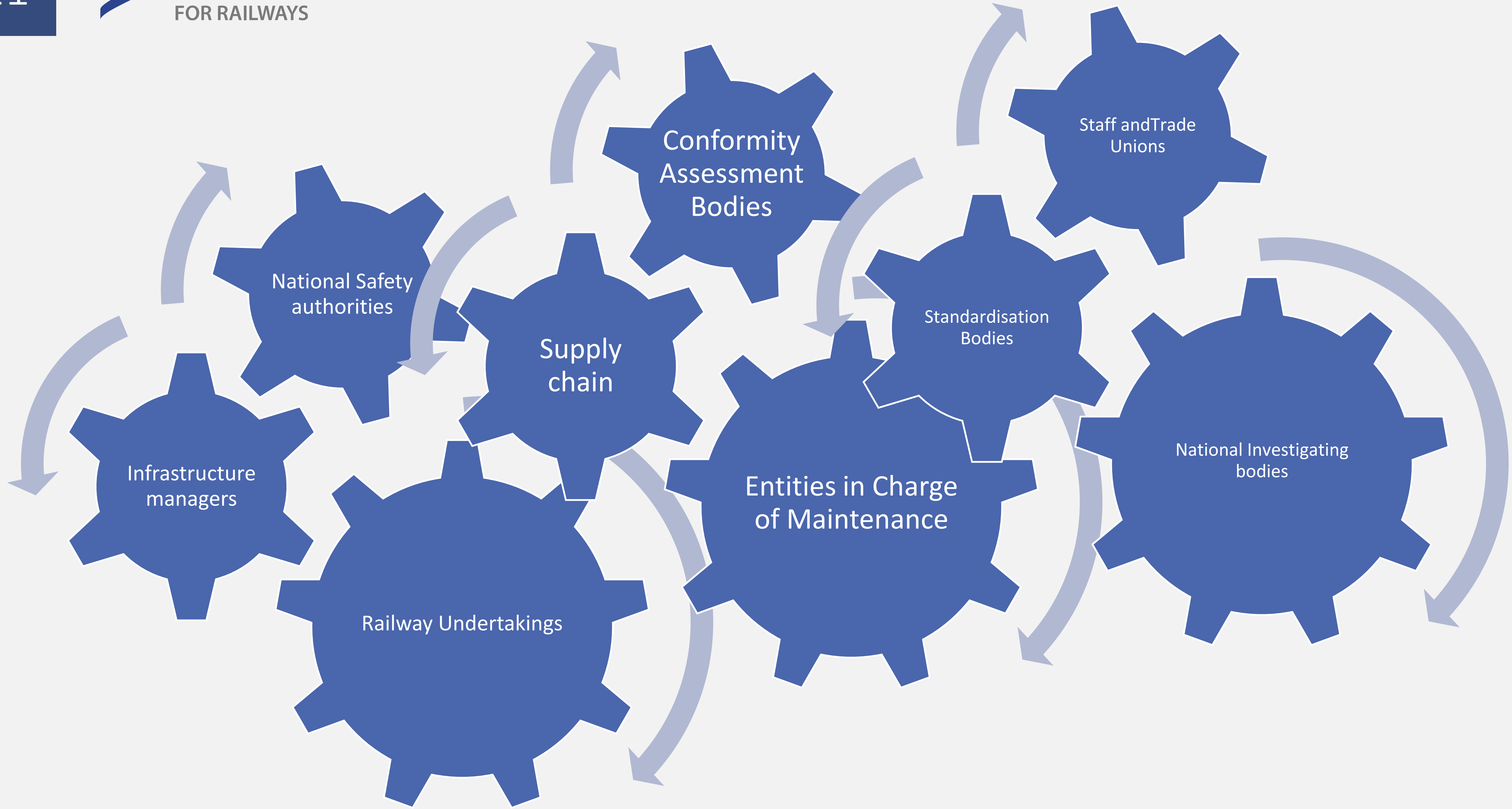

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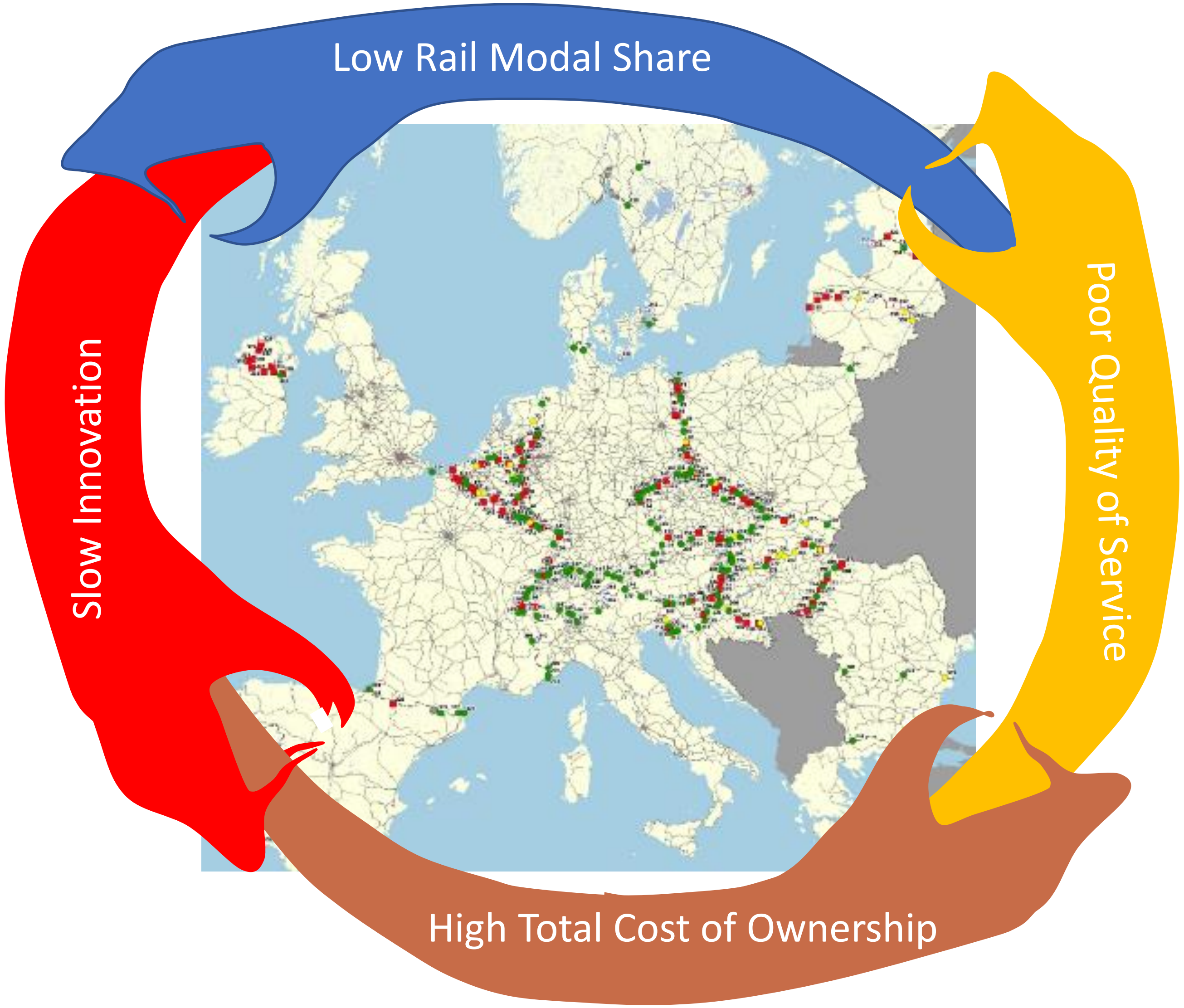
Fragmentation Impairs Competitiveness of Rail



- Fragmentation of operations
- Fragmentation of governance
- “Political economy” – socio-economic value

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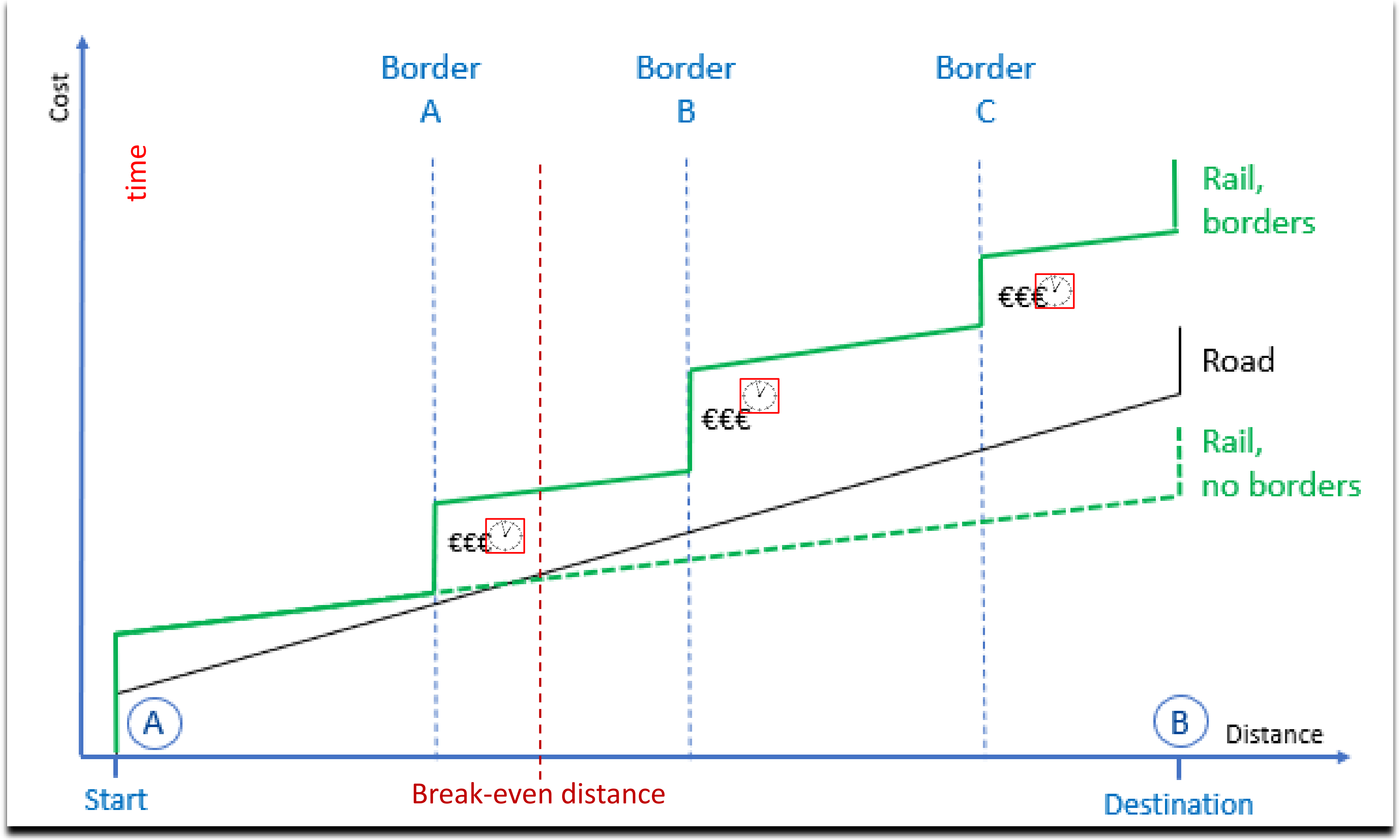
Cross-Border is the Critical Issue for Rail in the EU



- Language
- National Rules
- Timetable mismatch
- Capacity mismatch
- Priority mismatch
- Divergent financial models
- Change of train number
- No real-time communication
- Works not coordinated

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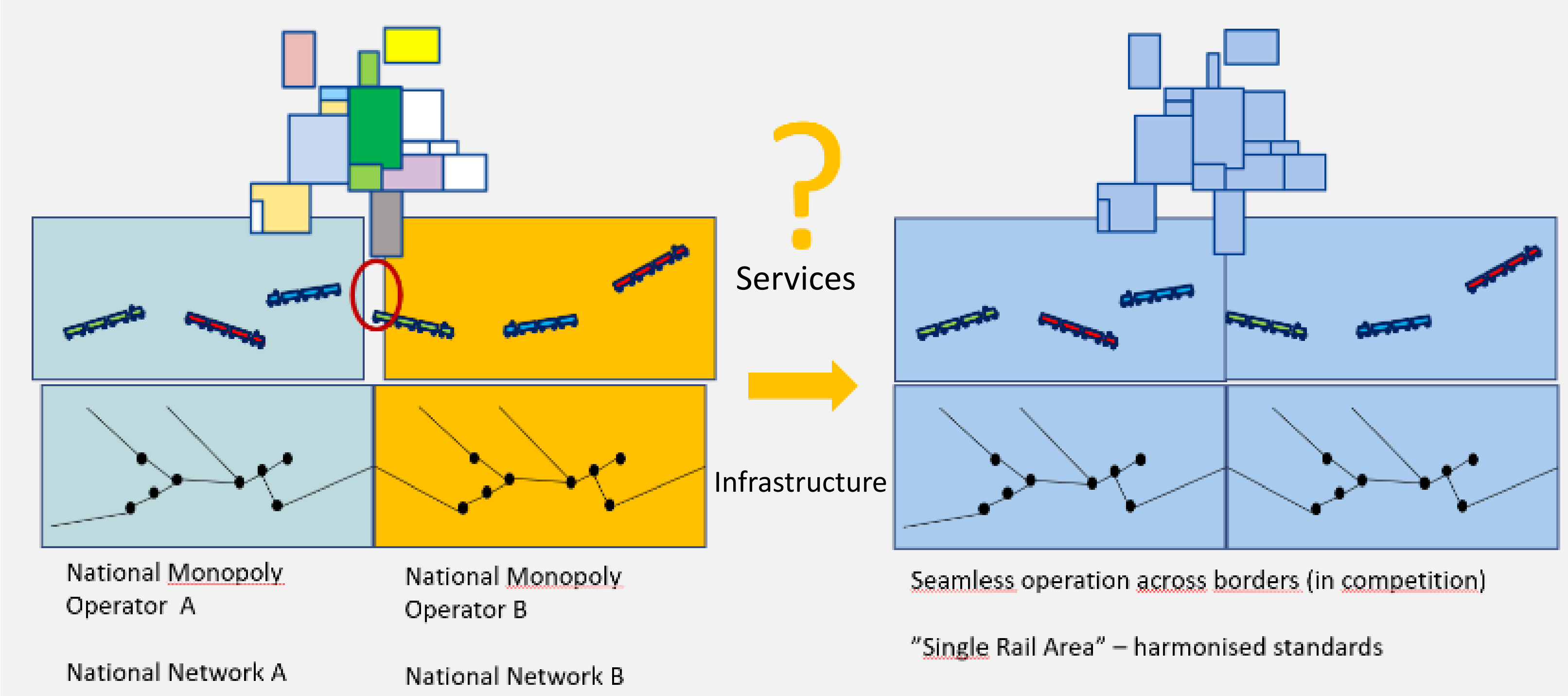
The Single European Railway Area (SERA)



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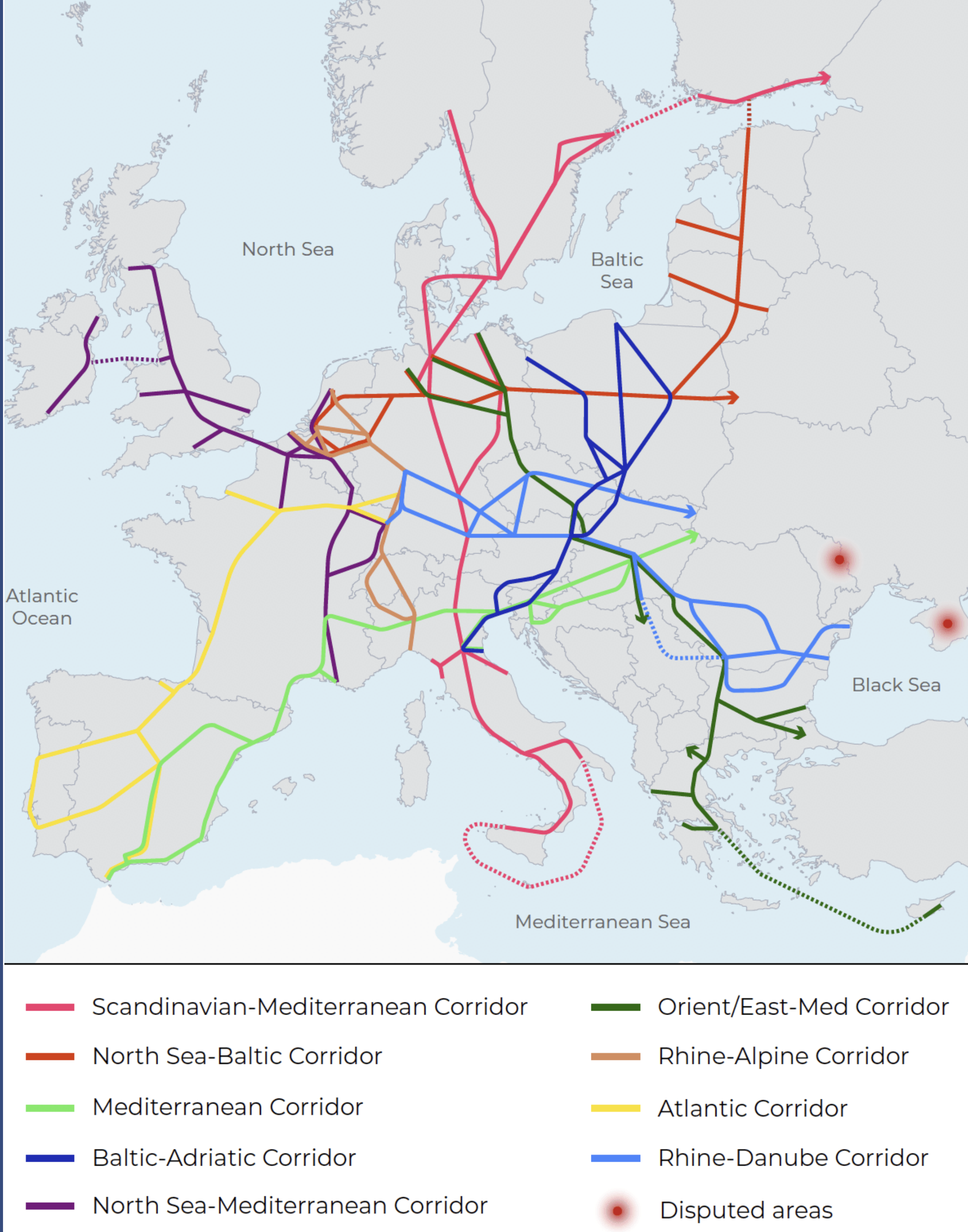
Rail Resilience/ Military Mobility

Climate Crisis

Heavy rain, flooding, storms, extreme temperatures – rail infrastructure increasingly vulnerable to effects of climate crisis

Political Crisis

ERA is getting ready to support the European Defence Union



Rail – the Sustainable Mode of Transport

ERA Environmental Report
(to be published on 2 July 2024)

1. Overview of railway transport in the EU

A/ European objectives for railway transport
B/ Transport trends in the EU
C/ Railway fleet composition
D/ EU rail network

2. Railway environmental impacts

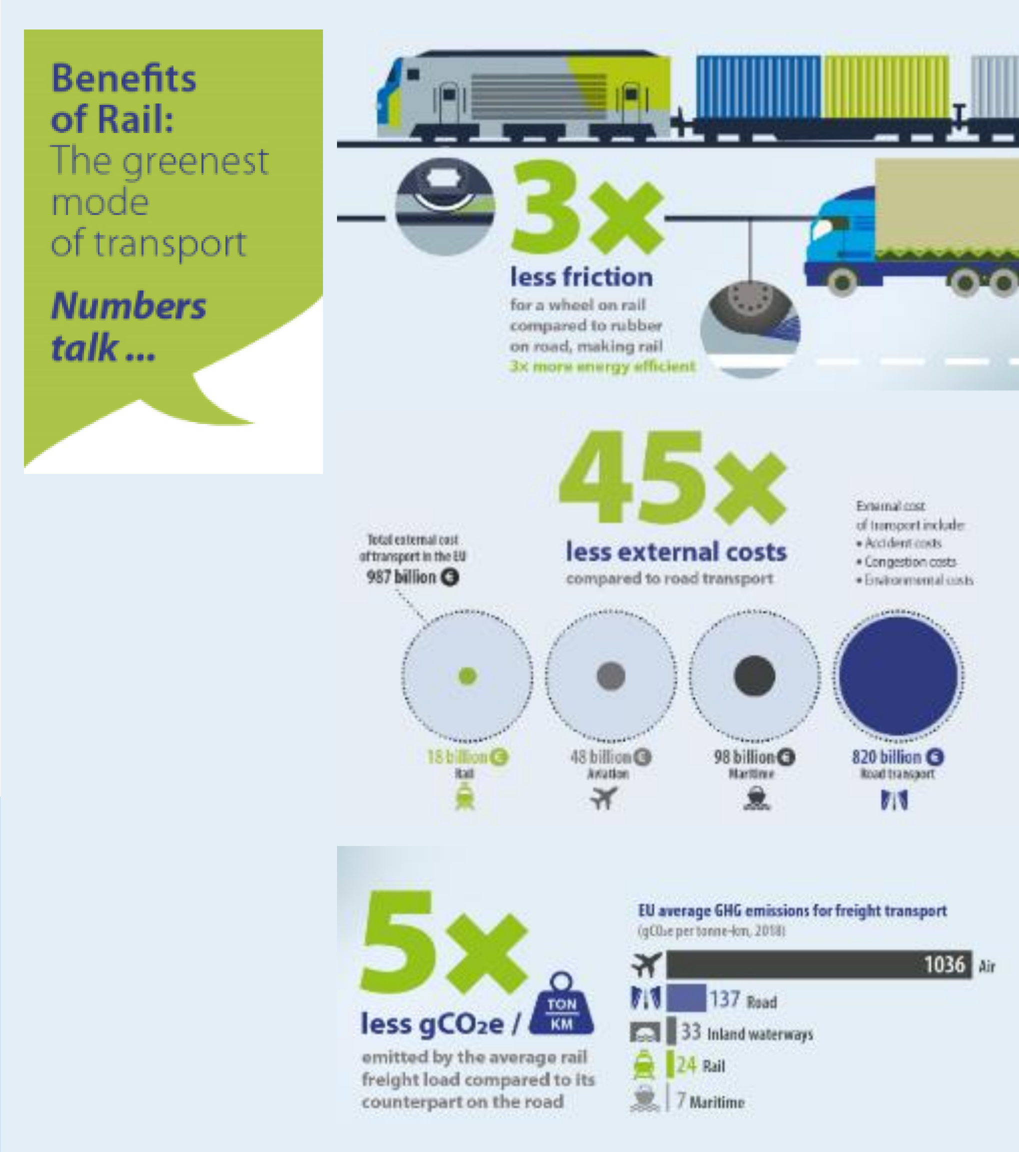
A/ Noise and vibrations
B/ GHG emissions and air pollutants
C/ Land occupancy
D/ Nature conservation and biodiversity
E/ External costs in a comparative approach

3. Railway and transport path to sustainability

A/ Measures against railway noise
B/ Rail electrification
C/ Rail innovation
D/ Modal shift to rail

4. Adapting the transport system to the climate evolution

A/ Rail resilience
B/ Multimodality



A Time-line of EU Railway legislation

2001

European Commission's White paper
A strategy for revitalising the Community's railways

2001

Rail infrastructure package
- levying of charges for the use of railway infrastructure
- licensing of railway undertakings

2004

Second railway package
- Interoperability and Safety Directives
- Establishment of ERA

2007

Third railway package
- Access rights rail freight service from 2007
- Opening of the international passenger transport service market from 2010

2008

- Interoperability Directive **extended to the whole EU Network**
- Directive 2008/110/EC amending Safety Directive:
  duties for entity in charge of maintenance (ECM)

2016

Fourth Railway Package
- Recast of all major railway Directives
- Single EU wide vehicle authorisation and certification

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EU Transport policy for railways

Improve competitiveness of rail with other modes to increase the market share of the most environment-friendly mode of transport

Spend public money more efficiently on public rail transport services

Encourage market entry by reducing administrative and technical barriers

Open domestic rail passenger transport to competition

Encourage market entry and ensure non – discrimination through a better governance of the infrastructure

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Questions

How are the EU « laws » defined and adopted ?

Which are the weak/strong points of railways?

Why the EU is so interested in railways?

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Wrap-up

- Rail is by far the most **energy-efficient** mode of transport, and **very safe**
- Modal share of rail in Europe is low – modal shift needs **targeted investment** in a coherent, integrated European network
- Europeanisation – from national patchwork to a **European network** – standardization and interoperability
- ERA as System Authority and as Authorising Entity supports the transformation to the **Single European Railway Area**
- **Multimodal integration** (transport chains)
- **Digitalisation** - intelligent railway network
- Safety can be further improved by open sharing of safety and safety performance data, to further develop the **Safety Management System (SMS)** to control the **risks** of operational activities

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Why do we need Rail research?

- Slow uptake of innovation in rail
- Need to define an EU Target rail system
- Innovative solutions
- A Compelling vision for the EU target rail system

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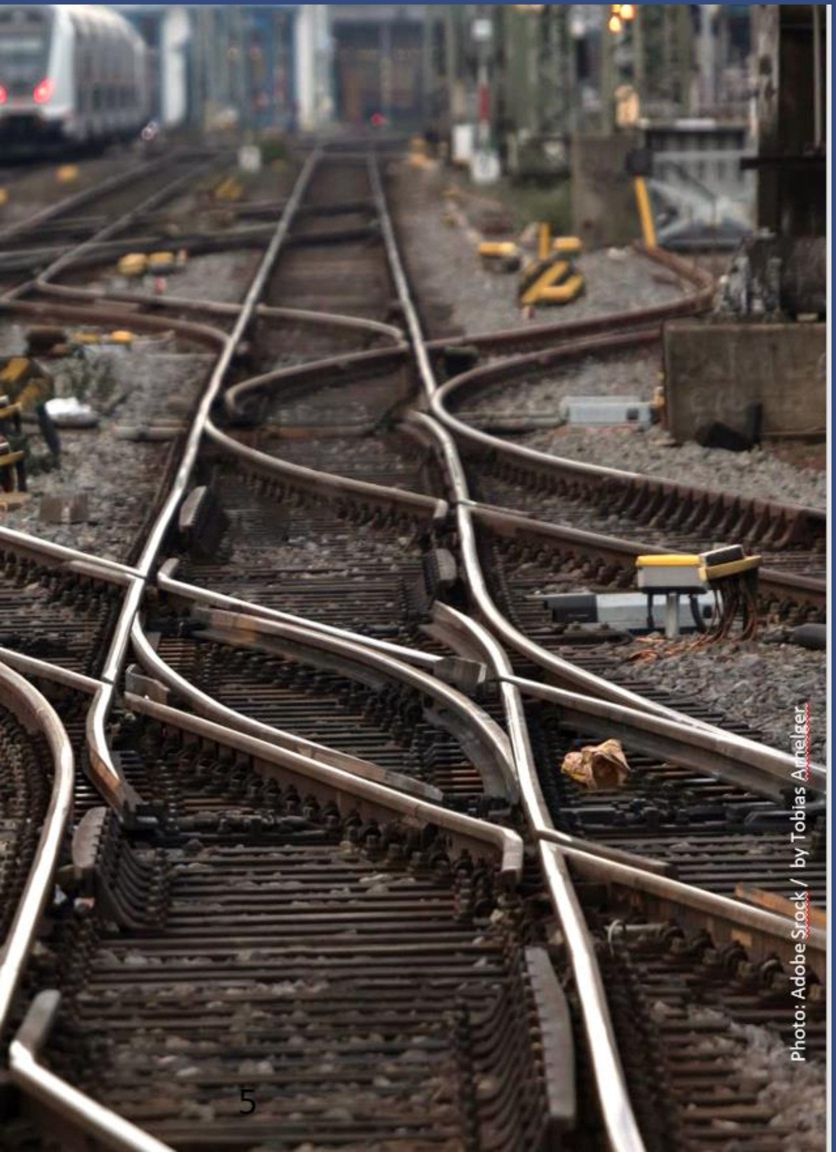
The target railway system



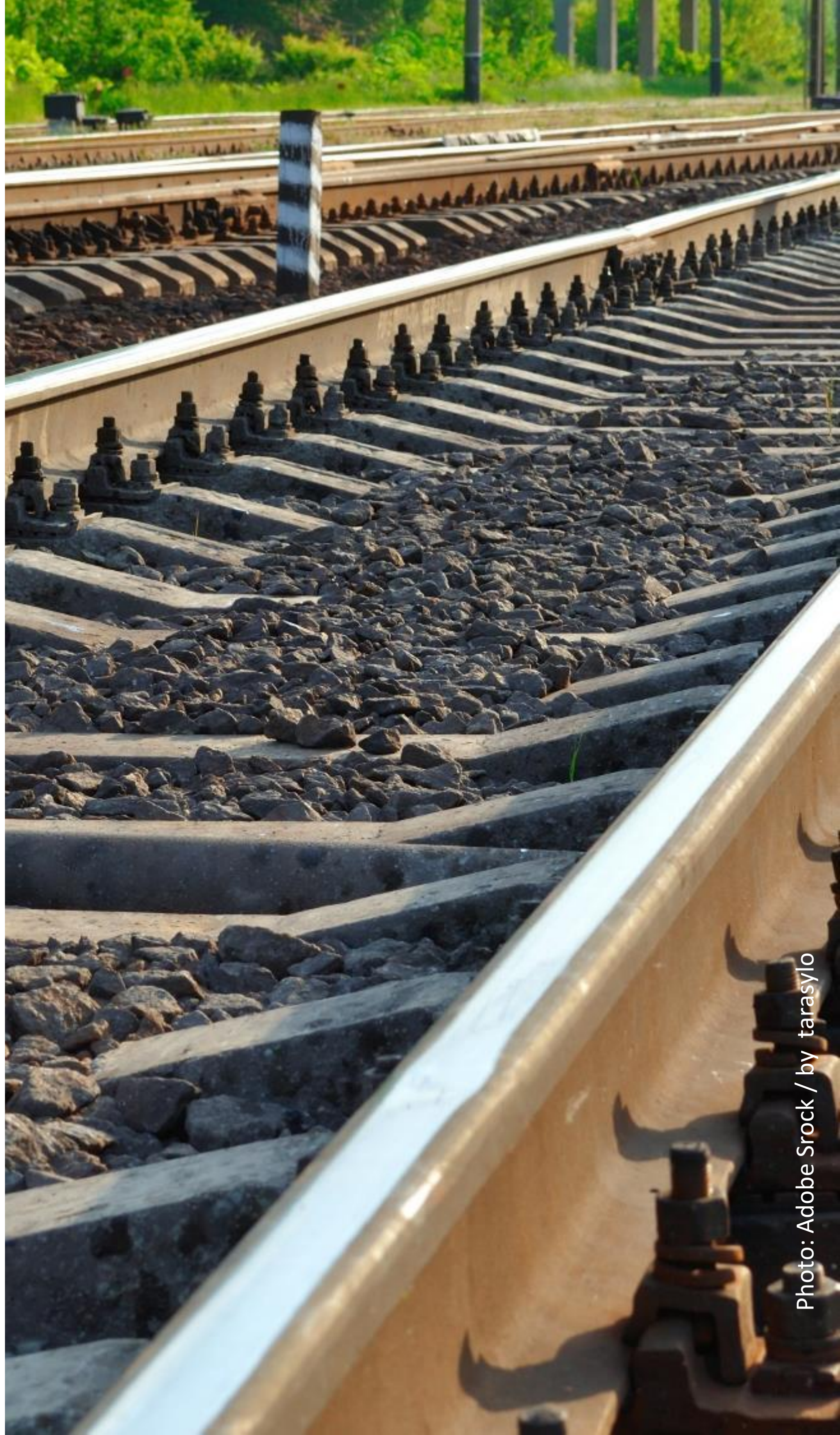
The target railway system defines an optimal level of technical and safety harmonization making it possible to facilitate, improve and develop railway services within the Union and with third countries,
and to contribute to the completion of the Single European Railway Area (SERA) and the progressive achievement of the internal market.

Why a compelling vision?

A common single vision for the target railway system would serve as a generic guidance for the various initiatives to achieve a sustainable transport system.

This framework will allow to:

- Enhance technical and operational harmonisation
- Ensure multimodal integration
- Optimise railway transport system with regard to wider economy, and
- Accommodate and incorporate research & innovation.



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How to develop the target railway system?

This would require to develop each element of the target railway system in a structured way, involving the main actors, taking account of constraints and opportunities.

The analysis of these elements will allow to identify what needs to be further developed (research and innovation) and what needs to be harmonised (regulation, standards).

The following principles should always apply where possible:

- 'Users first';
- Sharing information;
- Sharing facilities, tools (e.g. testing facilities, training tools);
- 'Plug & play';
- Cost-efficient solutions, and
- 'Products from the shelf'.

Among the prerequisites, better access to data and involvement of specialists from different fields are needed.

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Target railway system from the perspective of the end-users and citizens

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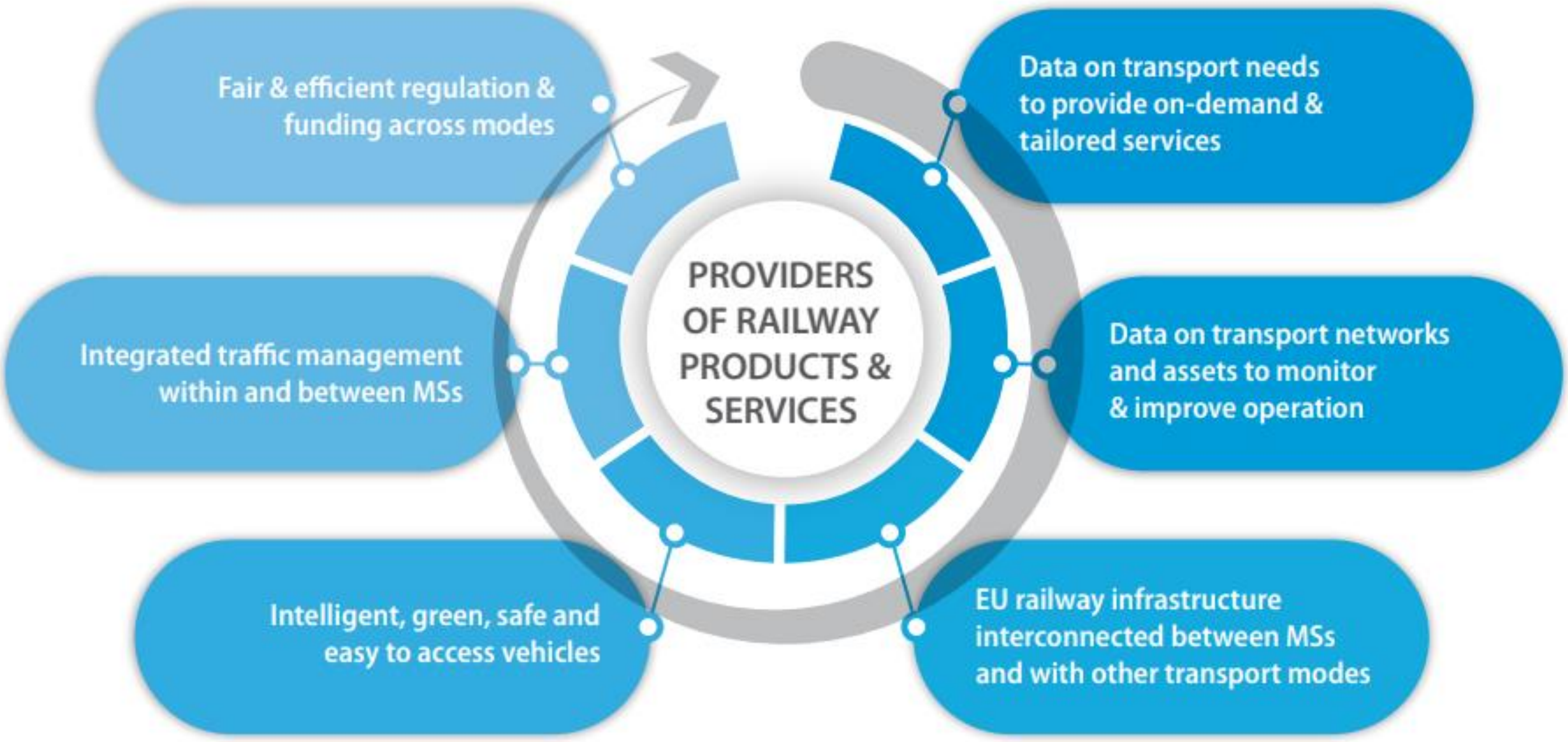
Target railway system from the perspective of providers of railway products & services



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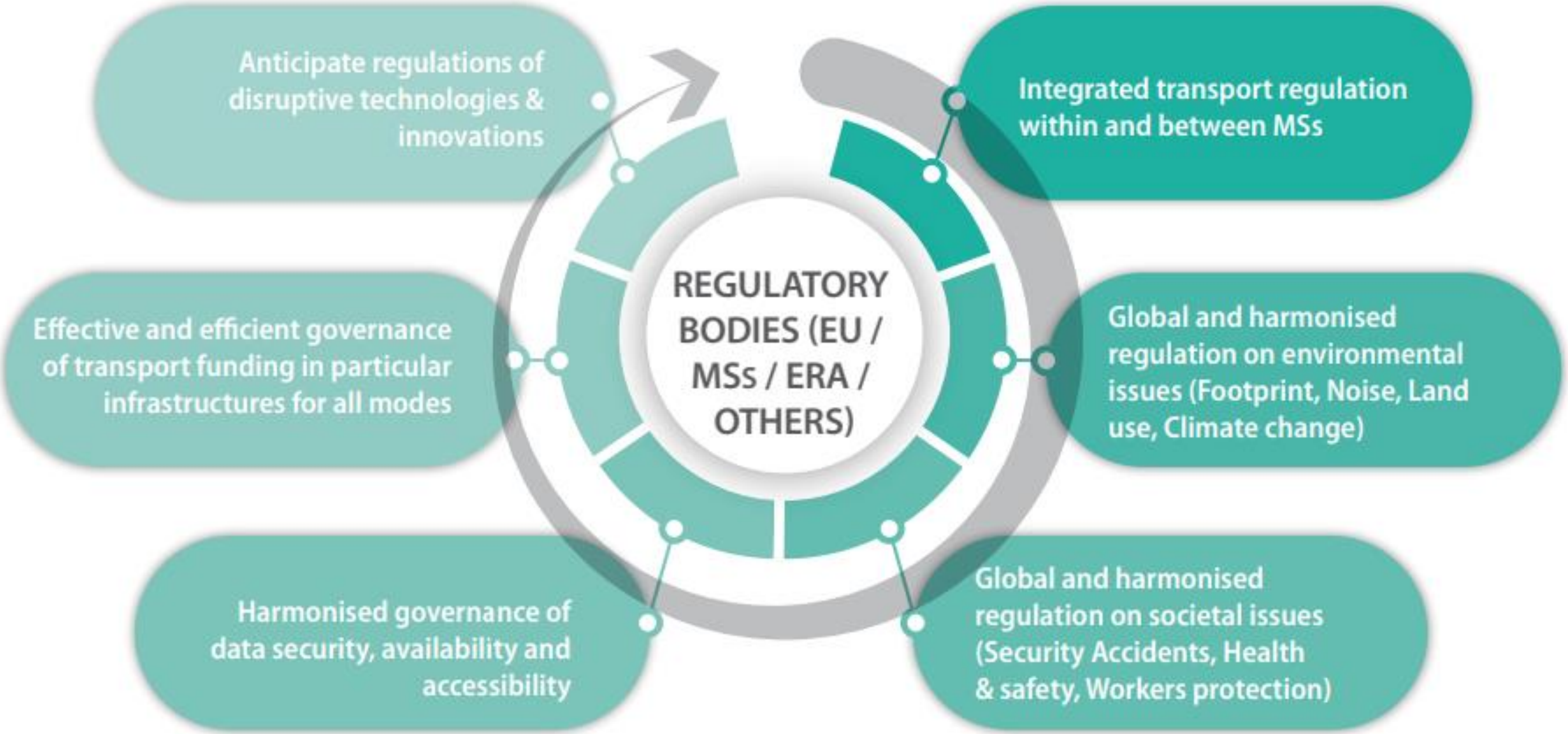
Target railway system from the perspective of the regulatory bodies



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Challenges to reach the target

- **Users** (freight & passengers): **Service tailored** to the needs of end-users (Maas, On-demand transport)
- **Financial arrangements**: support implementation of multimodal approach
- **Regulation**: to cover automated transport, multimodal user charging, disruptive technologies
- **Data management**: open access, real time information, asset monitoring, AI
- **Harmonised operations**: political, legal, technical and commercial barriers removed (including language)
- **Cross-border traffic with third countries**: political, legal, technical and commercial barriers removed

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Challenges to reach the target

- **Ticketing and information**: Open market for retailing to enable multimodal end to end (e)-ticket
- **Traffic management including CCS**: ATO, intermodal traffic management
- **Infrastructure**: increased capacity and interconnection with other transport modes, automated terminals, vehicle autonomy to reduce infrastructure costs
- **Energy**: e-vehicle, hydrogen fuels, solar cells, batteries, piezoelectric ballast
- **Vehicles**: DAC, virtual coupling, autonomous vehicles, infotainment
- **Personnel skills**: training using VR & AR, automation, less but highly competent staff

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Compelling vision document and short video

Publicly available on the ERA website and YouTube:

Compelling vision for a target rail system.pdf (europa.eu)

A compelling vision for the target railway system (youtube.com)

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Challenges for European Rail Research

- Fragmentation compared to other sectors
- Long life cycle of rail assets (infrastructure & vehicle) vs short life cycle for digital components
- Dynamic network (innovation can be local, or the elevation of the entire network to a new status)
- Slow uptake of innovations in rail

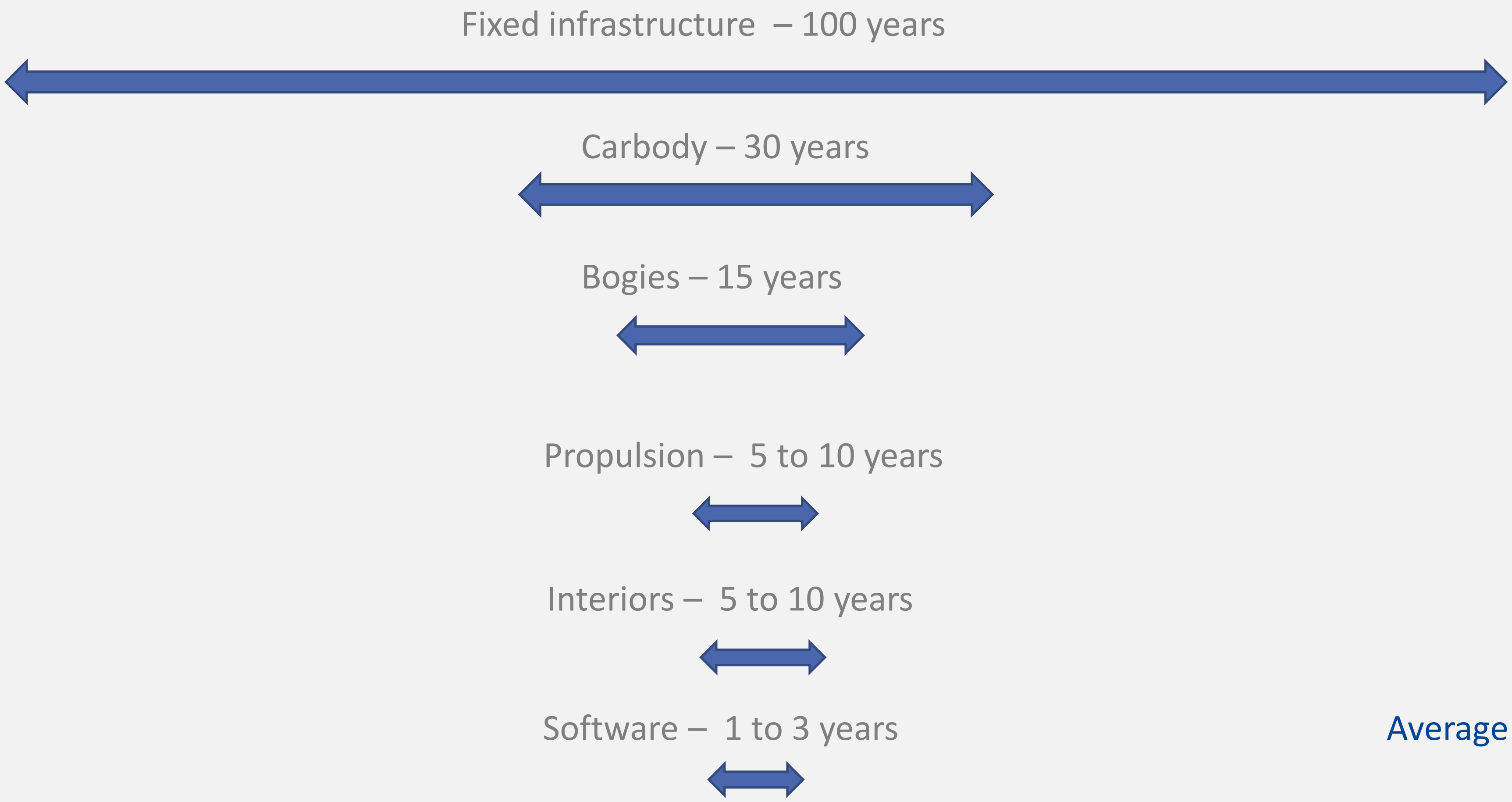
Operations & Maintenance

Tertiary Infrastructure: control command/signalling

Secondary Infrastructure: energy and communication

Primary infrastructure: tracks, tunnels, bridges, stations, other

Modularity is vital: Need to think ‘Systems’



Average life-time in rail

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An outlook to the future

- Transport of people and goods is essential for society and economy

- The transport sector is faced with enormous challenges: climate change, NO_x, fine dust, congestion
- Rail can become the mode of transport of the 21st century – if it provides a convincing offer

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Technology Readiness Levels (TRL)

TRL	Description of the technology maturity
1	Basic principles were observed
2	Technology concept was formulated - Basic research
3	Technology was experimentally proven - Applied research
4	Technology was tested in laboratory - Validation in laboratory & small scale prototype
5	Technology was validated in intended environment - Demonstration in intended environment
6	Technology was tested in relevant environment - Demonstration in relevant environment
7	System prototype was tested in real-life use - Demonstration in operational environment
8	System was completed and qualified - First kind of commercial model
9	System works in operational environment - Full commercial application

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How is rail research addressed in the EU?

At EU Level

- DG Research
- Other DGs
- JRC
- JU EU-Rail – Video on IN2Rail
- ERRAC
- EURNEX

At National level

- Research institutes (e.g. Railenium in France)
- Rail research centre (e.g. DZSF in Germany)

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Wrap-up

- Rail research is necessary for the future EU mobility
- An EU target railway system is required by the Interoperability Directive
- Main challenges for the EU rail research: fragmentation, desynchronisation of average life-cycle of subsystems, dynamic network, slow uptake of innovation
- Various types of innovation apply to rail with better efficiency for local & soft innovation
- Several steps (TRLs) are necessary to reach deployment of innovation
- Rail research is undertaken both at EU and at National level

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Questions

Why a compelling vision for the target railway system?

What are the future challenges for transport?

What are the challenges for rail research?

What are the TRL?

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ERA Educational Inventory

(work in progress)

Facilitate access to information on education and trainings in railways by making it available in one non-commercial place, accessible for all stakeholders

Improve the employability helping to reduce the expected skills shortage in the sector

Enhance the understanding of EU rail legislation, by motivating educational institutions to integrate this in their curricula

Enable analysis of the available railway education to serve policy makers

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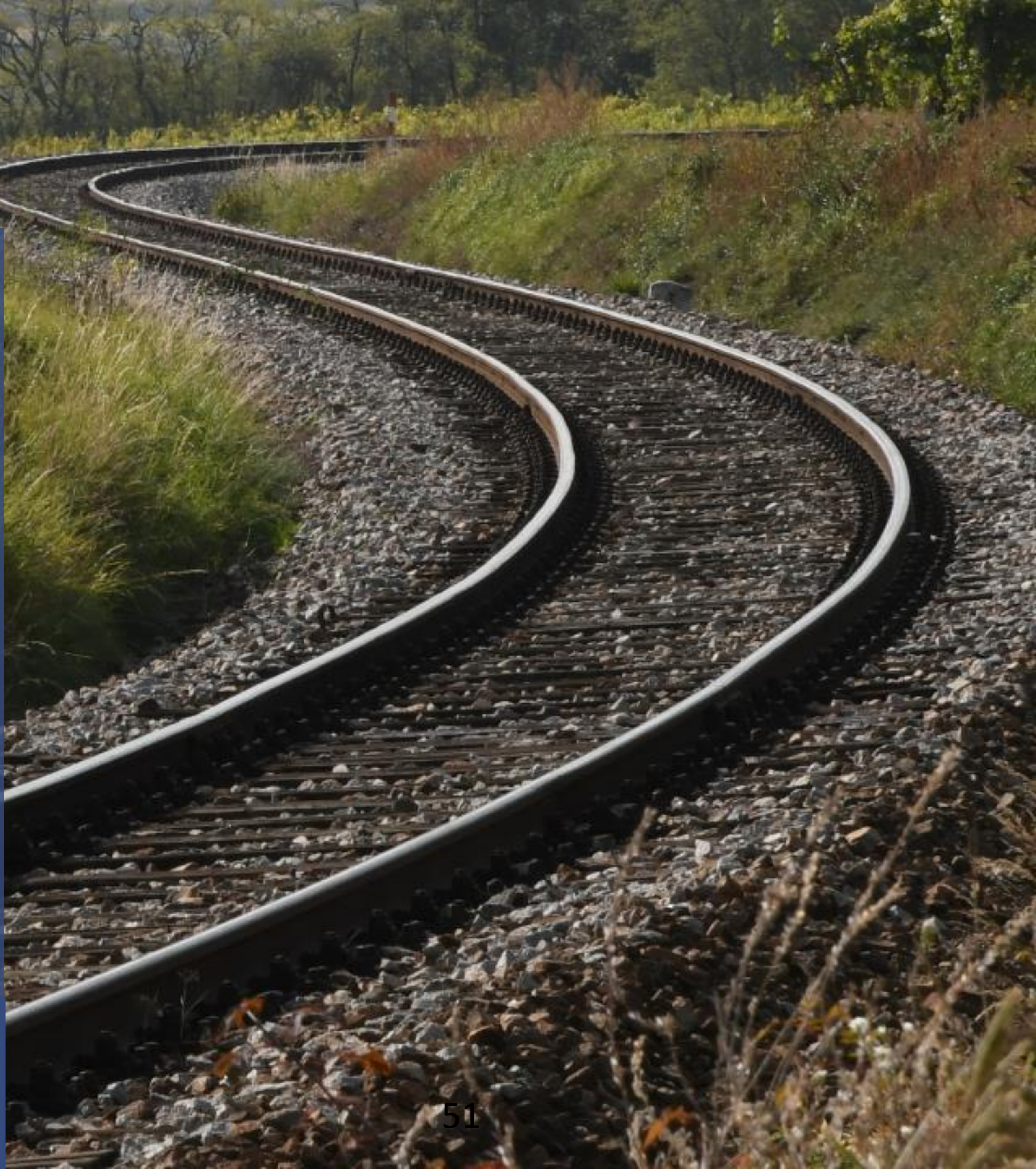
Questions & Answers

THANK YOU

Moving Europe towards a sustainable and safe railway system without frontiers.

Follow us:



Interoperability of the European railway system

The “New Approach” and conformity assessment

Staffer Summer School | 11.07.2024 | Rome

Anna Gigantino

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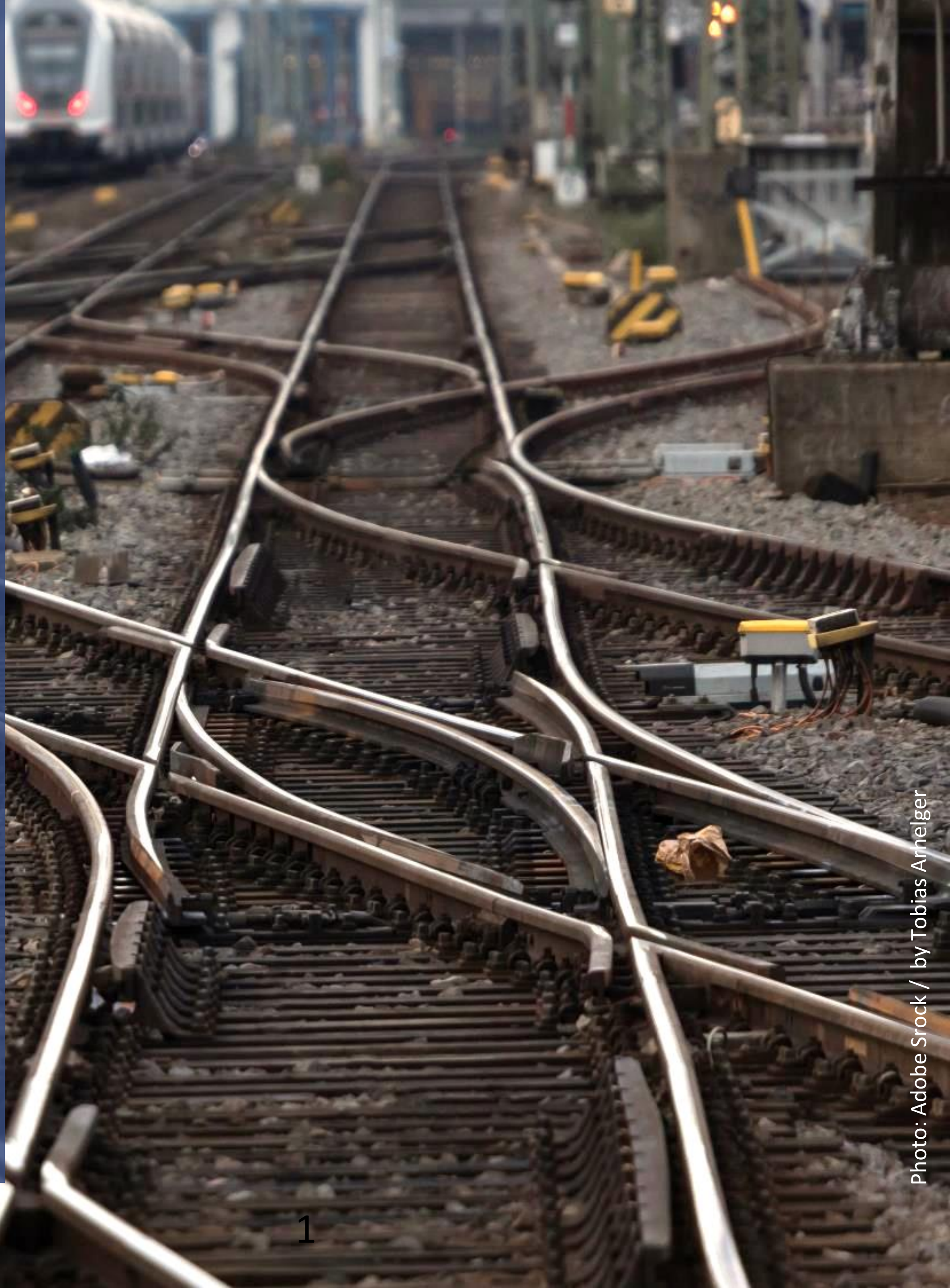

Photo: Adobe Srock / by Tobias Arnelger

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Outline

The EU « laws »

The « Modules »

The « New legislative framework »

Q&A

The EU « New Approach »

The « Blue Guide »

The Conformity Assessment Bodies

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Two pillars of EU law

Subsidiarity

The principle of subsidiarity is defined in Article 5(3) of the Treaty on European Union. It aims to ensure that decisions are taken at the closest possible level to the citizen and that constant checks are made to verify that action at the European Union (EU) level is justified in light of the possibilities available at the national, regional or local level.

=> the EU does not take action, unless it is more effective than action taken at the national, regional or local level.

The concept is applicable in the fields of government, political science, neuropsychology, cybernetics, management and in military command.

Proportionality

The principle of proportionality is laid down in Article 5(4) of the Treaty on European Union

=> any action taken by the EU does not go beyond what is necessary to achieve the aims of the treaties.

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Types of EU law (1/4)

Primary versus secondary law

The EU Treaties are the starting point for EU law and are known in the EU as primary law. They set out EU objectives, rules for EU institutions, how decisions are made and the relationship between the EU and its members.

The body of law that comes from the principles and objectives of the treaties is known as secondary law; and includes regulations, directives, decisions, recommendations and opinions.

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Types of EU law (2/4)

Legislative versus non-legislative acts

Legislative acts are adopted following one of the legislative procedures set out in the EU treaties (ordinary or special).

Non-legislative acts do not follow these procedures and can be adopted by EU institutions according to specific rules.

The EU can pass laws only in those areas where its members have authorised it to do so, via the EU treaties.

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Types of EU law (3/4)

EU treaties define the objectives of the European Union, the rules for EU institutions, how decisions are made and the relationship between the EU and its member countries. The treaties are negotiated and agreed by all the EU countries and then ratified by their parliaments, sometimes following a referendum.

Regulations are legal acts that apply automatically and uniformly to all EU countries without needing to be transposed into national law. They are binding in their entirety on all EU countries.

Directives require EU countries to achieve a certain result, but leave them free to choose how to do so. EU countries must adopt measures to incorporate them into national law (transpose) in order to achieve the objectives set by the directive.

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Types of EU law (4/4)

Decisions are binding in their entirety. A decision which specifies those to whom it is addressed shall be binding only on them.

Recommendations allow the EU institutions to make their views known and to suggest a line of action without imposing any legal obligation on those to whom it is addressed. They have no binding force.

Opinions allow the EU institutions to make a statement, without imposing any legal obligation on the subject of the opinion. An opinion has no binding force.

Delegated acts are legally binding acts adopted by the Commission to supplement or amend non-essential parts of EU legislative acts. The Commission adopts the delegated act and if Parliament and Council have no objections, it enters into force.

Implementing acts are legally binding acts adopted by the Commission – under the supervision of committees consisting of EU countries' representatives – to set conditions that ensure that EU laws are applied uniformly.

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The goal of harmonisation in the EU legislation

- Elimination of barriers
- Free movement of goods in the single market
- Protection of EU consumers
- Level playing field
- Competitive EU single market

Policies and legislative techniques have evolved over the last 40 years of European integration

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Minimum Vs. Maximum harmonisation in the EU law

Minimum harmonisation sets a threshold national legislation must meet. EU Member State national legislation may exceed the terms of minimum harmonisation law.

Much EU legislation has been implemented on a minimum harmonization basis as it can be easier to reach agreement, allowing existing EU Member State national to remain in place.

However, some MS indulge in protectionism when implementing directives into EU Member State national law by "gold-plating"

Therefore, on the opposite end of the regulation spectrum, a growing minority of EU law contains maximum harmonisation provisions.

The historical perspective of harmonisation

Five phases of the evolution:

- Old Approach: very detailed legislations
- New Approach (1985): ‘essential requirements’, while the details are in harmonised standards
- Development of the conformity assessment instruments
- The New Legislative Framework (2008): built on the New Approach, complemented it and brought coherence (conformity assessment, accreditation, market surveillance)
- The adoption of the new Market Surveillance Regulation and the new Mutual Recognition Regulation (2019).

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The « Old Approach »

- Traditionally, the technical national legislation was very detailed (lack of confidence in the rigour of economic operators, public authorities delivering certificates of conformity themselves mainly for health and safety reasons) -> very difficult

- 1983 : information procedure between MS and EC to avoid the creation of new technical barriers to the free movement of goods (standstill period of 3 to 12 months before adoption of new rules, with some exception in case of urgency)

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The « Cassis de Dijon » case (1978)

Mutual Recognition of Regulations: Member States must recognize each other's national regulations when there are no binding EU-wide rules. This means that goods produced and marketed in one EU country can be sold without additional restrictions in all other EU countries.

Free Movement of Goods: The principle allows products manufactured in accordance with the regulations of one EU member state to circulate freely within the entire EU, regardless of differing regulations in other member states.

This facilitates the free flow of goods across borders, promoting a unified internal market within the EU and beyond.

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The « New Approach » (1985)

— Legislative harmonisation should be limited to the essential requirements to be met by products to benefit from free movement within the EU

— The technical specifications for products meeting the essential requirements set out in legislation should be laid down in harmonised standards which can be applied alongside the legislation

— Products compliant with harmonised standards benefit from a presumption of conformity with the corresponding essential requirements

— The application of harmonised or other standards remains voluntary,

and the manufacturer can always apply other technical specifications to meet the requirements (but it holds the burden of proof)

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Product coverage

Union harmonisation legislation applies to non-food, non-agri industrial products:

- products placed on the EU market and to any subsequent operation until they reachethe end-user
- all forms of selling (catalogue, online, distance sale)
- newly manufactured, used and second-hand products (also those imported from a third country when they enter the EU market for the first time)
- finished products
- products subject to ‘substantial modifications’

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The « New Legislative Framework» (2008)

Objectives of the NLF:

- Reinforcing the New Approach
- Simple, clear and coherent legislation
- More effective market surveillance and accreditation of conformity assessment bodies
- EU framework for their accreditation
- Enhanced credibility of the CE marking

Conformity Assessment

Accreditation

Market surveillance

New Legislative Framework – Key features (1)

1) **Essential requirements** – level of protection of public interests: health, safety, protection of consumers or environment.

2) **Harmonised standards** detailing technical solutions to meet the essential requirements

- **Voluntary** – manufacturers can use other methods
- **Presumption of conformity with the essential requirements** they cover

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New Legislative Framework – Key features (2)

3) **Division of responsibilities** along the distribution chain.

Manufacturers, authorised representative, importer, distributor, *service providers, etc.*

4) **Conformity assessment procedures** (the so-called **"modules"**)

Choice of procedure : **Risk-based approach**

No third-party involvement- preferred for low to medium risk products

Third-party conformity assessment.

5) **Uniform rules for the designation and supervision of notified bodies**

Only **notified conformity assessment bodies** can perform the conformity assessment tasks.

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New Legislative Framework – Key features (3)

6) **Accreditation** - preferred method to demonstrate the competence of the notified body)

7) **Market surveillance**

- The authorities' obligation to check products covered by Union harmonisation legislation made available on the Union market
- May range from control of formal requirements to in-depth laboratory examinations

8) **CE marking**

- A declaration by the manufacturer that the product conforms to all the essential requirements of the relevant legislation
- Only the manufacturer can affix it on the product
- Visible, indelible

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The « New Legislative Framework» (2008)

The new legislative framework consists of:

- Regulation (EC) 765/2008 setting out the requirements for accreditation and the market surveillance of products
- Decision 768/2008 on a common framework for the marketing of products, which includes reference provisions to incorporate in product legislation revisions. In effect, it is a template for future product harmonisation legislation
- Regulation (EU) 2019/1020 on market surveillance and compliance of products

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The New Legislative Framework

REGULATION (EC) No 765/2008 + Regulation (EU) 2019/1020	DECISION No 768/2008/EC
❖ Accreditation ❖ Market surveillance - internal - imported products ❖ CE marking general principles ❖ Financing elements	❖ Definitions / obligations ❖ Essential requirements + Harmonised standards ❖ Conformity assessment procedures ❖ Notification (criteria / process / accreditation) ❖ Safeguard mechanisms (& market surveillance) ❖ CE marking Basis for future legislation

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Essential requirements

- Essential Requirements are the requirements that products must meet to be put on the market.
- They are mandatory.
  They define the results to be attained, or the risks to be dealt with.
- They do not specify the technical solutions for doing so.
- Suppliers are free to choose how the requirements are to be met.
  They are future-proof (do not become obsolete with technical progress).

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Exemple: Toy Safety Directive

Essential Safety Requirements for Toys

- Physical and Mechanical Properties
- Flammability
- Chemical porperties Electrical Porperties
- Hygiene
- Radioactivity

[Directive 2009/48/EC of the European Parliament and of the Council of 18 June 2009 on the safety of toysText with EEA relevance (europa.eu)]

N.B.: This Directive shall apply to products designed or intended, whether or not exclusively, for use in play by children under 14 years of age.

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Harmonised standards

The European Commission gives the European Standardization Organizations (CEN-CENELEC-ETSI) mandates to elaborate European Standards (EN), or identify existing ENs, which define technical solutions to meet the Essential Requirements.

These standards:

- are called ‘Harmonized Standards
- are published by the European Commission in the Official Journal of the European Union
- give manufacturers a presumption of conformity with respect to the applicable Essential Requirements
- remain voluntary: manufacturers can use other means to demonstrate conformity with the Essential Requirements, but the burden of proof will rest on the person affixing the CE marking (producer , importer, etc.)

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CE marking

General principles are set out in Article 30 of Regulation (EC) No 765/2008 (eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R0765):

1. The CE marking shall be affixed only by the manufacturer or his authorised representative.
2. The CE marking shall be affixed only to products to which its affixing is provided for by specific EU legislation (and not on any other product).
3. With the CE marking, the manufacturer indicates that he takes responsibility for the conformity of the product with all applicable requirements set out in the relevant EU legislation.
4. The CE marking shall be the only marking which attests the conformity of the product with the applicable requirements of the relevant EU legislation.
5. It is forbidden to use any other misleading markings, signs or inscriptions.
6. Other markings may be affixed but shall not impair the visibility of CE marking or create confusion.
7. Infringements will be subject to sanctions by Member States (pecuniary or even criminal)

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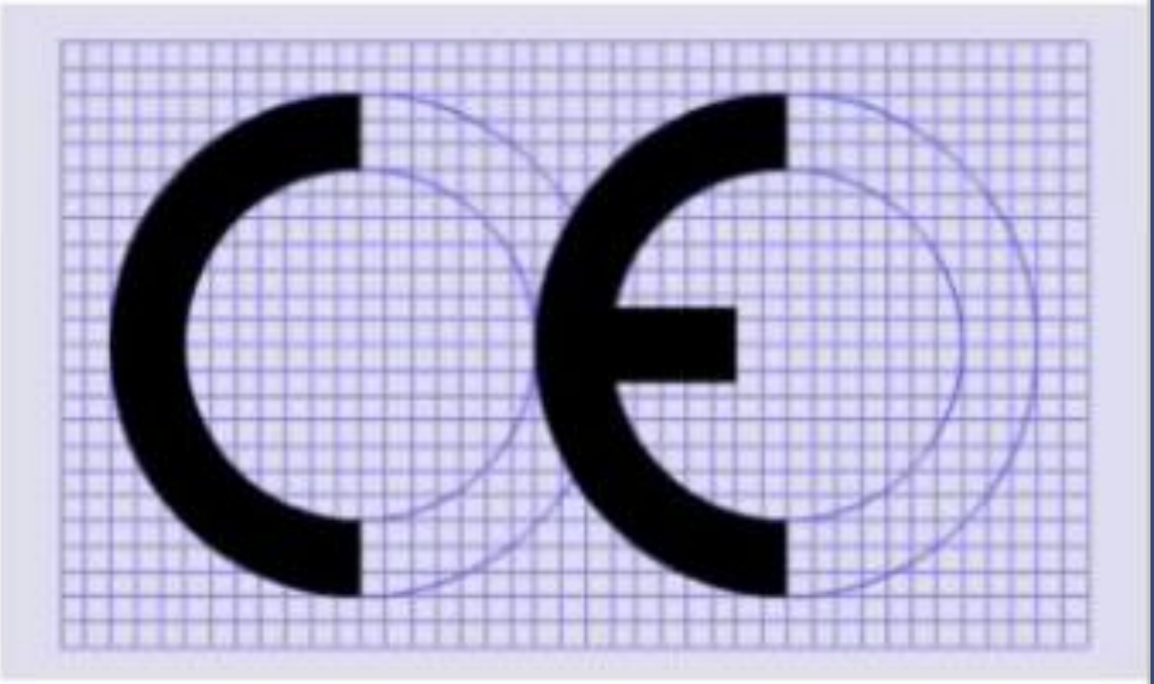
CE Marking

- ❑ It indicates that a product has been designed and manufactured in conformity with essential requirements
- ❑ CE marking is mandatory and must be affixed before the product is placed on the market



RICARDO

BUREAU VERITAS
1828

TÜV SÜD

IGQ

CERTIFER

INFRACERT d.o.o.
HRVATSKA

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Notified bodies

- What do they do ? They assess the conformity to of certain products to the applicable EU legislation before being put on the EU market.
- Notified by whom? By Member States (notifying authorities)
- To whom? To the European Commission
- On which basis? Decision 768/2008/EC (eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008D0768)

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EU acts aligned to the NLF

EU Legislation	Description
Directives	
Toy Safety Directive	Directive 2009/48/EU
Transportable Pressure Equipment Directive	Directive 2010/35/EU
Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive	Directive 2011/65/EU
Pyrotechnic Articles Directive	Directive 2013/29/EU
Recreational Craft and Personal Watercraft Directive	Directive 2013/53/EU
Civil Explosives Directive	Directive 2014/28/EU
Simple Pressure Vessels Directive	Directive 2014/29/EU
Electromagnetic Compatibility Directive	Directive 2014/30/EU
Non-automatic Weighing Instruments Directive	Directive 2014/31/EU
Measuring Instruments	Directive 2014/32/EU
Lifts Directive	Directive 2014/33/EU
ATEX Directive	Directive 2014/34/EU
Radio Equipment Directive	Directive 2014/53/EU
Low Voltage Directive	Directive 2014/35/EU
Pressure Equipment Directive	Directive 2014/68/EU
Marine Equipment Directive	Directive 2014/90/EU
Regulations	
Construction Products Regulation**	Regulation (EU) No 305/2011
Cableway Installations Regulation	Regulation (EU) 2016/424
Medical Devices Regulation	Regulation (EU) 2017/745
Personal Protective Equipment Regulation	Regulation (EU) 2016/425
In vitro Diagnostic Medical Devices Regulation	Regulation (EU) 2017/746
Gas Appliances Regulation	Regulation (EU) 2016/426
EU Fertilising Products Regulation	Regulation (EU) 2019/1009
Delegated acts	
Commission Delegated Regulation on unmanned aircraft systems and on third-country operators of unmanned aircraft systems	Commission Delegated Regulation (EU) 2019/945

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New Approach Notified and Designated Organisations Information System

NANDO

European Commission

English

Single Market Compliance Space

Home | Notified Bodies | Market surveillance | Noise emissions | Glossary

Home > Notified Bodies > Free search

Free search

Refine list of bodies using search criteria below (by entering appropriate keywords) and click on body name to view details

Search options

Notification status: Active

Body number: 0112

Body name:

Search results (1)

NOTIFICATION STATUS Active

BODY NUMBER 0112

Items per page: 30

Body type	Body name	Country
NB 0112	Konformitätsbewertungsstelle des Landesbetrieb Mess- und Eichwesen NRW	Germany

Products	Procedures	Articles/Annexes
Active Electrical Energy Meters (Annex V MI-003)	Conformity to type based on instrument verification	Annex II - Module F
− Dimensional Measuring Instruments (Annex XI MI-009)		
Area measuring instruments	Conformity to type based on instrument verification	Annex II - Module F
Length measuring instruments	Conformity to type based on instrument verification	Annex II - Module F
Multi-dimensional measuring instruments	Conformity to type based on instrument verification	Annex II - Module F
Automatic Weighing Instruments (Annex VIII MI-006)	Conformity to type based on instrument verification	Annex II - Module F
− Thermal Energy Meter (Annex VI MI-004)		
Calculator (type of temperature sensors)	Conformity to type based on instrument verification	Annex II - Module F
Flow sensor (heat meter subassembly)	Conformity to type based on instrument verification	Annex II - Module F
Temperature sensor pair	Conformity to type based on instrument verification	Annex II - Module F
Thermal Energy meter complete	Conformity to type based on instrument verification	Annex II - Module F
− Material Measures (Annex X MI-008)		
Capacity serving measures	Internal production control plus supervised instrument checks at randoms intervals	Annex II - Module A2
Material measure of length	Conformity based on instrument verification	Annex II - Module F1
Exhaust Gas Analysers (Annex XII MI-010)	Conformity to type based on instrument verification	Annex II - Module F
Measuring Instruments for Liquids Other than Water (Annex VII MI-005)	Conformity to type based on instrument verification	Annex II - Module F
Taximeters (Annex IX MI-007)	Conformity to type based on instrument verification	Annex II - Module F
− Gas Meters and Volume Conversion Devices (Annex IV MI-002)		
Volume conversion device (gas meter subassembly)	Conformity to type based on instrument verification	Annex II - Module F
Water Meters (Annex III MI-001)	Conformity to type based on instrument verification	Annex II - Module F

Organization details

BODY VERSION 7

Body Name	Konformitätsbewertungsstelle des Landesbetrieb Mess- und Eichwesen NRW
Address	Hugo-Eckener-Straße, 14 50829 Köln; Briefpostanschrift: 40208 Düsseldorf
Country	Germany
Phone	+49 (0) 221 5 97 78-10888
Fax	+49 (0) 221 5 97 78-30101
Email	Poststelle.Direktion@LBME.nrw.de
Website	http://www.lbme.nrw.de/
Body Number	0112
Last approval date	14/11/2022

List of notifications

NOTIFICATION STATUS Active

Body type	Legislation	End date	PDF
NB	2014/31/EU Non-automatic weighing instruments		
NB	2014/32/EU Measuring Instruments Directive		

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« Modules » for Conformity Assessment

CHAPTER II

Capacity serving measures

The relevant essential requirements of Annex I, and the specific requirements and the conformity assessment procedures listed in this chapter, apply to capacity serving measures defined below. However, the requirement for the supply of a copy of declarations of conformity may be interpreted as applying to a batch or consignment rather than each individual instrument. Also, the requirement for the instrument to bear information in respect of its accuracy shall not apply.

DEFINITIONS

Capacity serving measure	A capacity measure (such as a drinking glass, jug or thimble measure) designed to determine a specified volume of a liquid (other than a pharmaceutical product) which is sold for immediate consumption.
Line measure	A capacity serving measure marked with a line to indicate nominal capacity.
Brim measure	A capacity serving measure for which the internal volume is equal to the nominal capacity.
Transfer measure	A capacity serving measure from which it is intended that the liquid is decanted prior to consumption.
Capacity	The capacity is the internal volume for brim measures or internal volume to a filling mark for line measures.

MODULE A2: INTERNAL PRODUCTION CONTROL PLUS SUPERVISED INSTRUMENT CHECKS AT RANDOM INTERVALS

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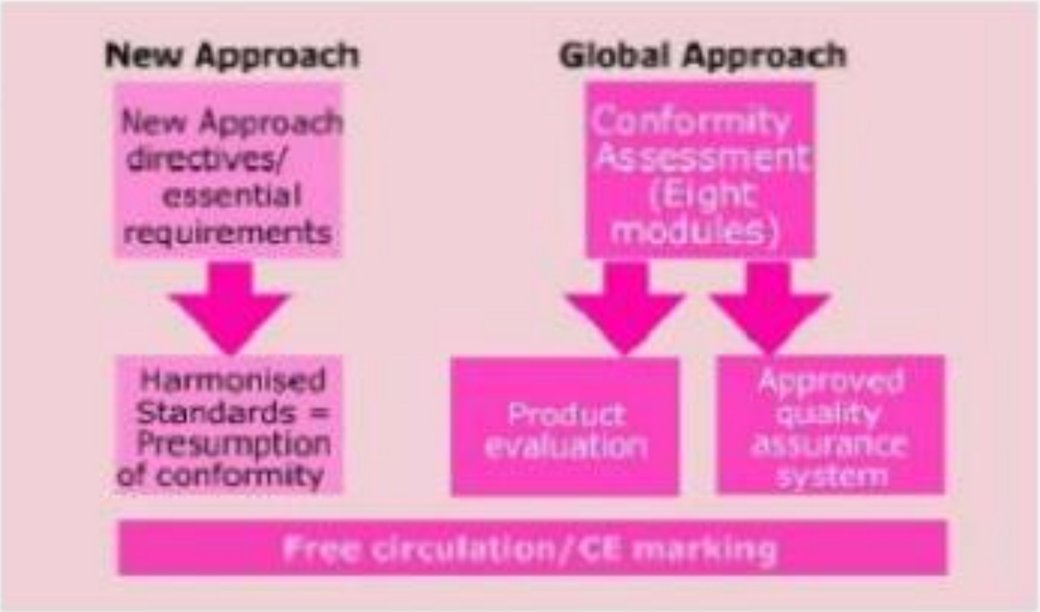
New Approach / Global Approach

- ❑ Every New Approach directive will use refer to determined modules in accordance with the level of possible risk
- ❑ The Global approach provides 8 different modules (design and production phases) to perform conformity assessment



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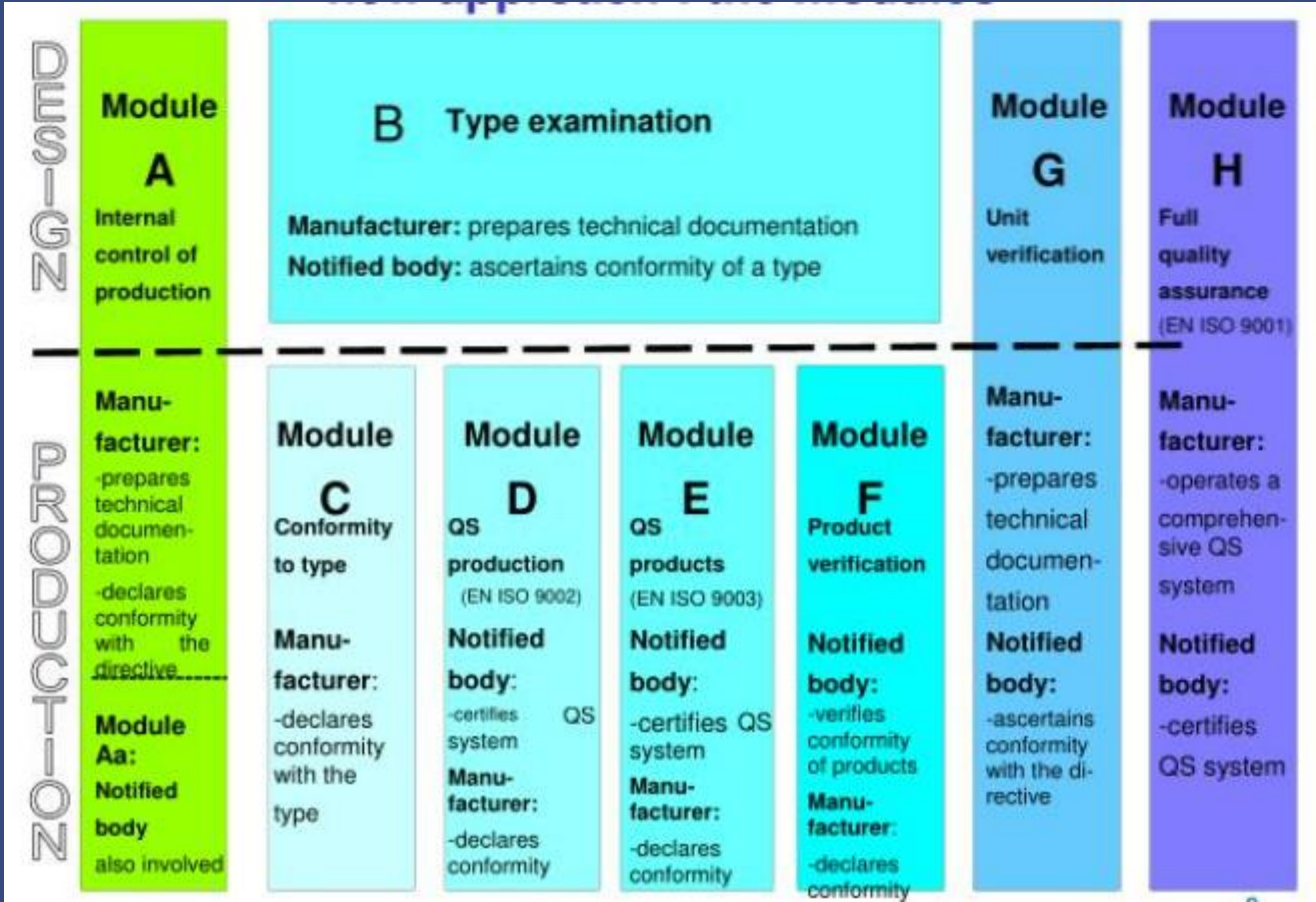
Modules for Conformity Assessment

(simplified diagram)



Modules	Description
A Internal production control	Covers both design and production. The manufacturer himself ensures the conformity of the products to the legislative requirements (no EU-type examination).
A1 Internal production control plus supervised product testing	Covers both design and production. A + tests on specific aspects of the product carried out by an in-house accredited body or under the responsibility of a notified body chosen by the manufacturer.
A2 Internal production control plus supervised product checks at random intervals	Covers both design and production. A + product checks at random intervals carried out by a notified body or in-house accredited body.

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B EU-type examination	Covers design. It is always followed by other modules by which the conformity of the products to the approved EU-type is demonstrated. A notified body examines the technical design and or the specimen of a type and verifies and attests that it meets the requirements of the legislative instrument that apply to it by issuing an EU-type examination certificate. There are 3 ways to carry out EU-type examination: 1) production type, 2) combination of production type and design type and 3) design type.
C Conformity to EU-type based on internal production control	Covers production and follows module B. Manufacturer must internally control its production in order to ensure product conformity against the EU-type approved under module B.
C1 Conformity to EU-type based on internal production control plus supervised product testing	Covers production and follows module B. Manufacturer must internally control its production in order to ensure product conformity against the EU-type approved under module B. C + tests on specific aspects of the product carried out by an in-house accredited body or under the responsibility of a notified body chosen by the manufacturer (*).
C2 Conformity to EU-type based on internal production control plus supervised product checks at random intervals	Covers production and follows module B. Manufacturer must internally control its production in order to ensure product conformity against the EU-type approved under module B. C + product checks at random intervals tests on specific aspects of the product carried out by a notified body or in-house accredited body.

D Conformity to EU-type based on quality assurance of the production process	Covers production and follows module B. The manufacturer operates a production (manufacturing part and inspection of final product) quality assurance system in order to ensure conformity to EU-type. The notified body assesses the quality system.
D1 Quality assurance of the production process	Covers both design and production. The manufacturer operates a production (manufacturing part and inspection of final product) quality assurance system in order to ensure conformity to legislative requirements (no EU-type, used like D without module B). The notified body assesses the production (manufacturing part and inspection of final product) quality system.
E Conformity to EU-type based on product quality assurance	Covers production and follows module B. The manufacturer operates a product quality (=production quality without the manufacturing part) assurance system for final product inspection and testing in order to ensure conformity to EU-type. A notified body assesses the quality system. The idea behind module E is similar to the one under module D: both are based on a quality system and follow module B. Their difference is that the quality system under module E aims to ensure the quality of the final product, while the quality system under module D (and D1 too) aims to ensure the quality of the whole production process (that includes the manufacturing part and the test of final product). E is thus similar to module D without the provisions relating to the manufacturing process.
E1 Quality assurance of final product inspection and testing	Covers both design and production. The manufacturer operates a product quality (=production quality without the manufacturing part) assurance system for final product inspection and testing in order to ensure conformity to the legislative requirements (no module B (EU-type), used like E without module B). The notified body assesses the quality system. The idea behind module E1 is similar to the one under module D1: both are based on a quality system. Their difference is that the quality system under module E1 aims to ensure the quality of the final product, while the quality system under module D1 aims to ensure the quality of the whole production process (that includes the manufacturing part and the test of final product). E1 is thus similar to module D1 without the provisions relating to the manufacturing process.

F Conformity to EU-type based on product verification	Covers production and follows module B. The manufacturer ensures compliance of the manufactured products to approved EU-type. The notified body carries out product examinations (testing of every product or statistical checks) in order to control product conformity to EU-type. Module F is like C2 but the notified body carries out more systematic product checks.
F1 Conformity based on product verification	Covers both design and production. The manufacturer ensures compliance of the manufactured products to the legislative requirements. The notified body carries out product examinations (testing of every product or statistical checks) in order to control product conformity to the legislative requirements (no EU-type, used like F without module B) Module F1 is like A2 but the notified body carries out more detailed product checks.

G	Covers both design and production.
Conformity based on unit verification	The manufacturer ensures compliance of the manufactured products to the legislative requirements. The notified body verifies every individual product in order to ensure conformity to legislative requirements (no EU-type).
H	Covers both design and production.
Conformity based on full quality assurance	The manufacturer operates a full quality assurance system in order to ensure conformity to legislative requirements (no EU-type). The notified body assesses the quality system.
H1	Covers both design and production.
Conformity based on full quality assurance plus design examination	The manufacturer operates a full quality assurance system in order to ensure conformity to legislative requirements (no EU-type). The notified body assesses the quality system and the product design and issues an EU design examination certificate. Module H1 in comparison to module H provides in addition that the notified body carries out a more detailed examination of the product design. The EU-design examination certificate must not be confused with the EU-type examination certificate of module B that attests the conformity of a specimen 'representative of the production envisaged', so that the conformity of the products may be checked against this specimen. Under EU design examination certificate of module H1, there is no such specimen. EU design examination certificate attests that the conformity of the design of the product has been checked and certified by a notified body.

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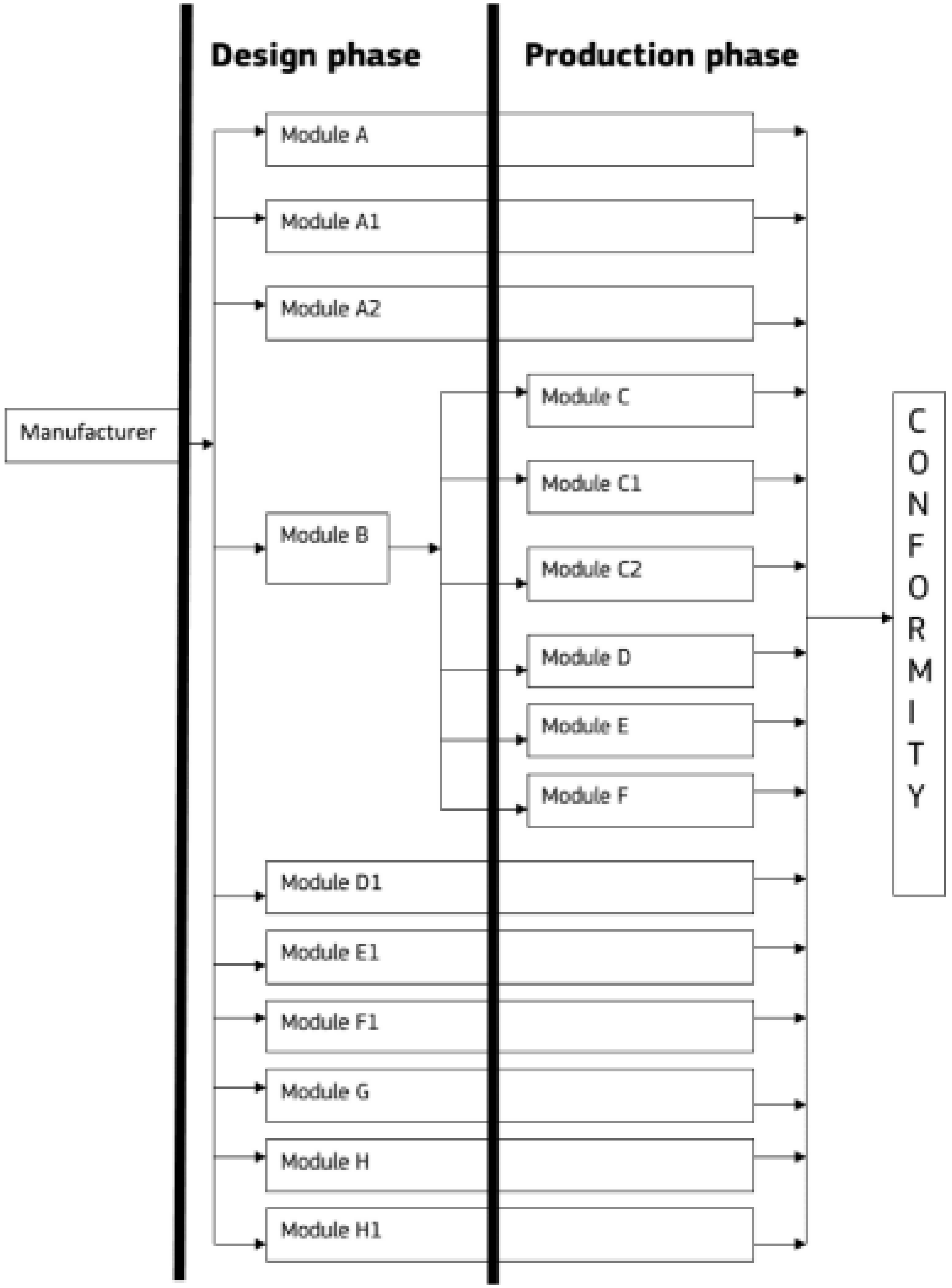
Overview of Conformity Assessment procedures using the various « Modules »

full diagram from the « Blue Guide »
Publications Office (europa.eu)



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Why Accreditation ?

Accreditation provides the last level of public control in a quality chain underpinning the free movement of goods in the Union.

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What is Accreditation ?

Accreditation is the attestation by a national accreditation body based on harmonised standards that a conformity assessment body has the technical competence to perform a specific conformity assessment activity.

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Accreditation following Regulation (EC) No 765/2008

- Each Member State may appoint one single national accreditation body.
- Accreditation is to be operated as a public authority activity.
- The responsibilities and tasks of the national accreditation body have to be clearly distinguished from those of other national authorities.
- Accreditation is to be provided on a not-for-profit basis.
- Within the EU, accreditation bodies are not allowed to compete with other accreditation bodies.
- Within the EU, accreditation bodies are only to be active on the territory of their own Member State

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Making available and placing a product on the EU market

A product is **<u>made available on the market</u>** when:

→ it is **supplied for distribution, consumption or use on the Union market in the course of a commercial activity**, whether in return for payment or free of charge

- The concept of making available refers to each individual product.

A product is **<u>placed on the market</u>** when:

→ it is **made available for the first time on the Union market**.

- According to Union harmonisation legislation, each individual product can only be placed once on the Union market.
- Why is the date of the placing on the market is important?

Market surveillance

Regulation (EC) No 765/2008 established the legal basis for market surveillance:

- Member States shall organise and carry out market surveillance
- Market surveillance shall ensure that products covered by EU legislation which can be dangerous for users, or do not conform to applicable requirements, are prohibited or withdrawn from the market
- The public, the Commission and the other Member States are informed accordingly

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The Blue Guide

- A hands-on document explaining EU product legislation
- The 1st edition was published in 1994 with a blue cover
- Subsequent editions: 2000, 2014 and 2016

Update 2022:

- Market Surveillance Regulation 2019/1020
- Complementary information on certain issues (substantial modifications)
- Withdrawal of the UK from the EU

EUR-Lex - 52022XC0629(04) - EN - EUR-Lex (europa.eu)

Questions

What is the difference between a Directive and a Regulation?

What is the difference between the « Old » and the « New » approach?

What is the « gold-plating » ?

What are the « modules » for conformity assessment

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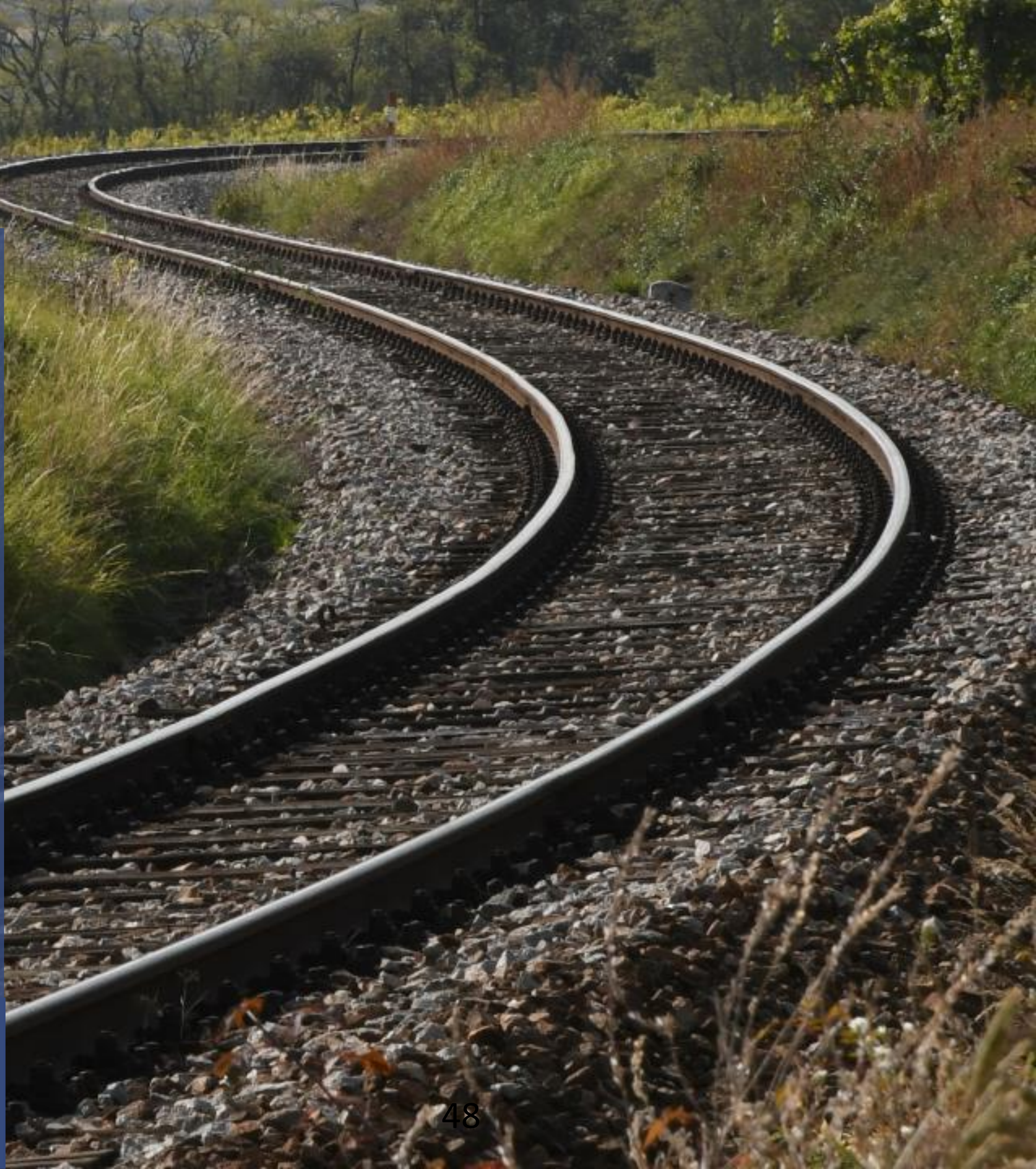
Questions & Answers

THANK YOU

Moving Europe towards a sustainable and safe railway system without frontiers.

Follow us:



Interoperability of the European railway system

The Technical Specifications for Interoperability

Staffer Summer School | 11.07.2024 | Rome

Anna Gigantino

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Photo: Adobe Stock / by Serjiob74

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Outline

Technical barriers

TSIs

Reduction of national rules

Q&A

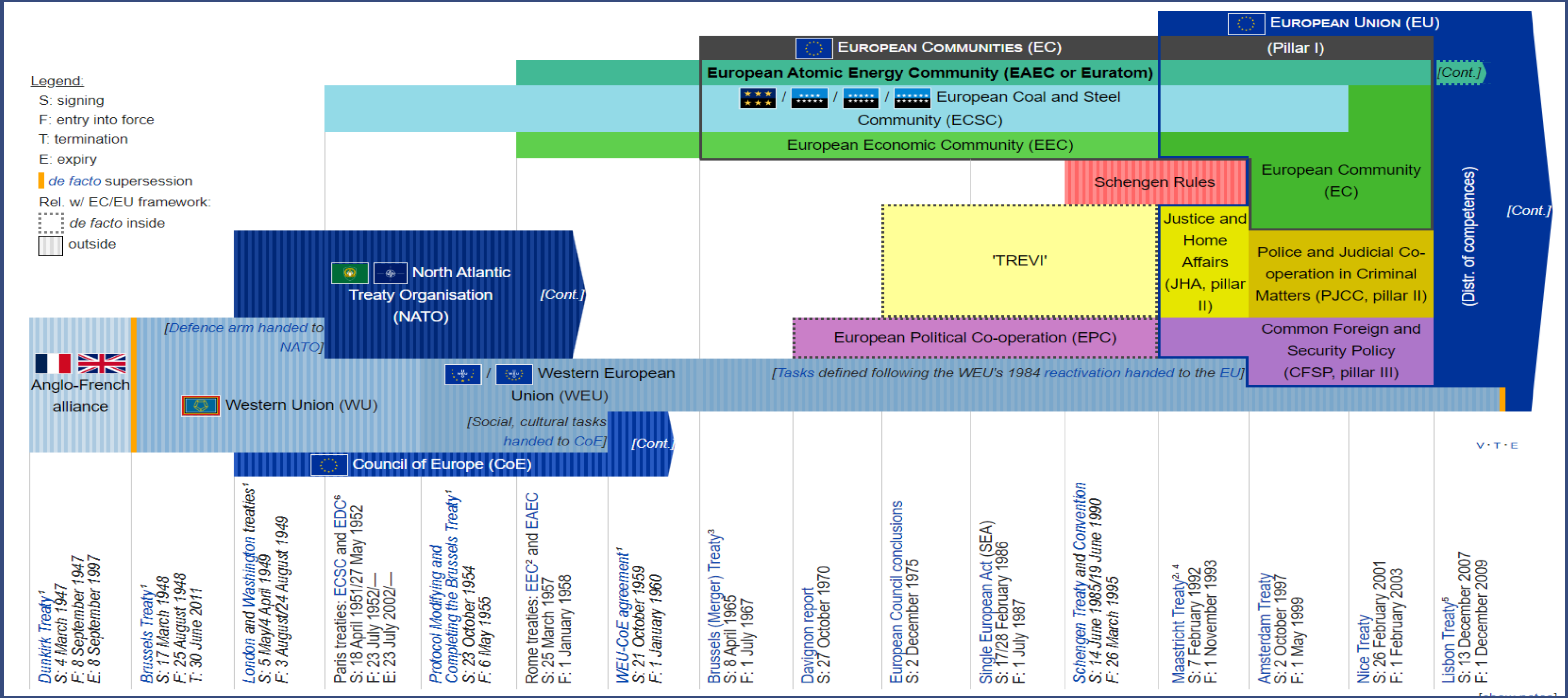
Innovative solutions

Railway interoperability

Railway “Modules” for CA

EU Legal context

The EU in a nutshell: evolution / policies



Source: *European Atomic Energy Community - Wikipedia*

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The EU railway System

A shared system, managed by many actors each responsible for their own part of the system - including safety - is intended to be operated as an open market for products and services:

A Single European Railway Area

This requires harmonised and transparent rules and processes – like roads and aviation – to define the optimal level of technical harmonisation and maintain/improve the overall safety levels.

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A Time-line of EU Railway legislation

2001

European Commission's White paper
A strategy for revitalising the Community's railways

2001

Rail infrastructure package
- levying of charges for the use of railway infrastructure
- licensing of railway undertakings

2004

Second railway package
- Interoperability and Safety Directives
- Establishment of ERA

2007

Third railway package
- Access rights rail freight service from 2007
- Opening of the international passenger transport service market from 2010

2008

- Interoperability Directive **extended to the whole EU Network**
- Directive 2008/110/EC amending Safety Directive:
  duties for entity in charge of maintenance (ECM)

2016

Fourth Railway Package
- Recast of all major railway Directives
- Single EU wide vehicle authorisation and certification

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The two pillars of the 4th Railway Package

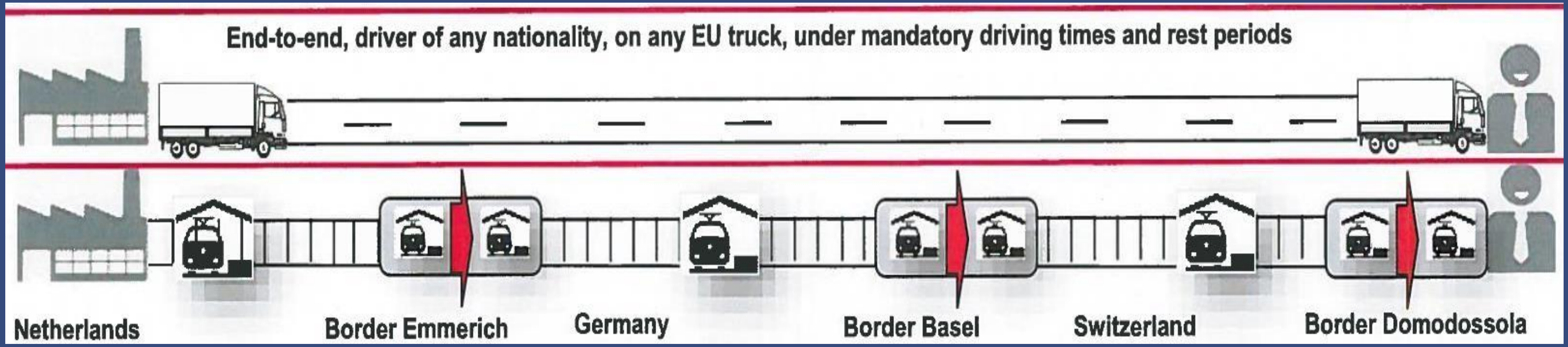
Technical pillar

- Regulation (EU) 2016/796 on the European Union Agency for Railways and repealing Regulation (EC) n° 881/2004
- Directive (EU) 2016/797 on the interoperability of the rail system within the European Union (Recast of Directive 2008/57/EC)
- Directive (EU) 2016/798 on railway safety (Recast of Directive 2004/49/EC)

Market pillar

- Regulation (EU) 2016/2338 amending Regulation (EU) 1370/2007, which deals with the award of public service contracts for domestic passenger transport services by rail ('PSO Regulation')
- Directive 2016/2370/EU amending Directive 2012/34/EU, which deals with the opening of the market of domestic passenger transport services by rail and the governance of the railway infrastructure ('Governance Directive')
- Regulation (EU) 2016/2337 repealing Regulation (EEC) 1192/69 on the normalisation of the accounts of railway undertakings

Interoperability



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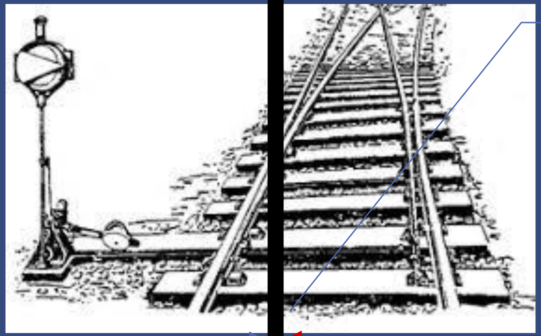
Cross-Border Issues

Legal Boundary



Where to put the operational boundary?

A

B

- Authorisation and Certification
- Tests and checks
- Train composition
- Buffer wagons
- Language
- National Supervision
- ….

- Authorisation and Certification
- Tests and checks
- Train composition
- Buffer wagons
- Language
- National Supervision
- ….

Who is in charge for cross-border issues?
Clarity of decision making?
Who carries the extra cost?

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Benefits of a Harmonised Approach

Interoperability without borders

Innovation without re-inventing the wheel

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Technical Specifications for Interoperability

The Agency prepares TSIs under a Mandate from the European Commission

A **TSI** is a common (harmonized) technical standard specifying the elements of essential requirements* that need to be harmonized to achieve interoperability

- Safety, reliability and availability, health, environmental protection, technical compatibility, accessibility

TSIs relate to
+ structural subsystems (infrastructure, rolling stock, energy, CCS), or
+ functional subsystems (maintenance, traffic operation and management, telematics applications for passengers and freight services)

The TSI framework is supplemented by notified national technical rules (NNTRs)

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What is covered by TSIs?

TSIs cover **parameters that need to be harmonised** to meet the objectives of the Interoperability Directive i.e. to optimise the shared railway system that is SERA:

- to define an **optimal level of technical harmonisation**
- to make it possible to **facilitate, improve and develop rail transport services** within the Union and with third countries
- to contribute to the **completion of the single European railway area** and
- the progressive achievement of the internal market.

Those conditions concern the design, construction, placing in service, upgrading, renewal, operation and maintenance of the parts of that system as well as the professional qualifications of, and health and safety conditions applying to, the staff who contribute to its operation and maintenance.

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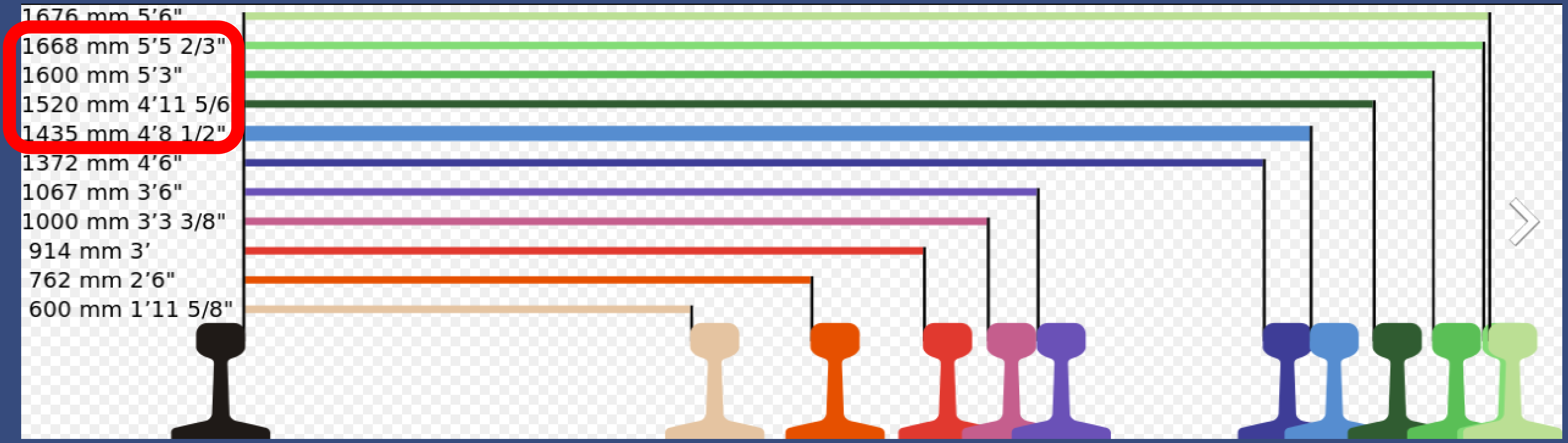
Track gauge

- *1435 (main EU standard)*
- *1520 /1524 (EE, LT, LV, PL, ES, FI)*
- *1600 (IE)*
- *1668 (ES, PT)*



Source: Wikipedia

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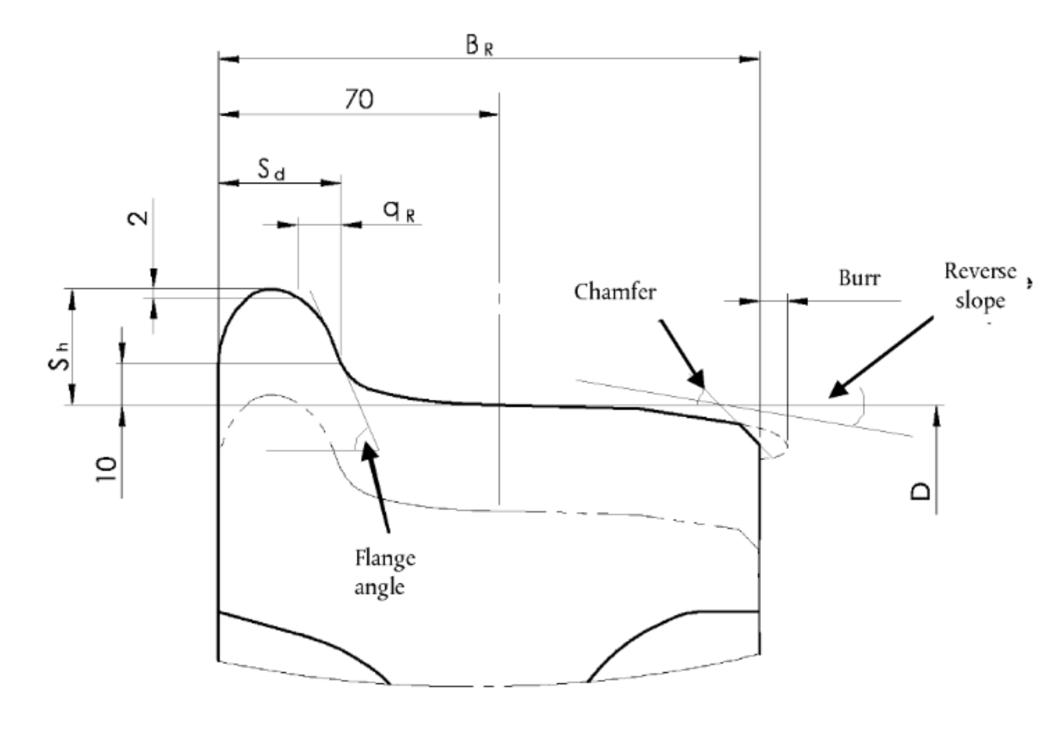
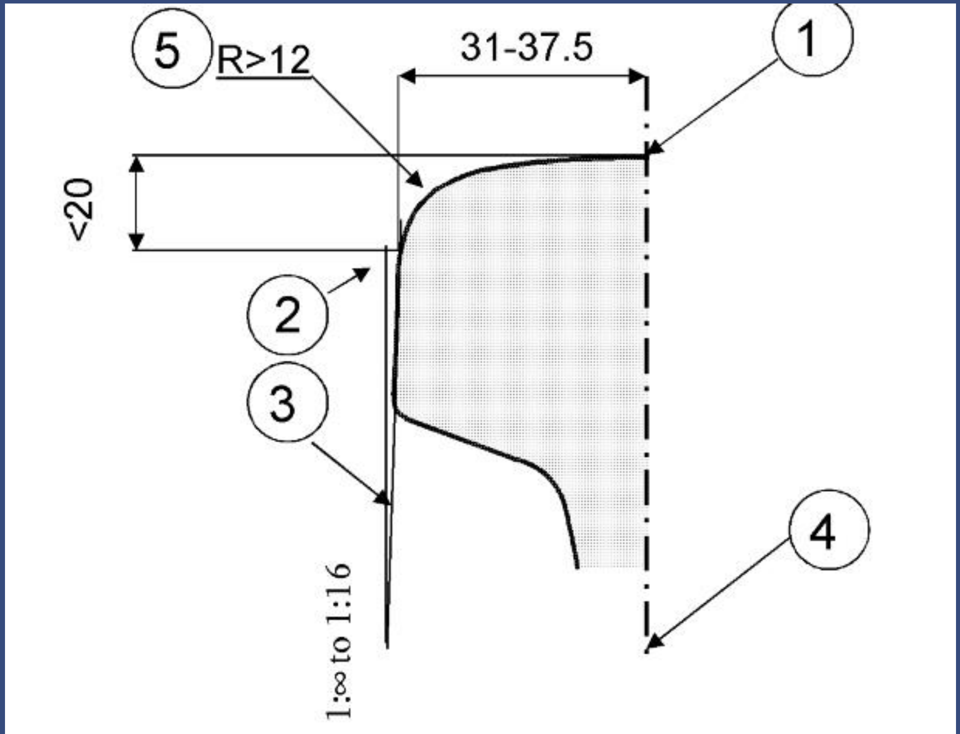
About interfaces…





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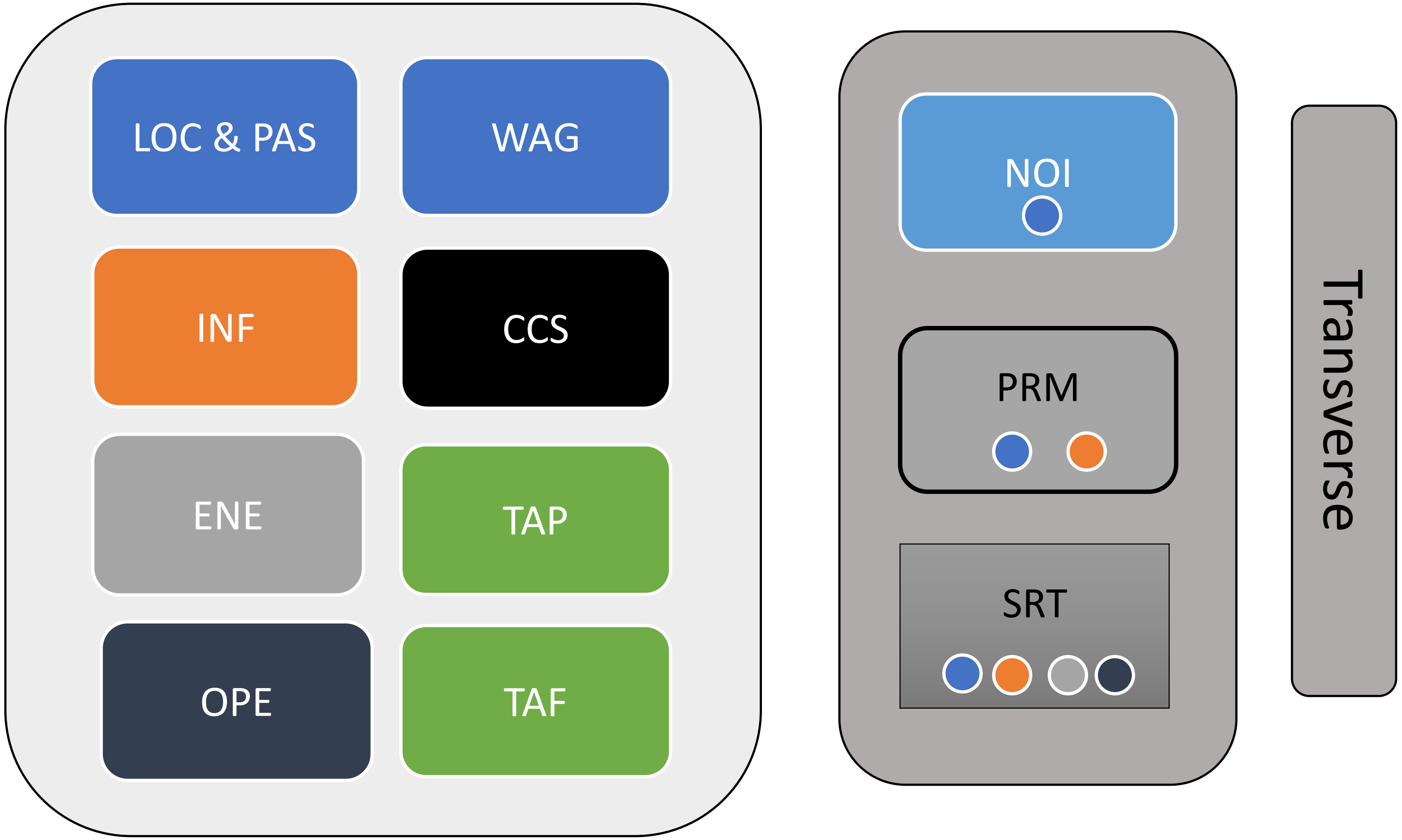
2015 – Simplified and Extended Scope TSIs Apply on the Entire Network



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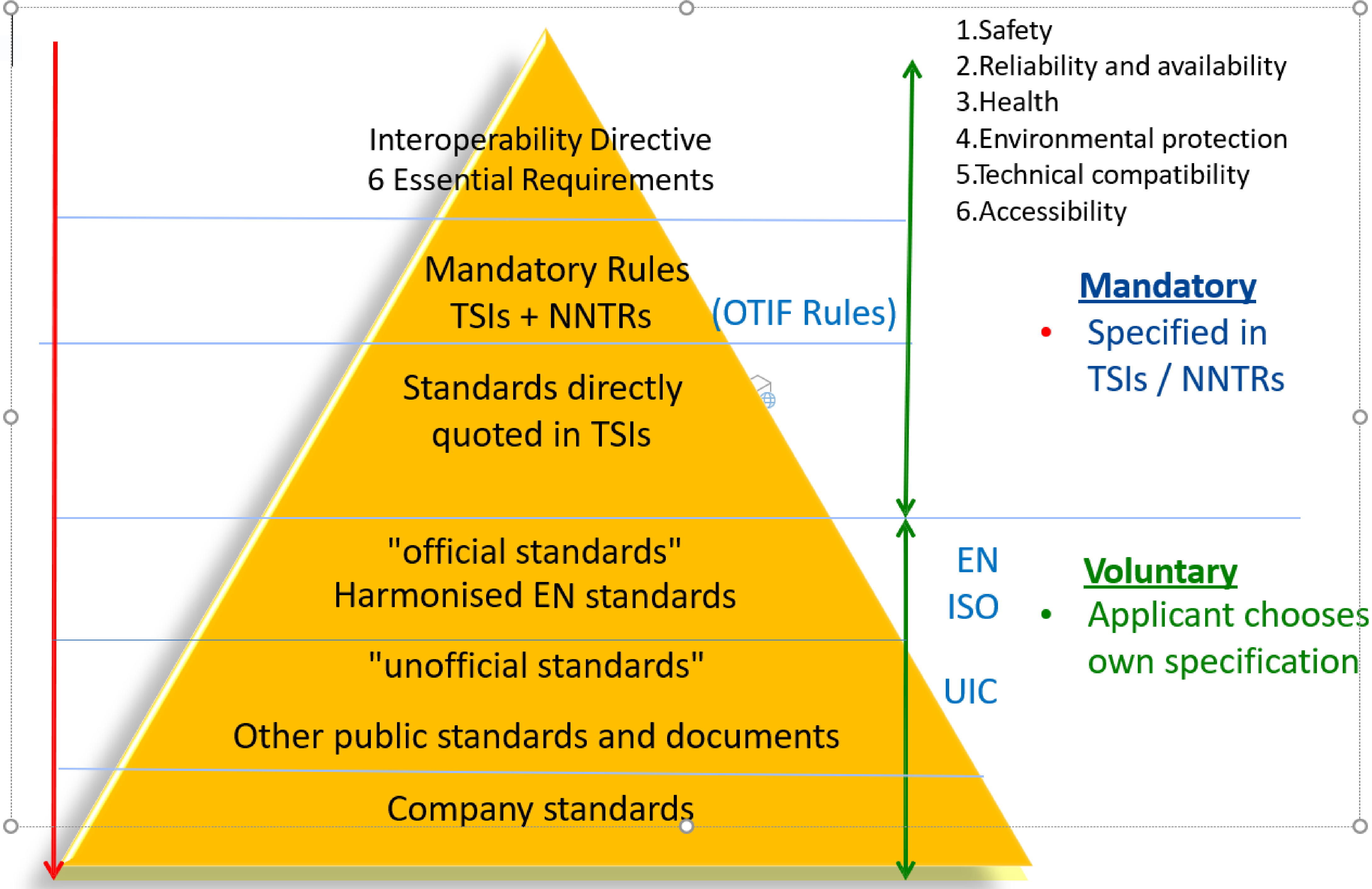
Railway Interoperability Essential requirements

Essential Requirements

- Safety
- Reliability and availability
- Health
- Environmental protection
- Technical compatibility
- Accessibility

Source: [PowerPoint Presentation (europa.eu)]



Interoperability Directive
6 Essential Requirements
Mandatory Rules
TSIs + NNTRs
(OTIF Rules)
Standards directly
quoted in TSIs
"official standards"
Harmonised EN standards
"unofficial standards"
Other public standards and documents
Company standards
1.Safety
2.Reliability and availability
3.Health
4.Environmental protection
5.Technical compatibility
6.Accessibility
Mandatory
Specified in TSIs / NNTRs
EN
ISO
UIC
Voluntary
Applicant chooses own specification

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Standards in TSIs

Standards in European Railway regulation can be :

- **Mandatory** when a direct reference to the standard is made in the TSIs (or in the documents quoted in TSIs).
- **Voluntary** when the standard provides presumption of conformity to a TSI requirement. The standard should then be listed in the European Union Official Journal (OJEU) and should contain an annex defining the presumption of conformity.

Note : In general, only some precise clauses of the standard are quoted in the TSIs, and a standard can be either mandatory because some clauses are quoted in the TSI and voluntary because other clauses provide presumption of conformity to other TSI requirements.

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Harmonised Standards

A harmonised standard is a European standard developed by a recognised European Standard Organisation: CEN, CENELEC, or ETSI. It is created following a request from the European Commission.

Manufacturers, other economic operators, or conformity assessment bodies can use harmonised standards to demonstrate that products, services, or processes comply with relevant EU legislation.

The references of harmonised standards must be published in the OJEU.

in communication 52018XC0810(06)
➔ List of harmonised standards

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Standards quoted in TSIs

Scope and definitions	Links with essential requirements	Functional and technical specs subsys.	Inter-operability Constituents	Conformity assessment + EC verification	Implementa-tion strategy
Chapters 1+2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7

TSIs refer to standards, making them mandatory

"TSIs may make an explicit, clearly identified reference to European or international standards or specifications or technical documents published by the Agency where this is strictly necessary in order to achieve the objectives of this Directive […] "
[Art. 4.8 IOD]

- Mandatory clauses of referenced standards are summarised in an Appendix of the TSI
  (e.g. Appendix J in LOC PAS TSI and Appendix D in WAG TSI)

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Voluntary harmonised standards

Scope and definitions
Chapters 1+2

Links with essential requirements
Chapter 3

Functional and technical specs subsys.
Chapter 4

Inter-operability Constituents
Chapter 5

Conformity assessment + EC verification
Chapter 6

Implementa-tion strategy
Chapter 7

Voluntary standards referring to TSIs

Note
TSI Application guides explain how TSIs may be applied and list voluntary standards giving presumption of conformity to TSI requirements.

- Voluntary harmonised standards may refer to TSI chapters when they give presumption of conformity to them (in addition to the mandatory clauses referred to in the TSIs).
  In this case their Annex ZA/ZZ shall reflect this.
- All harmonised standards are listed in the OJEU.

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How many standards in the 2022-2023 TSI package?

- Around 167 Mandatory standards
- Around 144 Voluntary standards

Note :

- Some standards are quoted in several TSIs. Therefore, there are around 220 references to standards in all TSIs
- Some standards can be in several categories listed above

TSI Revision Package 2022/23

Positive vote in RISC
30 March 2023

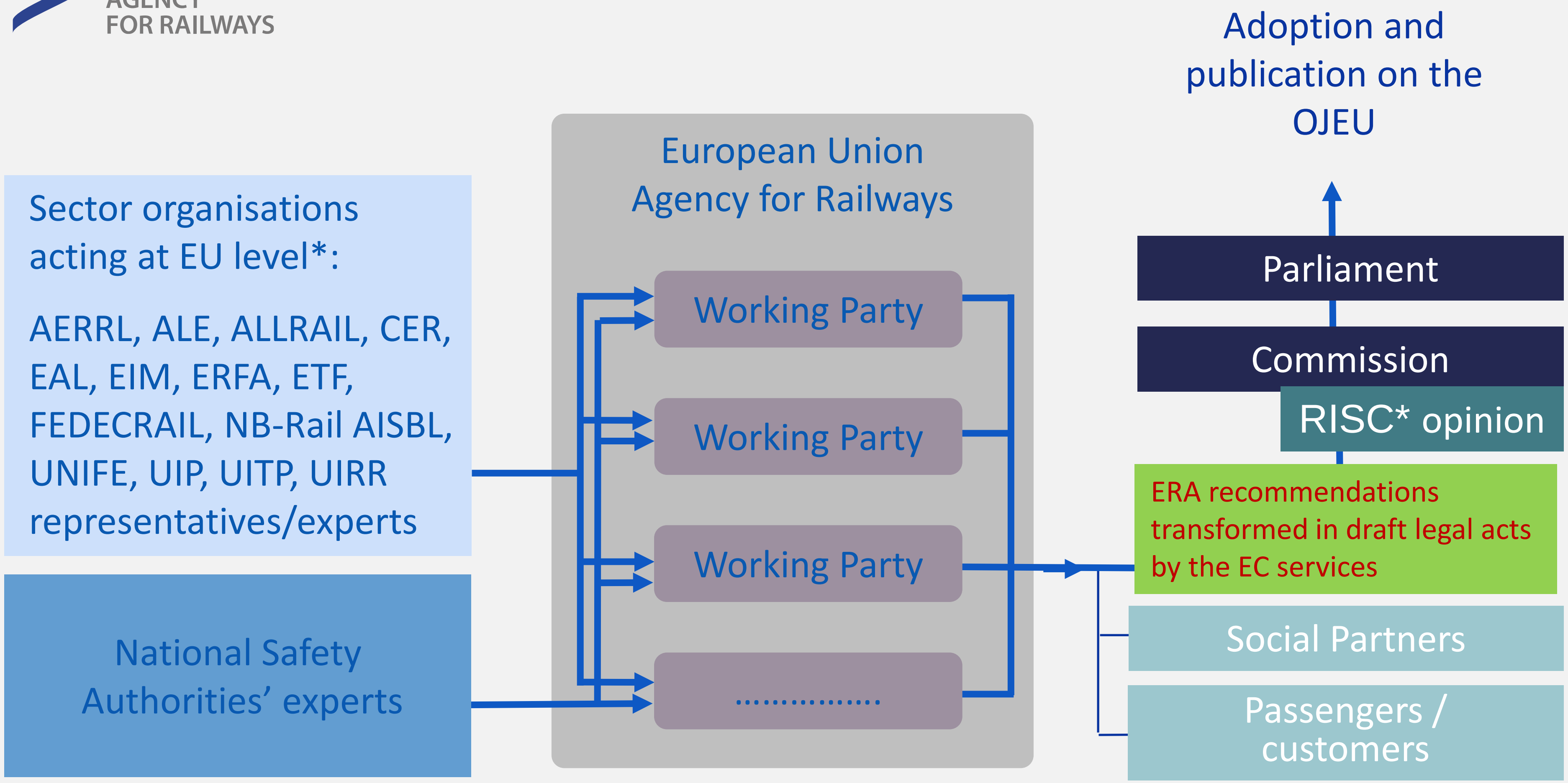
Topics covered (not exhaustive list)

Development of **Combined Transport**
Derailment detection function
Harmonisation between **Rolling Stock and Fixed Installation** TSIs
Provisions for **EU-wide authorisation of vehicles**
Procedure for testing the **acoustic performance of composite brake blocks**
ERTMS Game Changers

- Requirements for the use of **ATO GoA1/A2**
- **Modular** on-board architecture
- Definition of **FRMCS**

Enhancing **information flows** for goods and passengers

ERA working method to issue recommendations (e.g. on TSIs)



* The list of these representative bodies is established and amended by RISC Committee

* Railway Interoperability and Safety Committee (Member States)

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Conformity assessment

Conformity assessment is the process carried out by a manufacturer to demonstrate whether specific requirements relating to a product have been fulfilled.

In the EU legislation, conformity assessment procedures, called also “modules”, cover both design and production phases of a product.

The main reference document on conformity assessment is Decision 768/2008/EC, which, besides setting down the rules for the EC marking of products, lays down the modules that can be used for all regulated sectors.

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Railway « Modules » for CA

The specific nature of the railway sector requires a specific set of “modules” implementing the generic provisions of Decision 768/2008/EC.

This set of specific modules are defined in Decision 2010/713/EU.

Most railway specific modules require a third-party independent conformity assessment performed by bodies notified by Member States to the European Commission.

These bodies are known as Notified Bodies (NoBos).

ANNEX I

Modules for the procedures for assessment of conformity, suitability for use and EC verification to be used in the technical specifications for interoperability

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Exemple: Infrastructure TSI

Table 20

Modules for conformity assessment to be applied for interoperability constituents

<table>
<tr><th>Procedures</th><th>Rail</th><th>Rail fastening system</th><th>Track sleepers</th></tr>
<tr><td>Placed on the EU market before entry into force of relevant TSIs</td><td>CA or CH</td><td colspan="2" rowspan="2">CA or CH</td></tr>
<tr><td>Placed on the EU market after entry into force of relevant TSIs</td><td>CB + CC or CB + CD or CB + CF or CH</td></tr>
</table>

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Railway « Modules » for CA

List of terms used in the conformity assessment modules specific for railways and their equivalent in generic modules defined in Decision No 768/2008/EC

Decision No 768/2008/EC	This Decision	Module in this Decision
product	interoperability constituent	CA, CA1, CA2, CB, CC, CD, CF, CH, CH1
product	subsystem	SB, SD, SF, SG, SH1
legislative instrument	technical specification for interoperability	CA, CA1, CA2, CB, CC, CD, CF, CH, CH1
legislative instrument	relevant TSI(s) as well as any other regulations deriving from the Treaty;relevant TSI(s)	SB, SD, SF, SG, SH1
quality system	quality management system	CD, CH, CH1, SD, SH1
quality assurance	quality management system	CD, CH, CH1, SD, SH1
conformity (assessment)	EC verification	SB, SD, SF, SG, SH1
manufacturer	applicant	SB, SD, SF, SG, SH1
certificate of conformity	EC certificate of verification	SD, SF, SG, SH1
declaration of conformity	EC declaration of verification	SD, SF, SG, SH1

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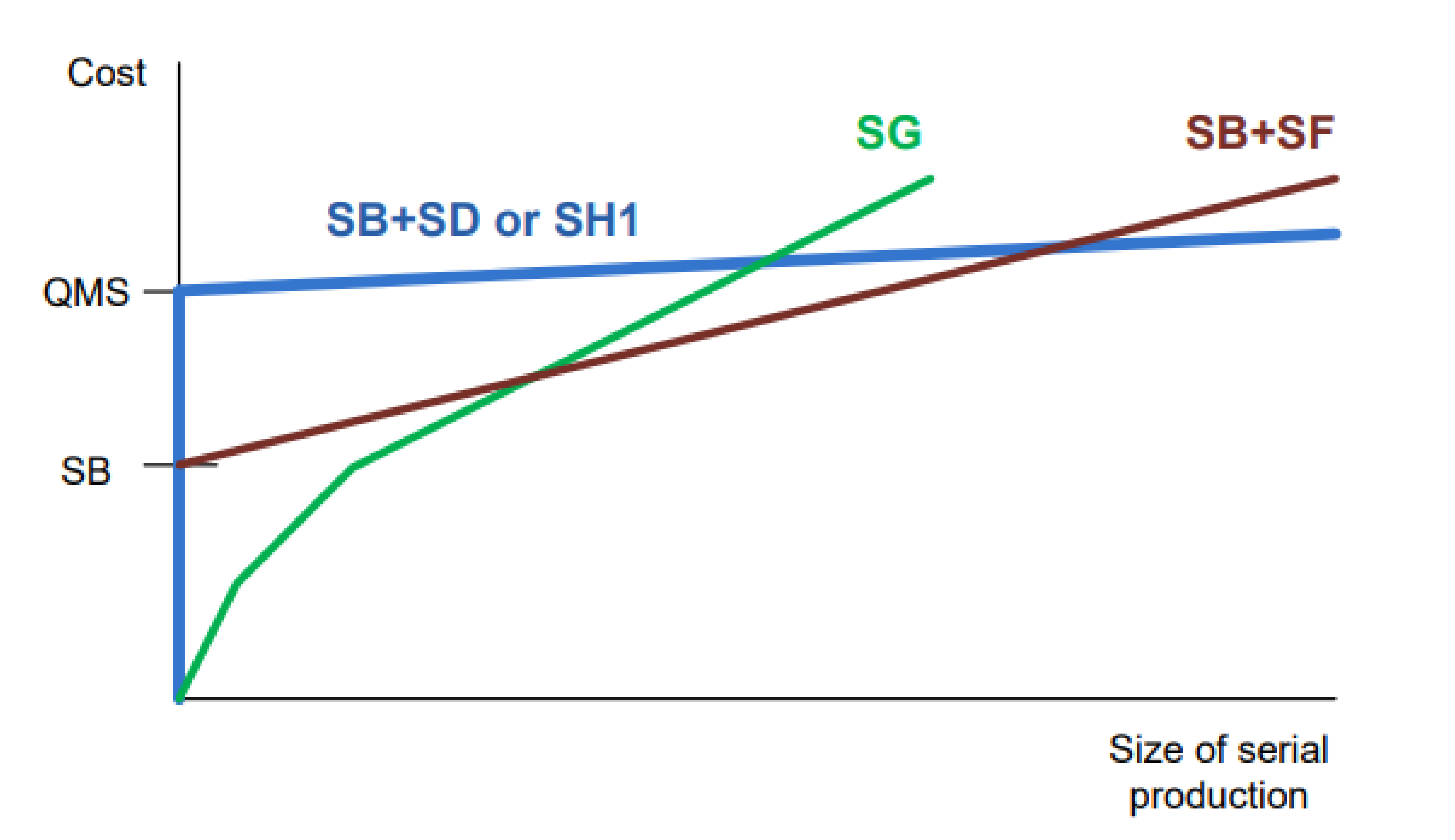
Cost of application of different conformity assessment modules depending on the size of serial production



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National rules may exist

- If no relevant TSI exists
- If a TSI requires the application of technical rules not fully described in the relevant TSI
- In case of derogation notified by a Member States:
  - *Isolated networks*
  - *Economic viability*
  - *Project at an advanced stage of development*
  - *Accident or natural disaster*
  - *Vehicles from 3rd countries with different track gauge*

All other national rules must be withdrawn

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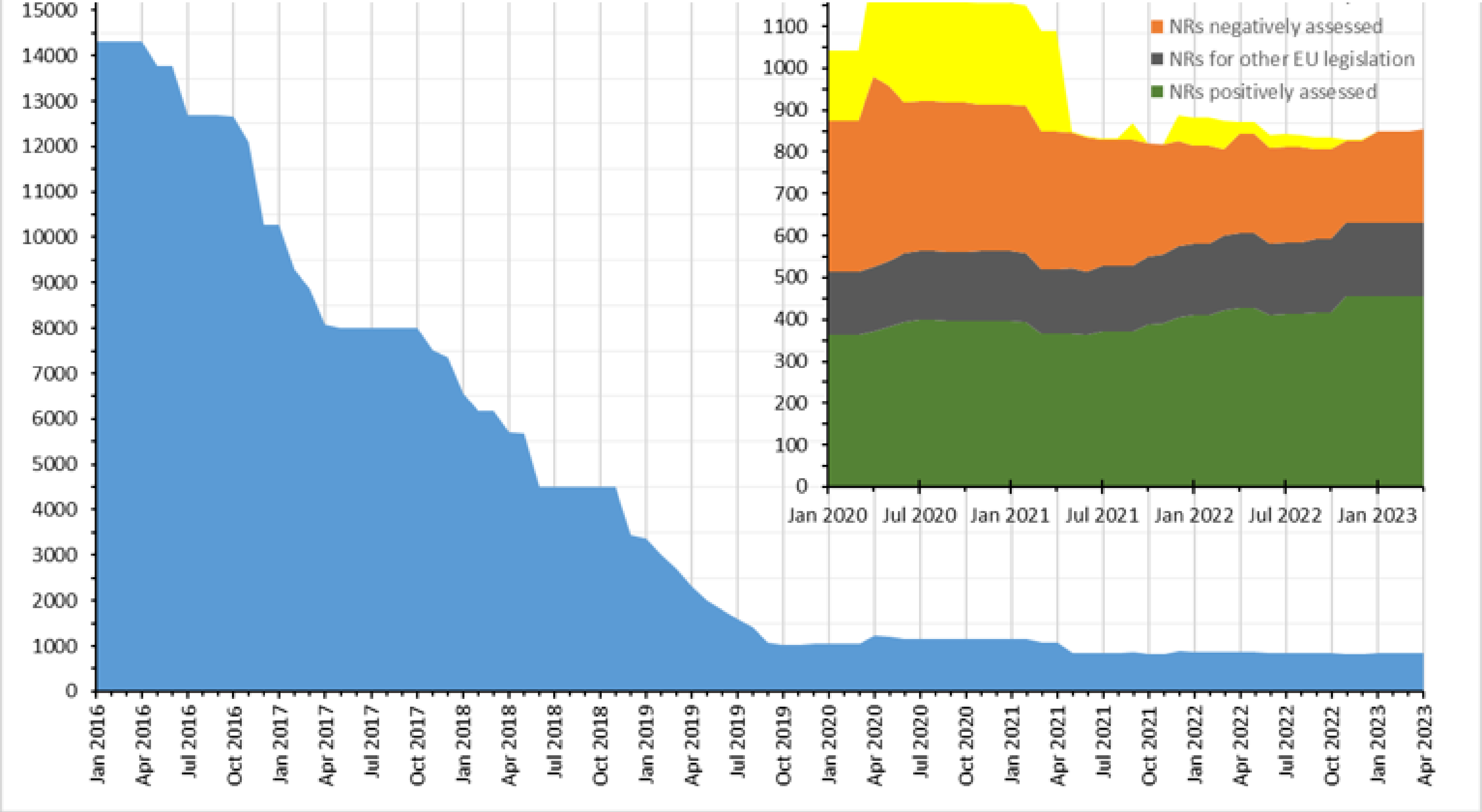
Cleaning up national rules: process ongoing since 2016



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Challenges for Railway interoperability in the EU

- Cleaning – up of National rules
- Long life cycle of railway assets that leads to long transition periods in implementing new regulations
- Funding issues to ensure timely implementation (especially on infrastructure)
- Huge capitals invested in physical assets

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ERA as System Authority

Operator

ERTMS

Infrastructure

The enabler for standardisation and digitalisation

Technical and operational interoperability (end-to-end)

Industrialized products and systems

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Progress made on Railway interoperability in the EU

- Under the 4th RP, the Agency is now the European authorisation and certification body for international railway transport
- Slow deployment of ERTMS deployment and patchy across Europe
- Delays in the implementation of legal requirements in a few MSs reducing benefits from the harmonised system e.g. TAP / TAF / PRM TSIs and RINF negatively affects railway customers daily experience
- Existing national rules can still represent an obstacle to interoperability and effective cross border traffic

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THE NEW PROCESS UNDER THE 4TH RAILWAY PACKAGE

	Activity		>1 MS	Only 1 MS
1	Placing on the market of mobile subsystems	• Essential requirements • No need for authorisation of the mobile subsystem • EC declaration of verification	Applicant	
2	Vehicle authorisation for placing on the market / Vehicle type authorisation	• Technical compatibility of the subsystems within the vehicle • Safe integration of the subsystems within the vehicle • Technical compatibility of the vehicle with the network in the area of use	**Authorising entity** The Agency in collaboration with NSAs	 The Agency or NSA (Applicant's choice)
			One-Stop-Shop	
3	Check before the use of authorized vehicle	Route compatibility on the basis of the Register of Infrastructure (RINF) and national rules	Railway Undertaking	
4	Supervision	In case of non-compliance to essential requirements noticed during operation by Railway undertakings or ultimately by NSA and inducing safety risks (e.g. during supervision activities) authorisation can be suspended, revoked or amended.	NSA(s)	

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Innovative solutions in TSIs

- To follow technological progress, innovative solutions may be required, which do not comply with the TSIs (including its assessment methods)
- In this case, the manufacturer shall declare how it deviates from the relevant TSIs and submit the deviations to the Commission for analysis.
- The Commission may request the opinion of the Agency and shall deliver an opinion on the proposed innovative solution.
- If this opinion is **positive**, appropriate specifications and assessment method, shall be developed and subsequently integrated in the TSI during their revision process. Pending the review of the TSI, the positive opinion delivered by the Commission shall be considered as an acceptable means of compliance with the essential requirements of the railway interoperability Directive.
- If the opinion is **negative**, the innovative solution proposed cannot be used.

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Questions & Answers

Questions

Is it possible to choose between CA modules?

Are all railway standards mandatory?

How is innovation addressed in TSI?

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Questions

In which cases national rules are allowed?

How are TSIs drafted?

On which principles?

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Abbreviations

Abbreviations

CCS: Control Command & Signalling
CEF: Connecting Europe Facility
CEN: Comité Européen de Normalisation
CENELEC: Comité Européen de Normalisation Électrotechnique
CEO: Chief Executive Officer
CINEA: European Climate, Infrastructure and Environment Executive Agency
CSI: Common Safety Indicator
CSM: Common Safety Methods
DeBo: Designated Body
DG: Directorate General
EC: European Commission
ECM: Entity in Charge of Maintenance
EN: European Norm
ENE: Energy
ERA: European Railway Agency – EU Agency for Railways
ERADIS: European Railway Agency Database of Interoperability and Safety
ERATV: European Register of Authorised Types of Vehicles
ERTMS: European Traffic Management System
ETCS: European Train Control System
EU: European Union
EU-27: The 27 Member States of the European Union
FP: Flagship Project
GDP: Gross Domestic Product
GHG: Green House Gas
HOF: Human & Organisational Factors
HS: High Speed
IC: Interoperable Constituents
IM: Infrastructure Manager
INEA: Innovation and Networks Executive Agency
INF: Infrastructure

EUROPEAN UNION AGENCY FOR RAILWAYS

Abbreviations

IOD: Interoperability Directive
ISO: International Standard Organisation
JU: Joint Undertaking
LOC & PAS: Locomotive & Passenger
MS: Member State
NIB: National Investigating Body
NNTR: Notified National Technical Rules
NoBo: Notified Body
NOI: Noise
NR: National Rule
NSA: National Safety Authority
OJEU: Official Journal of the European Union
OPE: Operations
OSS: One Stop Shop
OTIF: Organisation intergouvernementale pour les Transports Internationaux Ferroviaires
PESTEL: Political, Economical, Social, Technology, Legal
PPP: Public Private Partnership
PRM: Persons with Reduced Mobility
RA: Risk Assessment
RDD: Reference Document Database
RID: Regulation concerning the International carriage of Dangerous goods by Rail
RINF: Register of Infrastructure
RU: Railway Undertaking
SERA: Single European Railway Area
SMS: Safety Management System
SRT: Safety in Railway Tunnel
SSC: Single Safety Certificate
TAF: Telematic Applications for Freight
TAP: Telematic Applications for Passenger
TEN: Trans-European-Networks
TEN-T: TEN Transport
TSI: Technical Specifications for Interoperability
UIC: Union Internationale des Chemins de fer
VA: Vehicle Authorisation
WAG: Wagon

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Sources & droits d’auteur

Sources

EC Website

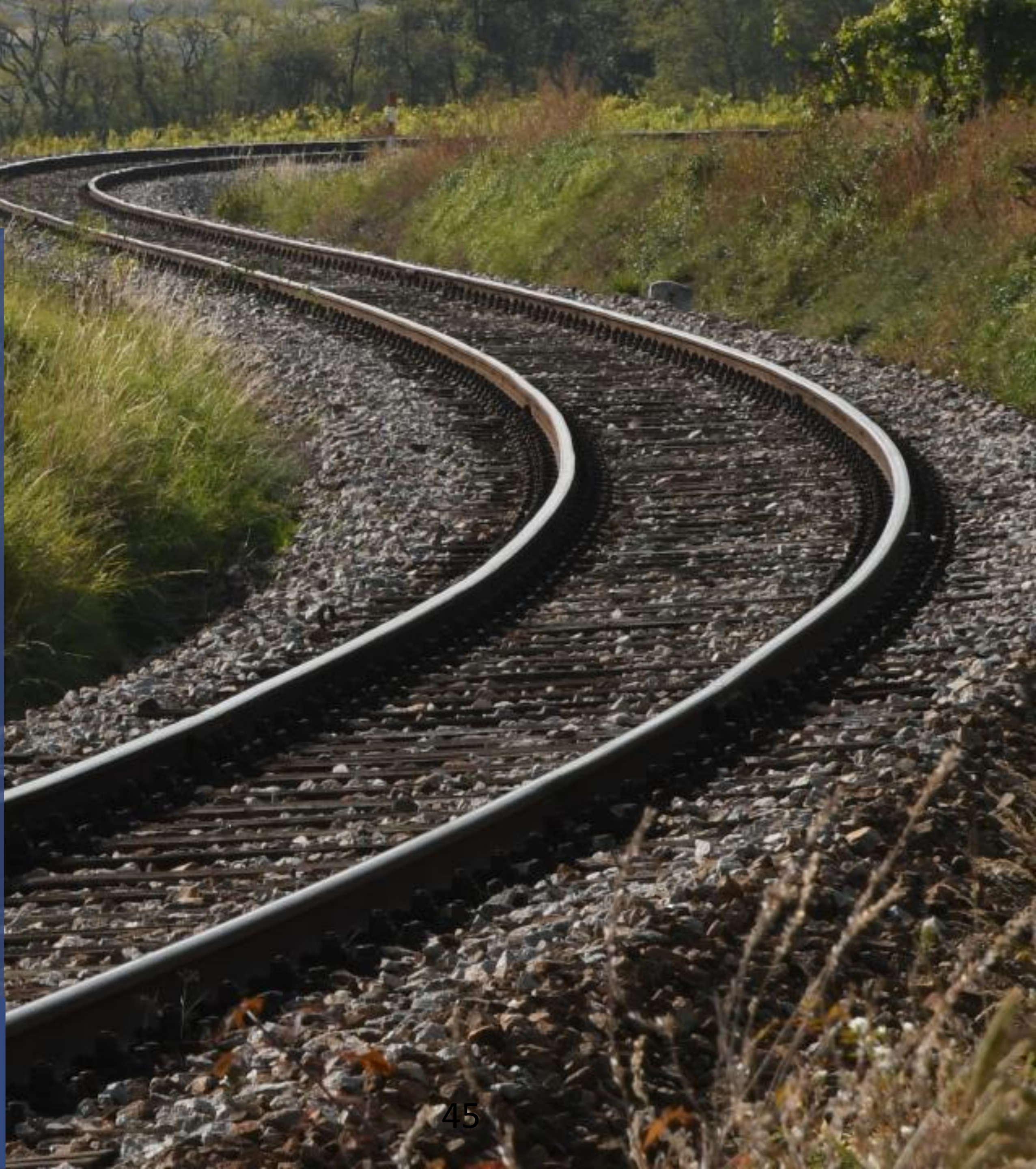
ERA Website

From the CEN website : The 'New Approach' (cen.eu)

From the Commission website : EUROPA – European Commission – Growth – Regulatory policy - SMCS

THANK YOU

Moving Europe towards a sustainable and safe railway system without frontiers.



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Summer School on “The European railway system”

Railway Engineering Education in Europe: experiences from Erasmus+ projects

Stefano Ricci

Università degli Studi di Roma "La Sapienza"

Rome, 16 July 2024

SAPIENZA
UNIVERSITÀ DI ROMA

STAFFER
EUROPEAN RAIL SKILLS ALLIANCE

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- Higher-education on Railways in Europe - Erasmus+ projects
- ASTONRAIL Project
  - State-of-the-art recognition of programmes and courses
  - Industry expectations and requirements
  - Study paths at different institutions
  - Multifunctional handbook
- STAFFER Project
  - Overview
  - Objectives
  - Implementation of training programmes

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Higher-education on Railways in Europe: Erasmus+ projects

ASTONRAIL

- Advanced approaches and practices for rail training and education to innovate Rail study programmes & Improve rail higher education provision
- September 2020 – August 2023
- 8 academic partners from 7 countries (Croatia, Germany, Italy, Slovakia, Spain, Sweden, United Kingdom)
- http://astonrail.eu/

STAFFER

- European Rail Skills Alliance
- November 2020 – October 2024 (ongoing)
- 31 academic and industrial partners from 13 countries (Austria, Belgium, Czechia, France, Germany, Greece, Italy, Luxembourg, Netherlands, Poland, Serbia, Slovakia, Spain)
- https://www.railstaffer.eu/

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ASTONRAIL Project
State-of-the-art recognition of programmes and courses

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REVIEWS

- Existing studies and structured information from various sources
- Data from previous EU projects
- Papers published on journals specialized on training education as well as railway technical and economic aspects
- International and national reports issued by railway operators, industries and public bodies responsible for education and training
- Web-portals dedicated to present the educational offer to potential learning audiences

SURVEYS

- Cross check and update of data from the reviews
- Detection and qualification of additional programmes and courses
- Organization and homogenization of collected data
- Building of an interactive database
- Issue of a handbook to use the database

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ASTONRAIL Project
State-of-the-art recognition of programmes and courses

MATRIX OF COMPETENCES

(Source: SKILLRAIL, 2012)

General topic	Rail systems activities – Innovative materials and production methods – Safety Intelligent mobility – Environment – Other							
2nd level topic	Economics	Traction	Rail Vehicles	Civil Engineering	Operations	Systems Engineering	Control Systems	General Terms
3rd level topic	Whole life or life cycle cost	Diesel	Wheel	Track	Resource management	Interoperability	ERTMS	Human factors
	Business cases	Electric (including supply systems)	Wheel set	Stations	Timetable management	Risk analysis	ETCS	Simulation
	Demand forecasting	Traction drives	Wheel/rail interface	Bridges	Track capacity management	Failure mode analysis	Route-based signalling	Verification
	Revenue Forecasting	Magnetic levitation	Active steering	Tunnels	Passenger management	System modelling	Speed-based signalling	Testing
	Government regulation	Gas turbine	Suspension (passive)	Earthworks	Freight management		Computer-based interlocking	Remote monitoring
	Business strategy	Distributed power	Suspension (active)	Drainage	Security		Solid state interlocking	Reliability
		Braking	Body construction	Level crossings	Train regulation		Electric/mechanical interlocking	Availability
		Fuel Cells		Heating and ventilation			Automatic train control	Maintenance
				Lighting				Safety
								Component
								Passenger
								Freight
								Noise pollution
								Air pollution
								Sustainability
								Light rail and tram systems
								Electromagnetic compatibility

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ASTONRAIL Project
State-of-the-art recognition of programmes and courses

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RAIL CAREERS MATRIX

(Source: UIC, 2019)

RAIL CAREERS MATRIX

LEVEL / GROUP	STRATEGIC	TACTICAL	OPERATIONAL
INFRASTRUCTURE	Managing Director Infrastructure	Infrastructure Planner	Track Inspector
VEHICLES	Managing Director Vehicles	Vehicle Design Engineer	Maintenance
OPERATIONS	Managing Director Operations	Timetable Planner	Train Crew
SIGNALLING	Managing Director Signaling	Signalling Planner	Signaling Inspector
ECONOMICS	Managing Director Commercial	Sales Director	Sales Assistant
ADMINISTRATION	Managing Administration Director	Administration Manager	Admin Assistant
ACADEMIA	Dean	Group Manager	Research Assistant

Rail Careers Matrix is a project aiming to classify jobs available within the railway industry using a matrix of 3 levels (strategic, tactical and operational) and 7 main groups of jobs. One example of a job title within each level/group matrix is presented in each box. Matrix updated: 02/04/2015.

RAILWAY

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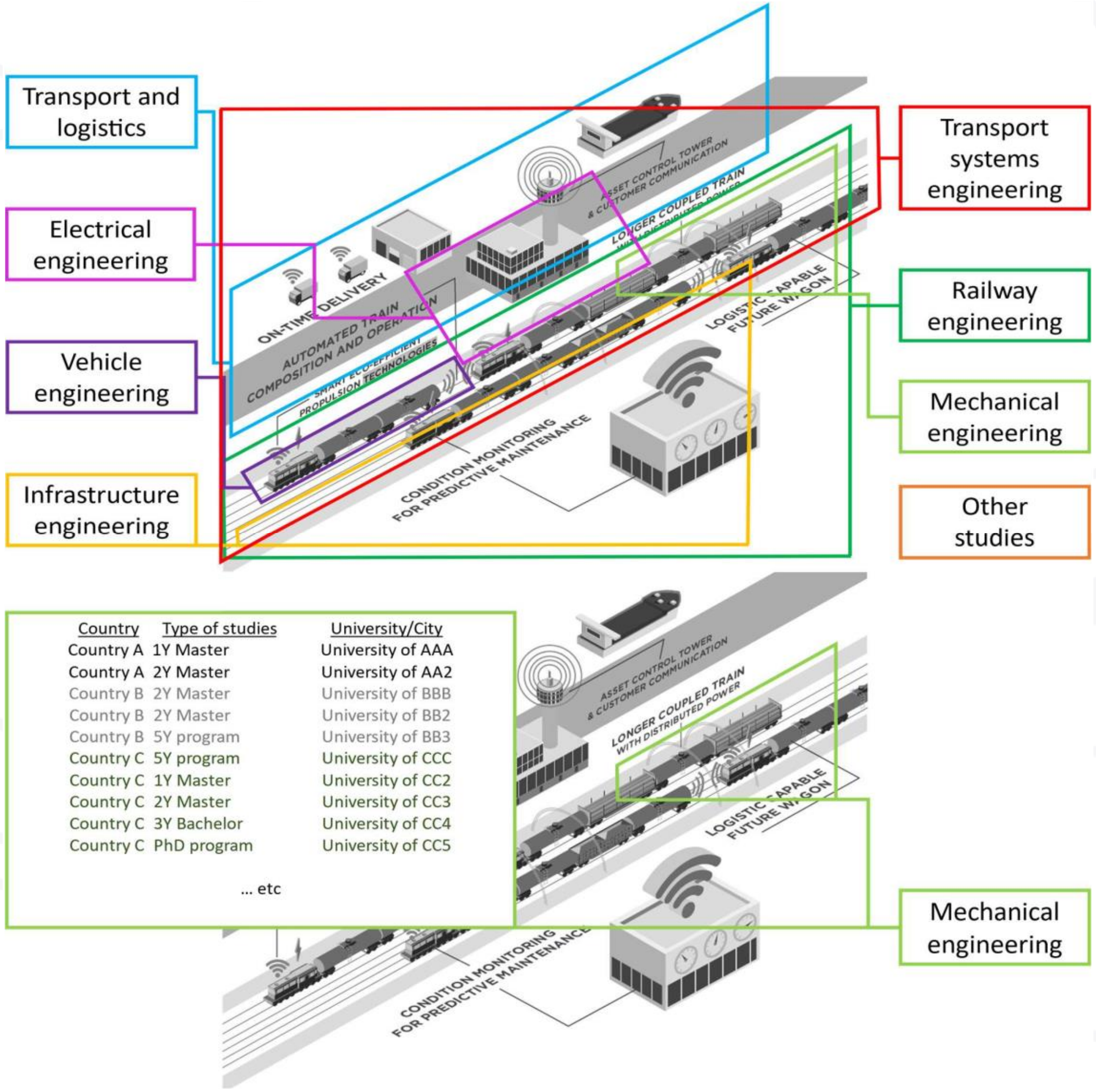
ASTONRAIL Project
State-of-the-art recognition of programmes and courses

VISUALIZATION OF PRIMARY CATEGORIES

OF PROGRAMMES IN THE DATABASE



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ASTONRAIL Project
Industry expectations and requirements

QUESTIONNAIRE TO INVESTIGATE INDUSTRIAL NEEDS

- Design of questionnaire
- Online survey deployment
- Data collection
- Data analysis

JOB MARKET OFFERS ANALYSIS

- Design of analysis
- Identification of sources of information
- Data collection
- Data standardization
- Data analysis

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ASTONRAIL Project
Structure of the questionnaire for the industries

Questions for all participants:
- About completed study courses that are preferred when recruiting engineers
- Whether the company is a practice partner of a dual study course and if so for which and where
- About preferred practical experience of newly hired employees
- To which participant category the company belongs

Question asked in selected participant category:
- To assess the knowledge required for graduates

Devided into:
- Infrastructure operator
- Passenger transport company
- Freight transport company
- Regulation authority
- Other administrative unit (national, international organization...)
- Manufacturer of rail vehicles or rail vehicle equipment
- Other manufacturing company of the railway industry
- Developer/manufacturer of control and safety technology in rail transport
- Development/supply of information in rail transport
- Engineering/consulting company

Questions for all participants:
- About the level of competence of university graduates
- About the skills of recruited graduates to work in international contexts
- About foreign language skills of newly hired employees
- About areas where graduates were best prepared for their current position and areas where additional preparation is required
- Comments or suggestions on the survey

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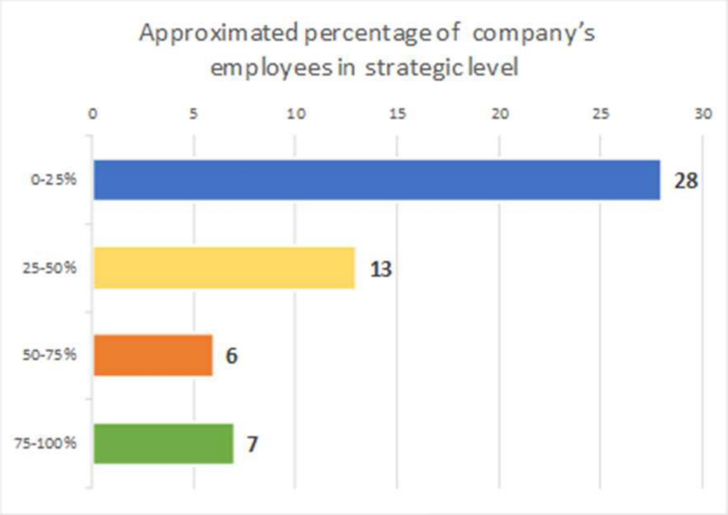
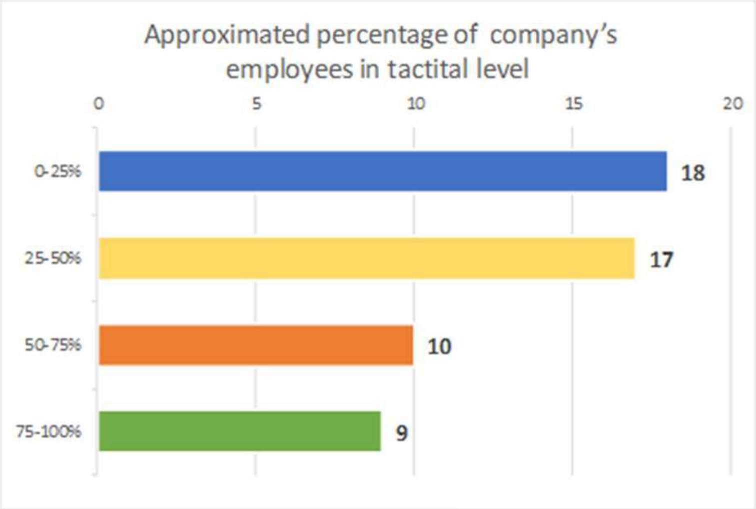
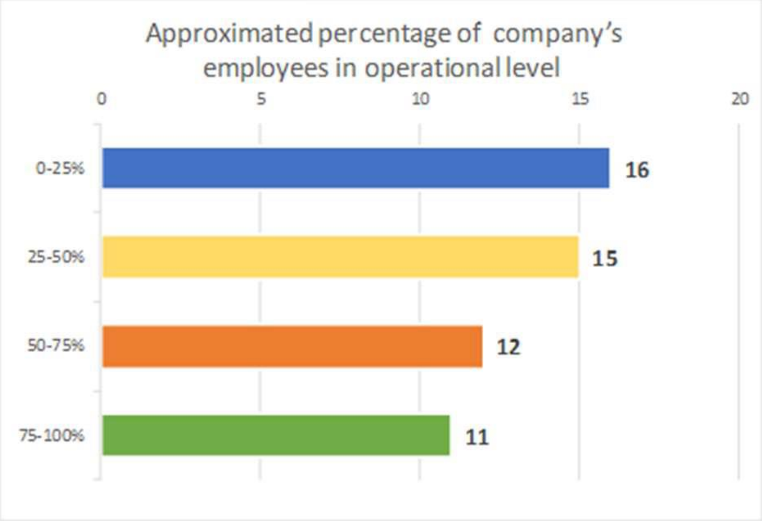
ASTONRAIL Project
Distribution of employees among the Rail Careers Matrix levels







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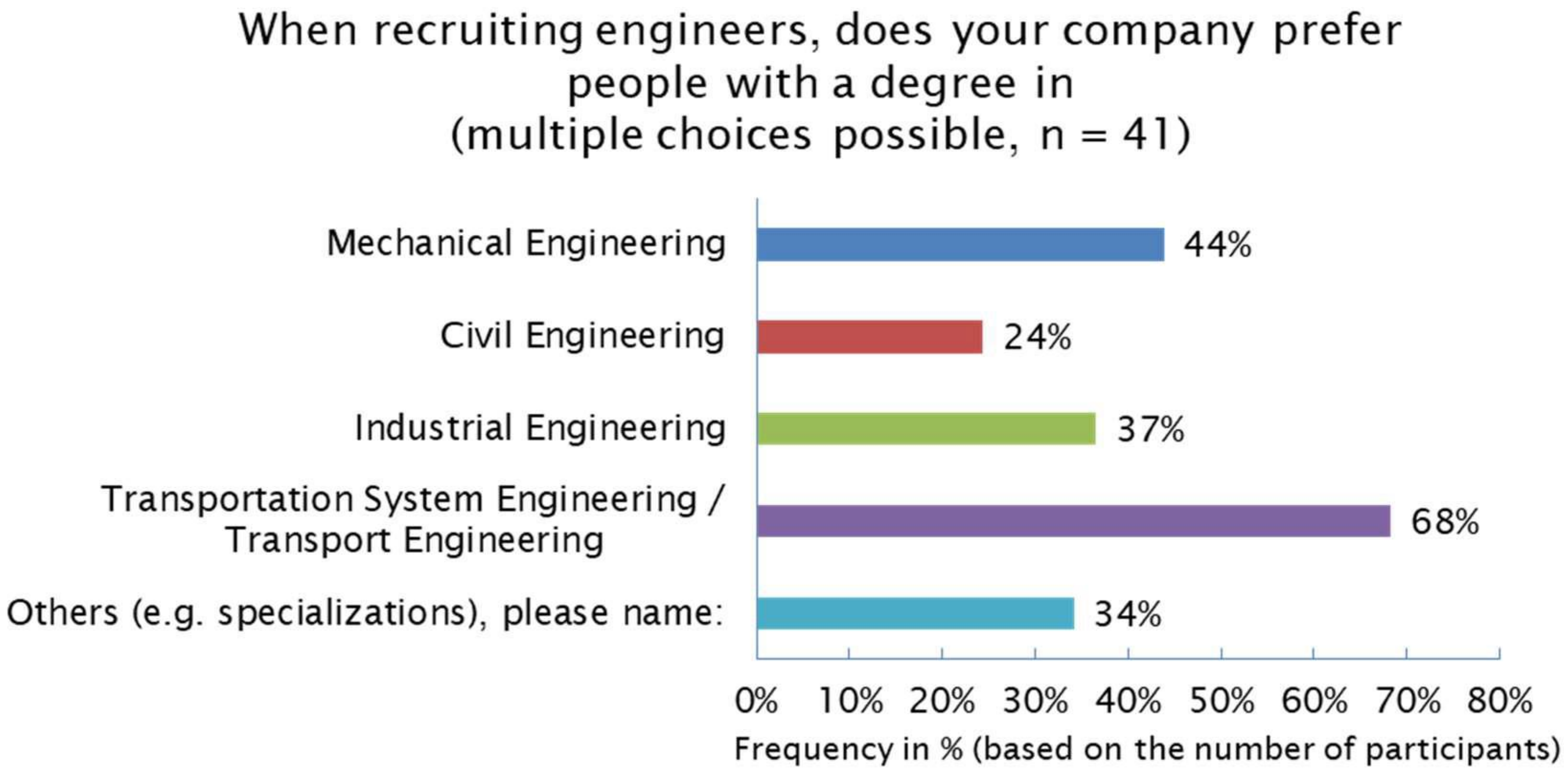
ASTONRAIL Project
Preferences on degrees acquired by the candidates



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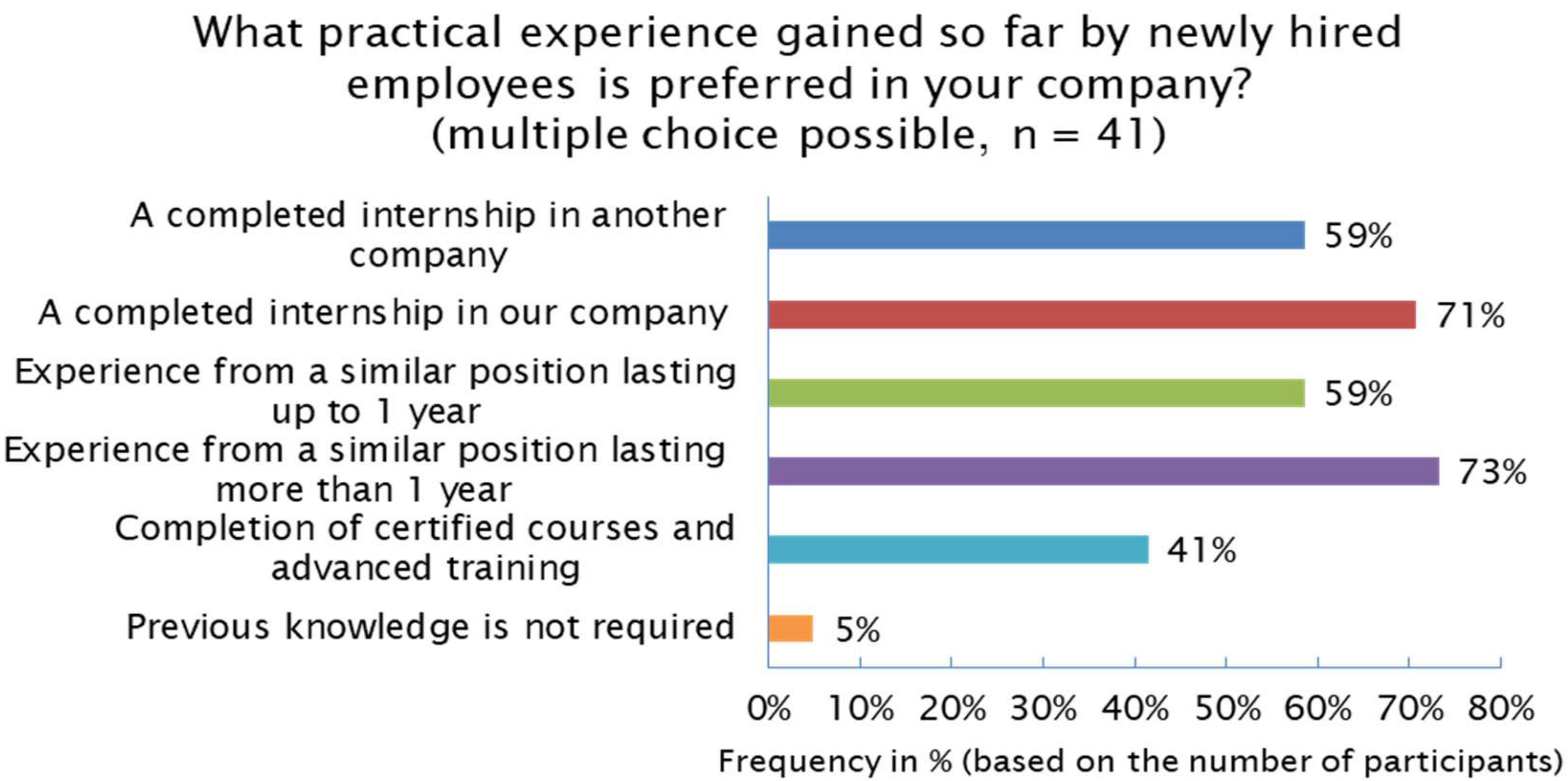
ASTONRAIL Project
Preferences on practical experience acquired by the candidates



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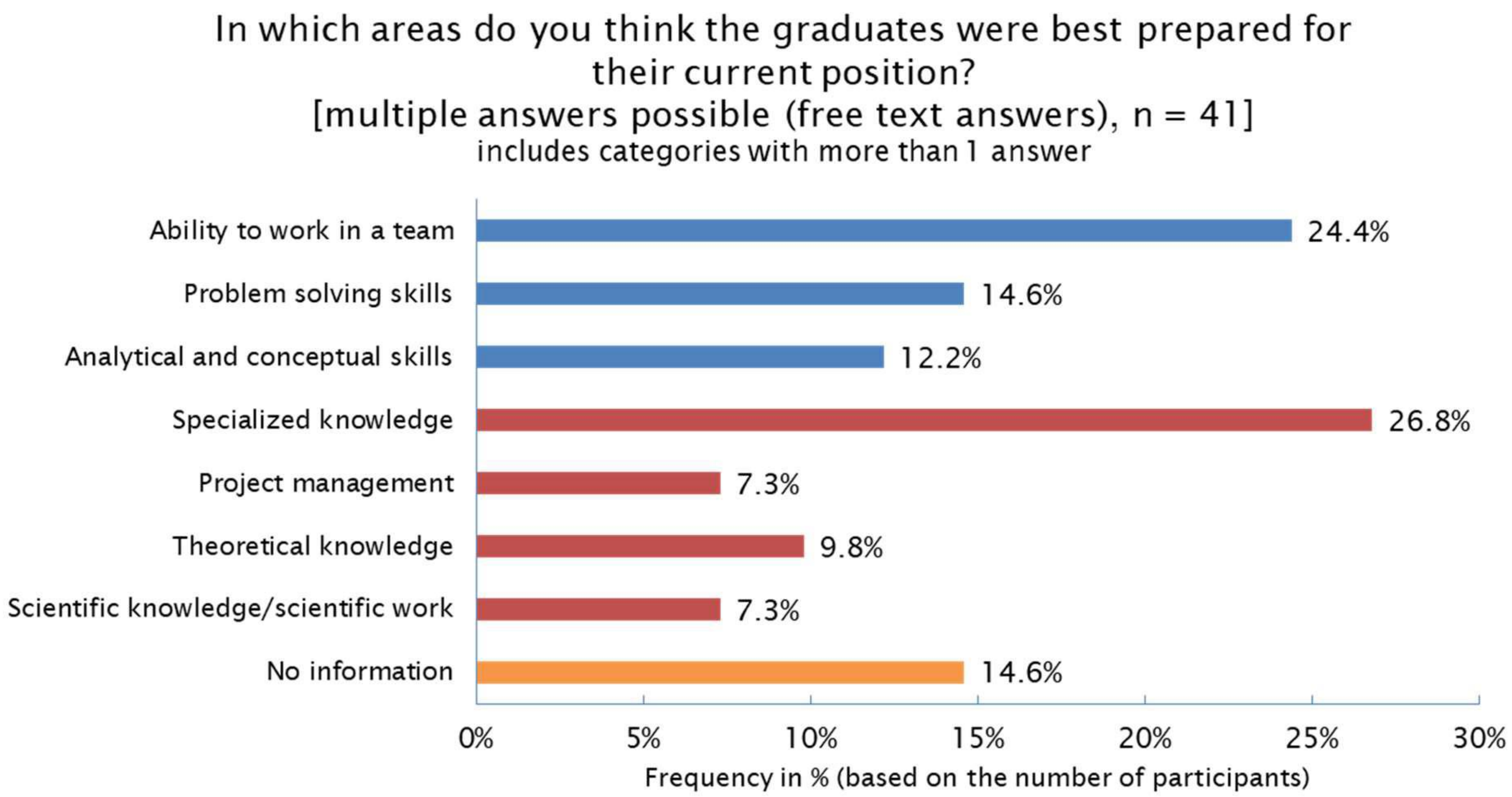
Judgements on best attitudes possessed by the candidates



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ASTONRAIL Project
Geographical distribution of investigated job offers

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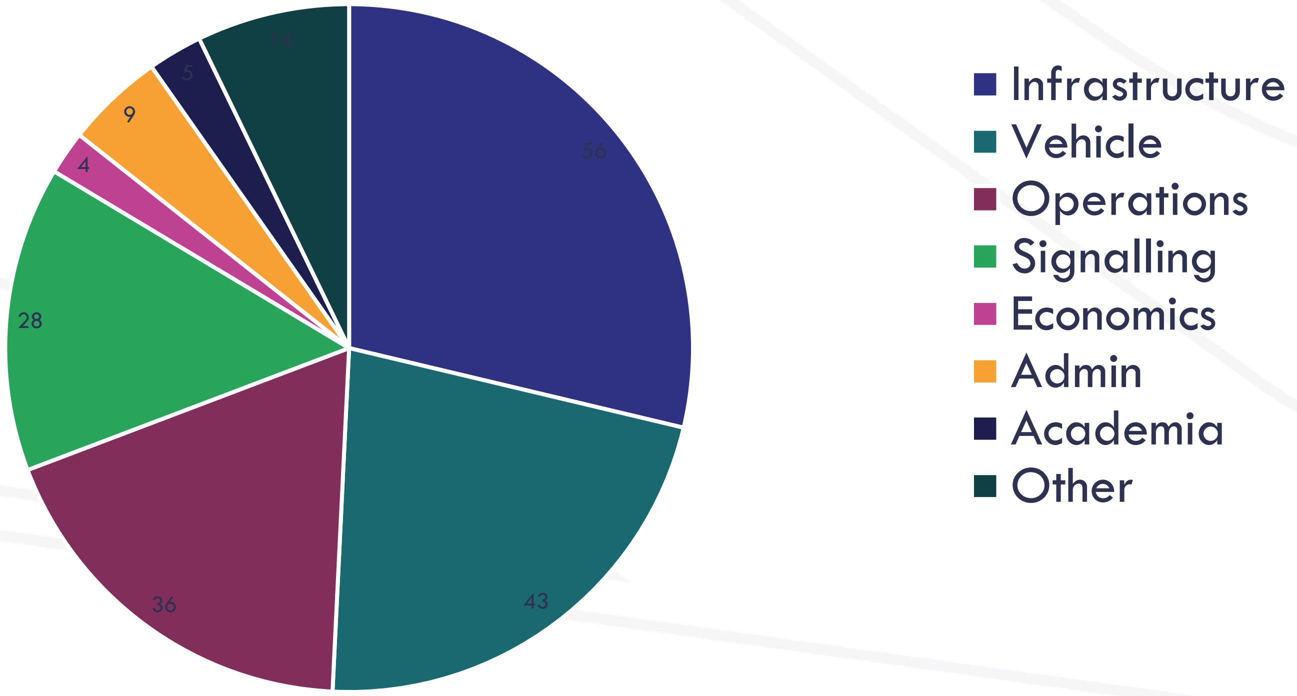
ASTONRAIL Project
Distribution of investigated job offers among groups of the Rail Careers Matrix

Share per Matrix row (groups)



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ASTONRAIL Project
Study paths at different institutions

MAPS OF STUDY PATHS AND COMBINATION WITH RAIL CAREERS MATRIX

- Rome La Sapienza
- KTH Stockholm
- Technical University of Applied Sciences Wildau
- University of Zilina
- University of Malaga
- University of Zagreb

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ASTONRAIL Project
Study paths at different institutions

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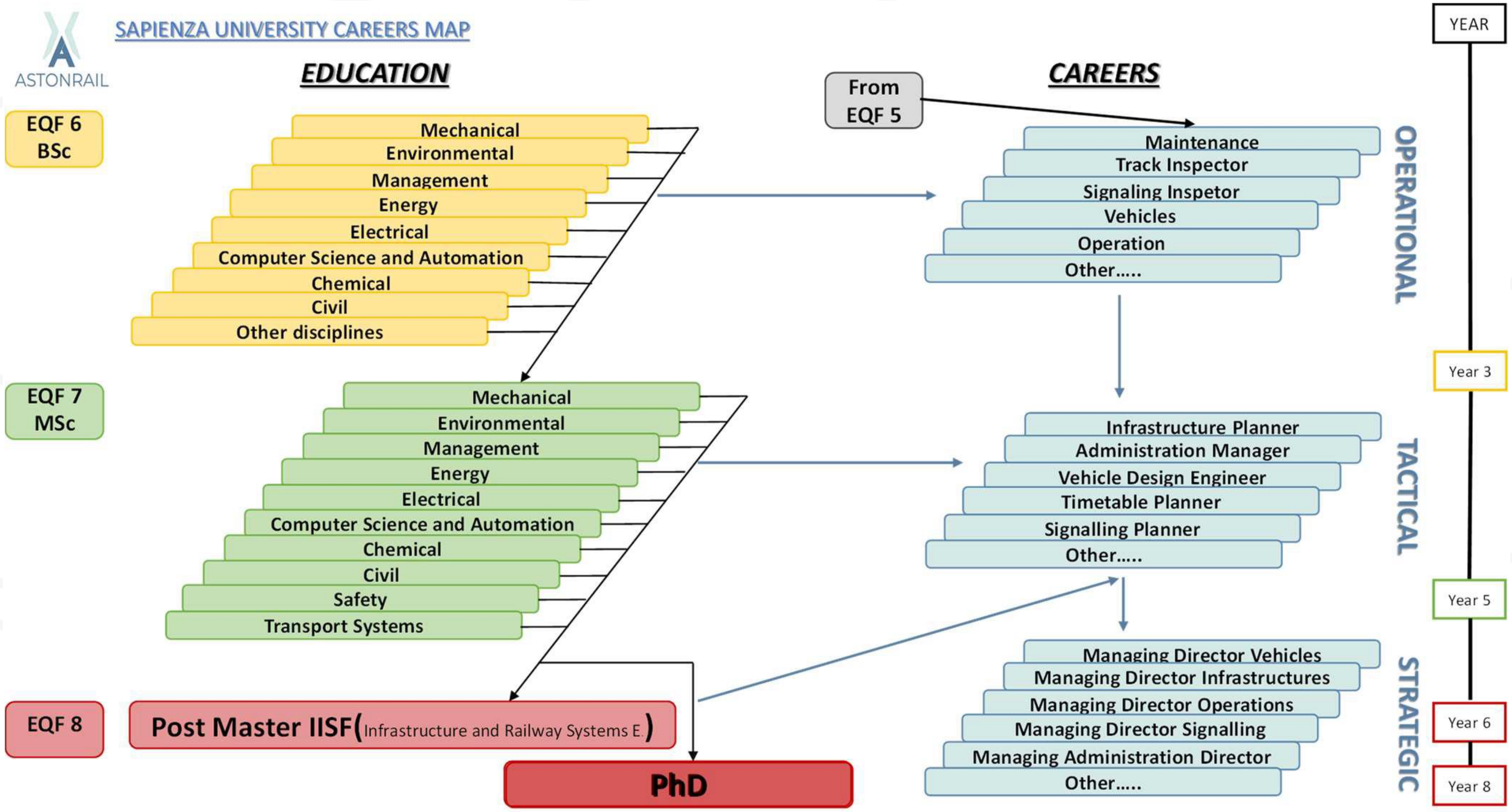
MAPS OF STUDY PATHS AND COMBINATION WITH RAIL CAREERS MATRIX

- Rome La Sapienza



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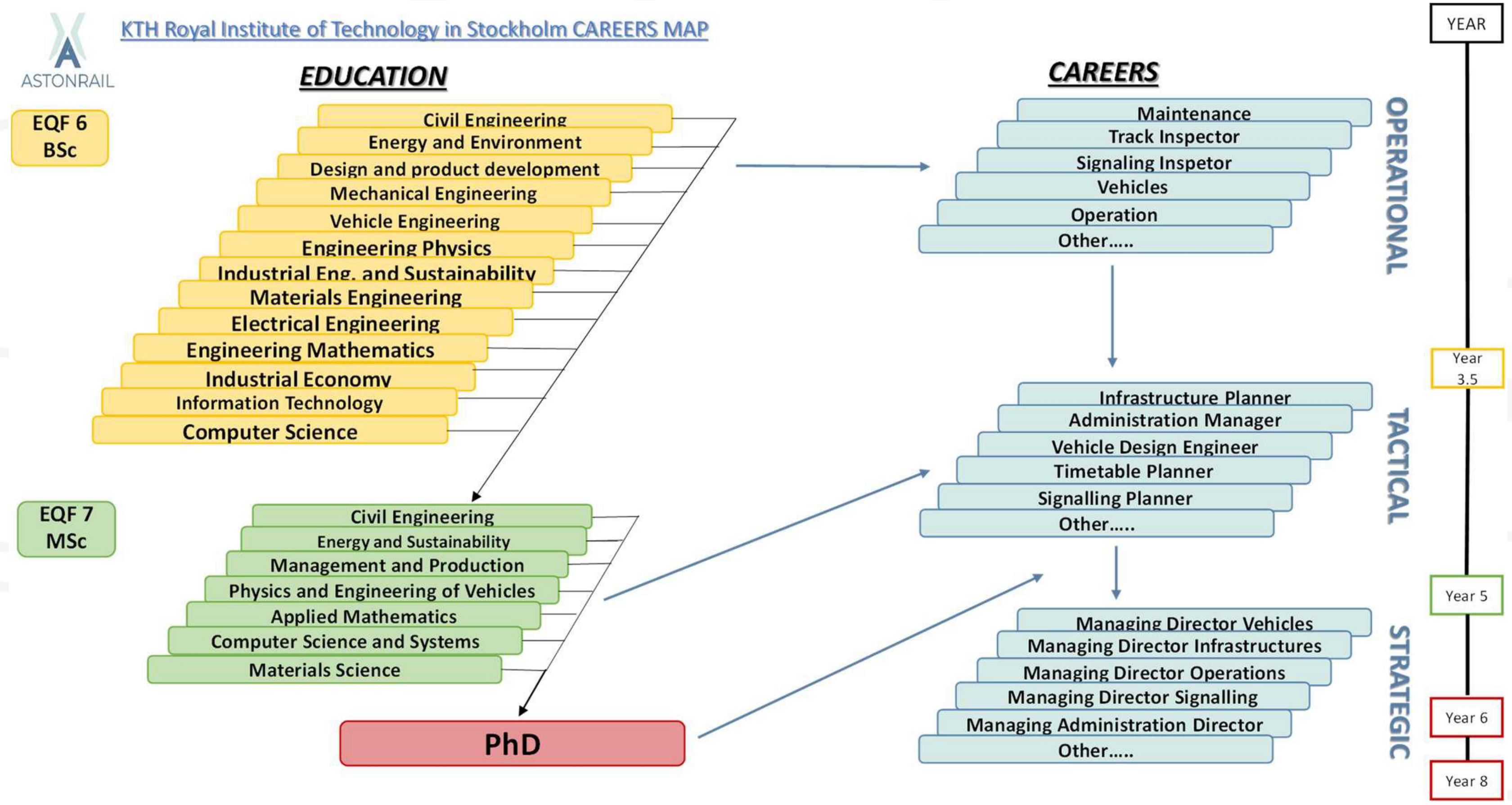
ASTONRAIL Project
Study paths at different institutions

MAPS OF STUDY PATHS AND COMBINATION WITH RAIL CAREERS MATRIX

- KTH Stockholm



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Multifunctional handbook

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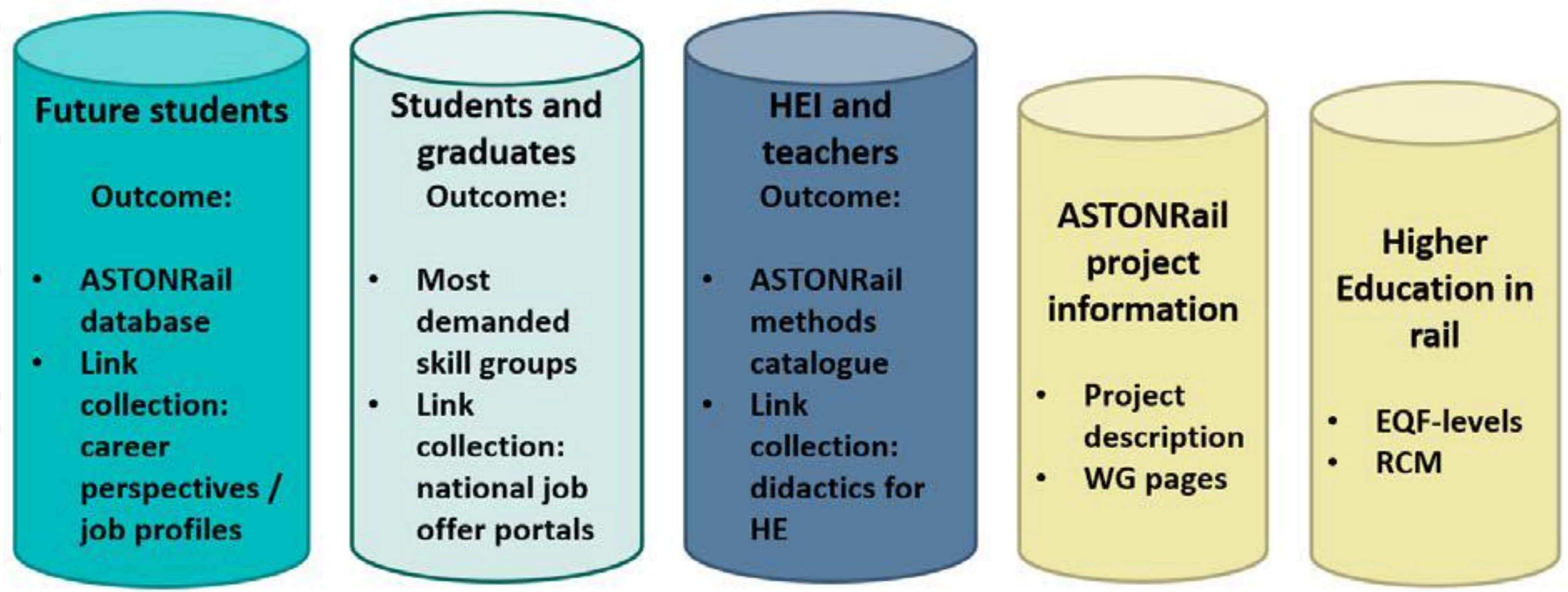
STRUCTURE AND PILLARS



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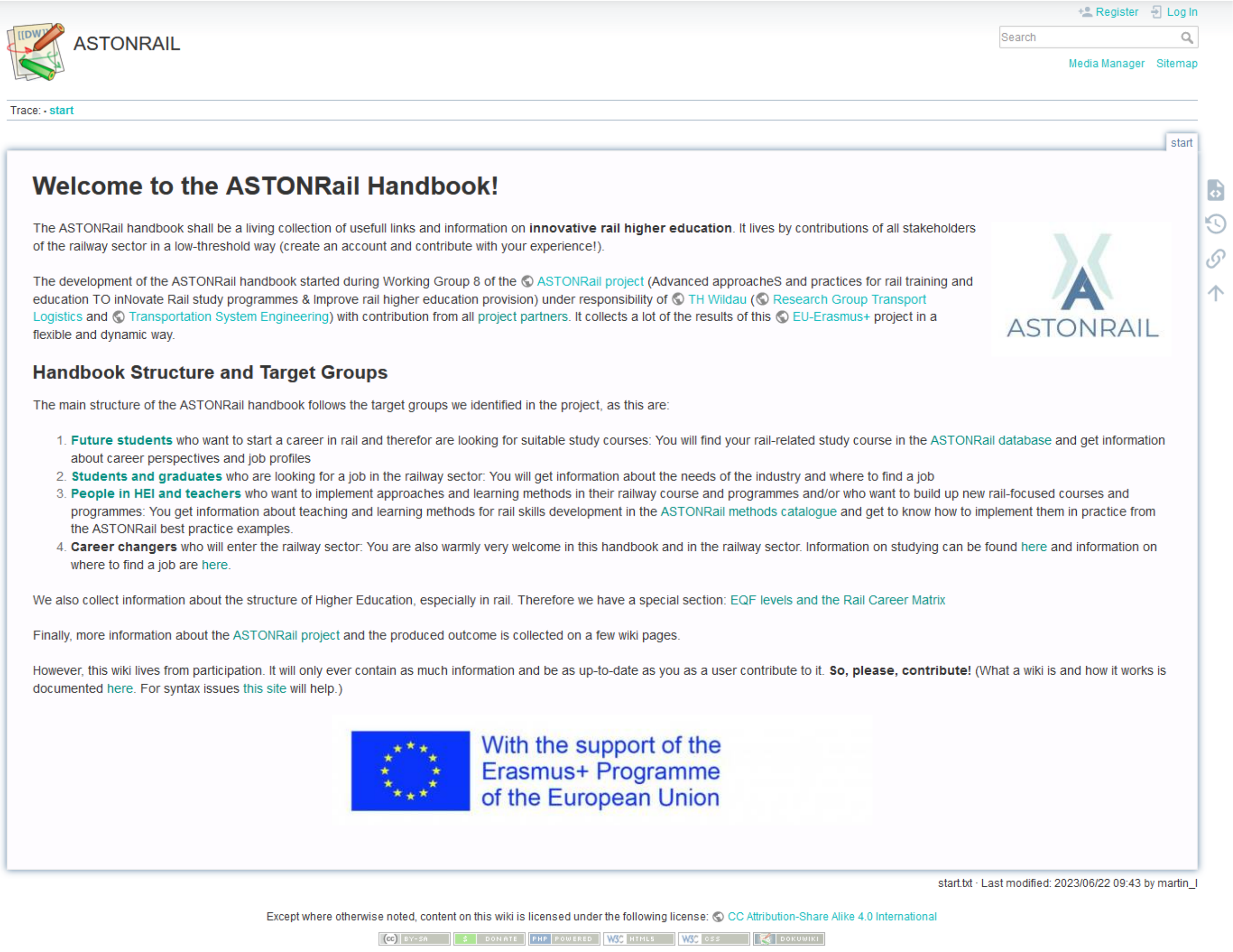
TARGET GROUPS

- Future students
- Students and graduate
- People in HEI and teachers
- Career changers



ASTONRAIL

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Trace: • start

start

Welcome to the ASTONRail Handbook!

The ASTONRail handbook shall be a living collection of usefull links and information on **innovative rail higher education**. It lives by contributions of all stakeholders of the railway sector in a low-threshold way (create an account and contribute with your experience!).

The development of the ASTONRail handbook started during Working Group 8 of the ASTONRail project (Advanced approacheS and practices for rail training and education TO inNovate Rail study programmes & Improve rail higher education provision) under responsibility of TH Wildau (Research Group Transport Logistics and Transportation System Engineering) with contribution from all project partners. It collects a lot of the results of this EU-Erasmus+ project in a flexible and dynamic way.

ASTONRAIL

Handbook Structure and Target Groups

The main structure of the ASTONRail handbook follows the target groups we identified in the project, as this are:

1. **Future students** who want to start a career in rail and therefor are looking for suitable study courses: You will find your rail-related study course in the ASTONRail database and get information about career perspectives and job profiles
2. **Students and graduates** who are looking for a job in the railway sector: You will get information about the needs of the industry and where to find a job
3. **People in HEI and teachers** who want to implement approaches and learning methods in their railway course and programmes and/or who want to build up new rail-focused courses and programmes: You get information about teaching and learning methods for rail skills development in the ASTONRail methods catalogue and get to know how to implement them in practice from the ASTONRail best practice examples.
4. **Career changers** who will enter the railway sector: You are also warmly very welcome in this handbook and in the railway sector. Information on studying can be found here and information on where to find a job are here.

We also collect information about the structure of Higher Education, especially in rail. Therefore we have a special section: EQF levels and the Rail Career Matrix

Finally, more information about the ASTONRail project and the produced outcome is collected on a few wiki pages.

However, this wiki lives from participation. It will only ever contain as much information and be as up-to-date as you as a user contribute to it. **So, please, contribute!** (What a wiki is and how it works is documented here. For syntax issues this site will help.)

With the support of the Erasmus+ Programme of the European Union

start.txt · Last modified: 2023/06/22 09:43 by martin_l

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FULL SEARCH IN STUDY COURSE DATABASE

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Trace: · start · database_welcome · full_course_search

astonrail_handbook:future_students:full_course_search

Full Search in Study Course Database

Down here the full database is shown. You can filter by clicking the mangifier glass icon and enter a filter string in every column. The individual whole information about the study course you can reach by the highlighted page name in the first column of the table.

The table seems to be too extensive for you? Please try the prefiltered compilationes listed here.

Page	University or Organisation	Name of Study Course	Country	Teaching Language	Duration in Month	EQF level	Year when course was launched	Level in Rail Career Matrix
course_001	Technical University of Denmark DTU	Railway Design and maintenance, 11404	Denmark	English	4	7	2010	strategic, tactical, operational
course_002	Michigan Tech	Railroad Engineering	United States	English	3		2006	tactical, operational
course_003	University of Rome La Sapienza	Railway infrastructures (within Civil Eng, transport infrastructures)	Italy	Italian	3	7		strategic, tactical, operational
course_004	University of Rome La Sapienza	Master's degree in transport systems engineering	Italy	English	3	7		strategic, tactical, operational
course_005	University of Rome La Sapienza	Ingegneria sistemi ferroviari	Italy	Italian	9	8		strategic, tactical, operational
course_006	Aston University	Rail Transport	United Kingdom	English	3	6	2010	strategic, tactical, operational
course_007	University of Zagreb	Rail Transport (bachelor)	Croatia		36	6	2006	strategic, tactical, operational
course_008	University of Zagreb	Rail Transport (master)	Croatia		24	7	2006	strategic, tactical, operational
course_009	Technical University of Applied Sciences Wildau	Transportation System Engineering (B. Eng.)	Germany	German	42	6	2014	tactical, operational

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TEACHING AND LEARNING TYPES AND METHODS

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astonrail_handbook:hei_teachers:types_and_methods_by_classification

Table of Contents

Types and Methodes by Classification

For an easy orientation all teaching and learning types and methods as well as the assessment methods from the database are listed by this classification on this page. In the tables some essential information is given only. The individual whole information about the types and methods you can reach by the highlighted page names in the first column of the table.

Teaching and learning types

Page	↓name of type or methode	short description	best practice examples
type-method_001	In-class teaching/lectures	Well-structured lectures executed in the classroom for introduction, presentation and discussion of key theoretical aspects, standards, operational rules, and similar for medium size and big size groups	bp_1_type_in-class_teaching_or_lectures_1.pdf, bp_2_type_in-class_teaching_or_lectures_2.pdf, bp_3_type_in-class_teaching_or_lectures_3.pdf
type-method_005	Invitation of guest lecturers/experts	Delivering the teaching content by university non-academic experts and professionals, coupling the course content to stakeholders and applications	bp_10_type_invitation_of_guest_lecturers_experts_1.pdf, bp_11_type_invitation_of_guest_lecturers_experts_2.pdf
type-method_004	Online teaching and learning	- Type where teaching process is delivered remotely through online platforms - Level of implementation is very different (starting from sharing learning material (produced in advance) via a static online platform up to interactive and synchronic virtual classrooms delivery)	bp_8_type_online_teaching_and_learning_1.pdf, bp_9_type_online_teaching_and_learning_2.pdf
type-method_006	Practical learning/internship	- Type of learning provided outside a university in a practical and real-live working context - Duration can be a few weeks or a whole semester - Can be an integrated part of the curriculum	bp_12_type_practical_learning_internship_1.pdf, bp_13_type_practical_learning_internship_2.pdf, bp_14_type_practical_learning_internship_3.pdf
type-method_007	Self-learning	Type of learning where students learn on their own without influence by teachers during that time	bp_15_type_self-learning_1.pdf, bp_16_type_self-learning_2.pdf
type-method_002	Seminars	- Type of small and medium sized group teaching (approx. 5 - 30 persons) with huge share of interaction between the students - Mostly in the classroom in an in-class teaching situation, but not necessarily - No front-of-class teaching instead of that tutor guide on the side or meddler in the middle, sometimes student-led - Research seminars: Can as well be a format to show students ongoing research activities of internal or external researchers or to let the students present research publications to each other	bp_4_type_seminars_1.pdf, bp_5_type_seminars_2.pdf

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STAFFER Project Overview

The partnership consists of **31 partners:**

- 6 infrastructure managers/operators
- 8 rail industry suppliers
- 2 organizations (UNIFE & CER)
- a consultant
- 14 educational institutions

and15 associated partners,

from 13 European Countries :

Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, Luxembourg, Netherlands, Poland, Serbia, Slovakia, Spain

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STAFFER Project Objectives

IDENTIFYING SKILLS NEEDS

STAFFER will help operators, infrastructure managers and suppliers anticipate their competence needs of tomorrow

ADAPTING CURRICULA

This Blueprint for Skills will design new training curricula to complement existing training programmes and adapt existing ones to meet future challenges

FACILITATING TRANSNATIONAL MOBILITY

Our consortium's work will allow the development of a framework facilitating transnational mobility for students, apprentices, trainees, or other staff groups in the rail industry

DEVELOPING A LONG-TERM STRATEGY

This initiative will help the whole rail sector come together around a long-term action plan for skills

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STAFFER Project
Implementation of training programmes

Number of partners involved	11
Number of programmes	22
Percentage of EQF level covered	100%
Total n. of expected learners at EQF level 6	<200
Total n. of expected learners at EQF level 7	>50÷60
Total n. of expected learners at EQF level 8	>few

Educational partner	Number of programmes	EQF levels covered		
		6	7	8
AUTh	2		1	1
CESI	4	2	2	
CTU	1		1	
ESTACA	2		2	
SGH	4	1	3	
TUD	2	1	1	
UASFHE	1		1	
UASSP	1	1		
UB	1		1	
UNIGE	2		1	1
UNIROMA1	4		2	2
Total n. of pogrammes	24	5	15	4
Total n. of expected learners	>740	>109	>635	>36

Selected programme	Number of programmes
Railway systems engineering	6
Rail traffic/operations engineering	2
Rail transport engineering	13
Railway systems technicians	2
European Railway System	1
Total n. of pogrammes	24

STAFFER Project
Implementation of training programmes

Summer school on
The EUropean railway system

www.railstaffer.eu

Period
10 – 19 July 2024

Location
Sapienza University of Rome, Faculty of Civil and Industrial Engineering
Via Eudossiana 18, Roma (Italy)

Topics
EU regulatory framework, interoperability, signalling systems, ERTMS/ETCS, sustainable powertrains, green mobility, safety management, risk assessment

Lecturers from
European Union Agency for Railways (ERA), Sapienza University of Rome (Italy), Conservatoire national des arts et métiers (France), University of Applied Science Erfurt (Germany)

Technical visits to
Traffic control rooms, maintenance workshops, CCS laboratory, construction site, national railway museum in Pietrarsa (Napoli) including Roma-Napoli transfer by high-speed train with visit in the driver's cabin

Admission requirements
Participation in the summer school is free of charge for Bachelor's, Master's and PhD students who have obtained at least 6 ECTS in modules related to railway engineering

Registration
Apply by 31 May 2024 by filling in the registration form at this link:
https://forms.gle/U1SWsGSpNqhgFCLHA
A maximum of 30 candidates will be admitted

Contacts
For information, please write to **luca.rizzetto@uniroma1.it**

Project partners

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Thank you for your kind attention

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Summer School on "The European railway system"

Safety management and risk assessment in European railways

Marco Antognoli, Luca Rizzetto
Università degli Studi di Roma "La Sapienza"

Rome, 16 July 2024

SAPIENZA
UNIVERSITÀ DI ROMA

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Evolution of European Union legislation

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- Liberalisation, Access, Competition
- Interoperability, safety, EU standards
- European Networks

- Dir. 91/440 on the development of the Community's railways

- Dir. 95/18 on the licensing of railway undertakings
- Dir. 95/19 on the allocation of railway infrastructure capacity and the charging of infrastructure fees

- Directive 96/48 on the interoperability of the trans-European high-speed rail system

- Dec. 1692/96 on the development of the trans-European network

First Railway Package (2001)

- Dir. 2001/12 separation of accounts of Rus/IMs and freight liberalisation
- Dir. 2001/13 licence extension
- Dir. 2001/14 essential functions on capacity and toll

- Directive 2001/16 on the interoperability of the trans-European conventional rail system

Second Railway Package (2004)

- Dir. 2004/51 completion of freight liberalisation
- Reg. 881/2004 establishment of the ERA
- Dir. 2004/49 railway safety
- Dir. 2004/50 interoperability

Third Railway Package (2007)

- Dir. 2007/58 international passenger liberalisation
- Reg. 1371/2007 passenger rights
- Dir. 2007/59 European driver's licence

- Reg. 1370/2007 OSP

- *Cross-Acceptance* Package
  Dir. 57/2008 Interoperability
  Dir. 131/2009

- Dir. 2012/34 so-called First Railway Package Recast

- Reg. 1315/2013 TEN development
- Reg. 1316/2013 TEN funding

Fourth Railway Package(2016)

- Dir. 2016/2370 new national liberalisation and governance review
- Reg. 2016/2337 standardisation of railway company accounts
- Reg. 2016/2338 revision of OSP regulation
- Reg. 2016/796 new ERA regulation
- Dir. 2016/797 new interoperability
- Dir. 2016/798 new railway safety

1990 — 2004 — 2008 — 2016 — 2019

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Directive (EU) 2016/798

Key points of Directive 2016/798 of 11 May 2016:

- Establishment of the SINGLE SAFETY CERTIFICATE, i.e. abolition of the division of the Safety Certificate for Railway Companies into Part A and Part B.
  - ✓ the ERA issues the SC to RUs that have an operating area in one or more Member States;
  - ✓ the request for a Certificate made directly to the ERA, with validity for one or more Member States;
  - ✓ the possibility of requesting the Safety Certificate directly from the National Safety Agency (NSA) in case of request in a single Member State.

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Directive (EU) 2016/798 –
Art. 16: National Safety Autority (NSA)

Each Member State shall establish a **national safety authority**, it shall be **independent** in its organization, legal structure and decision-making from:

- any railway undertaking;
- infrastructure manager;
- applicant or contracting entity;
- any entity awarding public service contracts.

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Directive (EU) 2016/798 – Art. 16: National Safety Autority (NSA)

The national safety authority shall be entrusted with at least the following tasks:

- authorising the placing in service of the trackside control-command and signalling, energy and infrastructure subsystems constituting the Union rail system;
- issuing, renewing, amending and revoking vehicle authorisations for placing on the market;
- supporting the Agency in the issuing, renewal, amendment and revocation of vehicle authorisations for placing on the market in and type authorisations of vehicle in accordance;
- supervising, in its territory, that interoperability constituents are in compliance with the essential requirements;
- ensuring that a vehicle number has been assigned in accordance with Article 46 of Directive (EU) 2016/797, without prejudice to Article 47(4) of that Directive;
- supporting the Agency in the issuing, renewal, amendment and revocation of single safety certificates;

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Directive (EU) 2016/798 – Art. 16: National Safety Autority (NSA)

The national safety authority shall be entrusted with at least the following tasks:

- issuing, renewing, amending and revoking single safety certificates;
- issuing, renewing, amending and revoking safety authorisations;
- monitoring, promoting, and, where appropriate, enforcing and updating the safety regulatory framework including the system of national rules;
- supervising railway undertakings and infrastructure managers;
- where relevant, and in accordance with national law, issuing, renewing, amending and revoking train driving licences;
- where relevant, and in accordance with national law, issuing, renewing, amending and revoking certificates granted to entities in charge of maintenance.

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Directive (EU) 2016/798 –
Art. 16: National Safety Autority (NSA)

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If, during supervision, a national safety authority identifies a serious safety risk, it may at any time **apply temporary safety measures**, including immediately restricting or suspending the relevant operations. If the single safety certificate was issued by the Agency, the national safety authority shall immediately inform the Agency thereof and provide supporting evidence for its decision.

The national safety authority shall **supervise the trackside, control-command and signalling, energy and infrastructure subsystems and ensure that they are in compliance with the essential requirements.** In the case of cross- border infrastructures, it will perform its activities of supervision in cooperation with other relevant national safety authorities.

If the national safety authority finds that an infrastructure manager no longer satisfies the conditions for its safety authorisation, it shall **restrict or revoke that authorisation**, giving reasons for its decision.

When **supervising the effectiveness of the safety management** systems of infrastructure managers and railway undertakings, the national safety authorities may **take into account the safety performance** of actors and, where appropriate, the training centres as long as their activities have an impact on railway safety.

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Directive (EU) 2016/798 –
Art. 16: National Safety Autority (NSA)

National safety authorities may address notices to **warn infrastructure managers and railway undertakings in cases of non-compliance with their obligations**

In the process of **developing the national regulatory framework**, the national safety authorities shall consult all actors and interested parties, including infrastructure managers, railway undertakings, manufacturers and maintenance providers, users and staff representatives.

The national safety authorities shall be free to **carry out all inspections, audits** and investigations that are needed for the accomplishment of their tasks, and they shall be granted access to all relevant documents and to premises, installations and equipment of infrastructure managers and railway undertakings and, where necessary, of any actor.

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Directive (EU) 2016/798 –
Art. 16: National Safety Autority (NSA)

National safety authorities shall publish an annual report concerning their activities in the preceding year and send them to the Agency by 30 September. The report shall contain information on:

- the development of railway safety, including an aggregation at Member State level of the CSIs;
- important changes in legislation and regulation concerning railway safety;
- the development of safety certification and safety authorisation;
- the results of, and experience relating to, the supervision of infrastructure managers and railway undertakings, including the number and outcome of inspections and audits;
- the derogations decided; and
- the experience of the railway undertakings and infrastructure managers on the application of the relevant CSMs.

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Directive (EU) 2016/798 – Art. 22: Investigating Body

Each Member State ensure that **investigations of the accidents and incidents are conducted by a permanent body**, which shall comprise at least one investigator able to perform the function of investigator-in-charge in the event of an accident or incident.

That body is **independent in its organisation, legal structure and decision-making** from:

- any infrastructure manager;
- railway undertaking;
- charging body;
- allocation body;
- conformity assessment body and from
- any party whose interests could conflict with the tasks entrusted to the investigating body

furthermore, be **functionally independent** from:

- the national safety authority,
- the Agency
- any regulator of railways.

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Directive (EU) 2016/798 – Art. 22: Investigating Body

Member States provide for **railway undertakings, infrastructure managers** and, **where appropriate, the national safety authority** to be obliged to immediately **notify the accidents and incidents** to the investigating body and to provide all available information.

The investigating body decides, without delay and in any event no later than 2 months after receipt of the notification, whether or not to start the investigation.

If necessary, and provided it does not undermine the independence of the investigating body, the investigating body **may request the assistance of investigating bodies from other Member States or from the Agency** to supply expertise or to carry out technical inspections, analyses or evaluations.

The investigating bodies shall **conduct an active exchange of views and experience** for the purposes of the development of common investigation methods, drawing up common principles for follow up of safety recommendations and adaptation.

the **Agency shall support the investigating bodies in the performance of this task**. The investigating bodies, with the support of the Agency, shall establish a programme of peer reviews where all investigating bodies are encouraged to participate.

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Directive (EU) 2016/798 – Art. 22: Investigating Body

An investigation of an accident or incident shall be the subject of **reports**.

These shall be in a form appropriate to the type and seriousness of the accident or incident and the relevance of the investigation findings; **reports state the objectives of the investigations and contain, where appropriate, safety recommendations**.

The investigating body makes public the final report in the shortest possible time and normally not later than 12 months after the date of the occurrence. If the final report cannot be made public within 12 months, the investigating body shall release an interim statement.

The report, including the safety recommendations, shall be communicated to the relevant parties and to bodies and parties concerned in other Member States. Taking into account experience gained by the investigating bodies, the Commission shall establish, by means of implementing acts, the reporting structure to be followed as closely as possible for accident and incident investigation reports.

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Directive (EU) 2016/798 –
Art. 22: Investigating Body

This reporting structure shall include the following elements:

(a) description of the occurrence and its background;

(b) a record of the investigations and inquires, including on the safety management system, the rules and regulations applied, the functioning of rolling stock and technical installations, the organisation of man power, the documentation on the operating system and previous occurrences of a similar character;

(c) analysis and conclusions with regard to the causes of the occurrence, including contributory factors, relating to:

- (i) actions taken by persons involved;
- (ii) the condition of rolling stock or technical installations;
- (iii) skills of the staff, procedures and maintenance;
- (iv) the regulatory framework conditions; and
- (v) the application of the safety management system.

By 30 September every year the investigating body shall publish an annual report accounting for the investigations carried out in the preceding year, the safety recommendations that were issued and actions taken in accordance with recommendations issued previously.

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Directive (EU) 2016/798 –
Article 9: Safety management systems

1. Infrastructure managers and railway undertakings shall **develop** their **safety management systems (SMS)** to ensure that the EU rail system can achieve at least the CSTs, complies with the safety requirements contained in the TSIs and that the relevant elements are applied of the CSMs and the national rules.
2. The safety management system is **documented in all its relevant elements** and describes in particular the distribution of responsibilities within the organization.
3. Fix the **essential elements** of the safety management system.

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Directive (EU) 2016/798 –
Article 9: Safety management systems

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4. The SMS must **be adapted** according to the **type, size, operating area and other conditions of the activity** carried out. It guarantees the control of all risks associated with the activity of the infrastructure manager or railway undertaking,
5. The SMS of each infrastructure manager must take into account the **effects of the activities carried out on the network by the various railway undertakings** and **ensure that all railway undertakings can operate in compliance with the TSIs as well as the national rules** and the conditions established by the respective safety certificates.
6. Safety management systems are designed to **ensure coordination** of the **infrastructure manager's emergency procedures with all railway undertakings operating** on its infrastructure and with the emergency services.

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Directive (EU) 2016/798 –
Article 9: Safety management systems

7. Before **31 May** each year, all **infrastructure managers and railway undertakings shall submit an annual safety report** relating to the previous calendar year to the national safety authority.
8. Based on information provided by national safety authorities, the **Agency may address a recommendation to the Commission for a CSM relating to elements of the safety management system** to be harmonized at Union level.

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Safety Management System

- The Safety Management System (SMS) is one of the cornerstones of the safety regulatory framework that helps to ensure a high level of railway safety.
- **Railway Undertakings**, when applying for a single safety certificate, and **Infrastructure Managers**, when applying for a safety authorization, **must prove that they have a SMS** compliant with the requirements set out in Annex I (Rus) or Annex II (Ims) of the **CSM on SMS** (Reg. (EU) 2018/762). This ensures that design its SMS in a manner to comply with the requirements set out in Article 9 of Directive (EU) 2016/798 in order to ensure the **safe management of its operations**.

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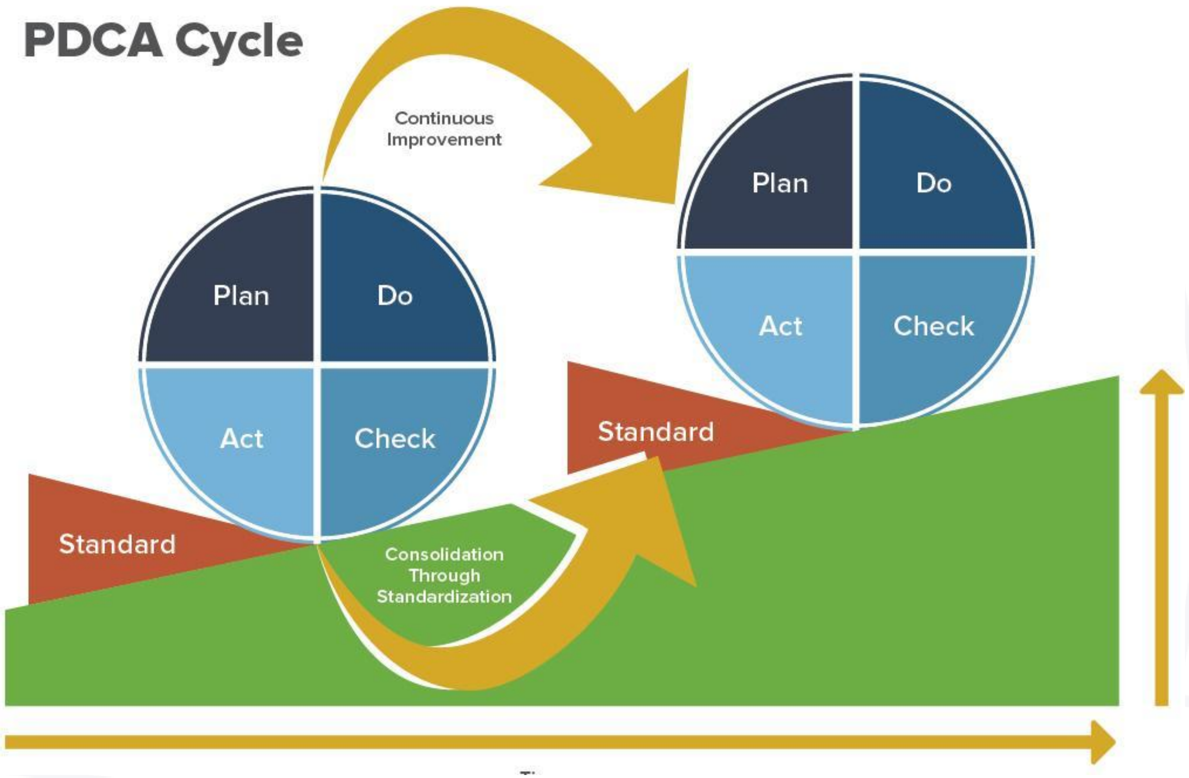
Safety management systems - Concept

Continuous improvement: make the accident rate tend towards zero



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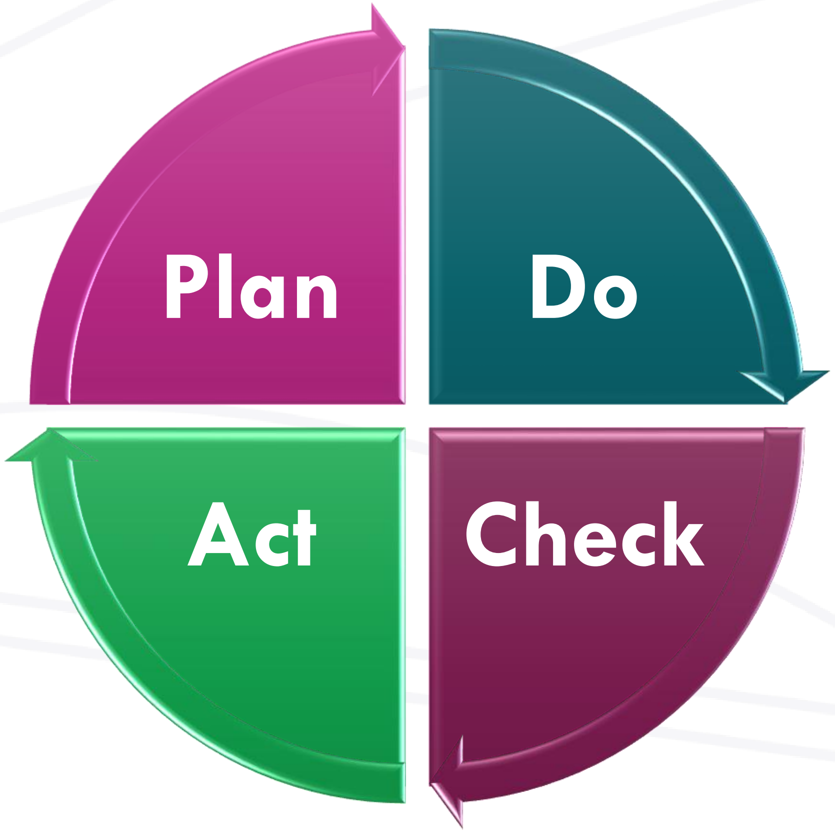
Safety management systems - Concept

Like all Management Systems it is based on the Deming cycle (**P-D-C-A cycle**) created by W. Edward Deming in the 1950s in Japan in order to pursue continuous improvement in industrial production.



P: Plan – Planning

D: Do – Execution of the program, initially in limited contexts

C: Check – Test and control, study and collection of results and feedback

A: Act – Action to finalize and/or improve the process

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ISO High Level Structure (HLS)

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High
Level
Structure

1. SCOPE
2. REFERENCE REGULATION
3. TERMS AND DEFINITIONS
4. CONTEXT OF THE ORGANIZATION
5. LEADERSHIP
6. PLANNING
7. SUPPORT
8. OPERATION
9. PERFORMANCE EVALUATION
10. IMPROVEMENT

The safety management system (of railway operation) shall be designed according to the **high-level structure of the ISO standards** also to be **easily integrated** with the **Occupational health and safety management systems (ISO 45001:2018)** and with the **Environmental management system (ISO 14001:2015)**

PLAN

4. Organizational context
- 4.1 Understand the organization and its context
- 4.2 Understand the needs and expectations of stakeholders
- 4.3 Determine the scope
- The XXX management system

5. Leadership
- 5.1 Leadership and commitment
- 5.2Policy
- 5.3 Roles, responsibilities and authorities

6. Planning
- 6.1 Actions to address risks and opportunities
- 6.2 Goals and related planning

7. Support
- 7.1 Resources
- 7.2 Skills
- 7.3 Awareness
- 7.4 Communication

DO

8. Operation
- 8.1 Operational planning and control

CHECK

9. Performance evaluation
- 9.1 Monitoring, measurement, analysis and improvement
- 9.2 Internal Audit
- 9.3 Management review

ACT

10. Improvement
- 10.1 Non-compliance and corrective actions
- 10.2 Continuous improvement

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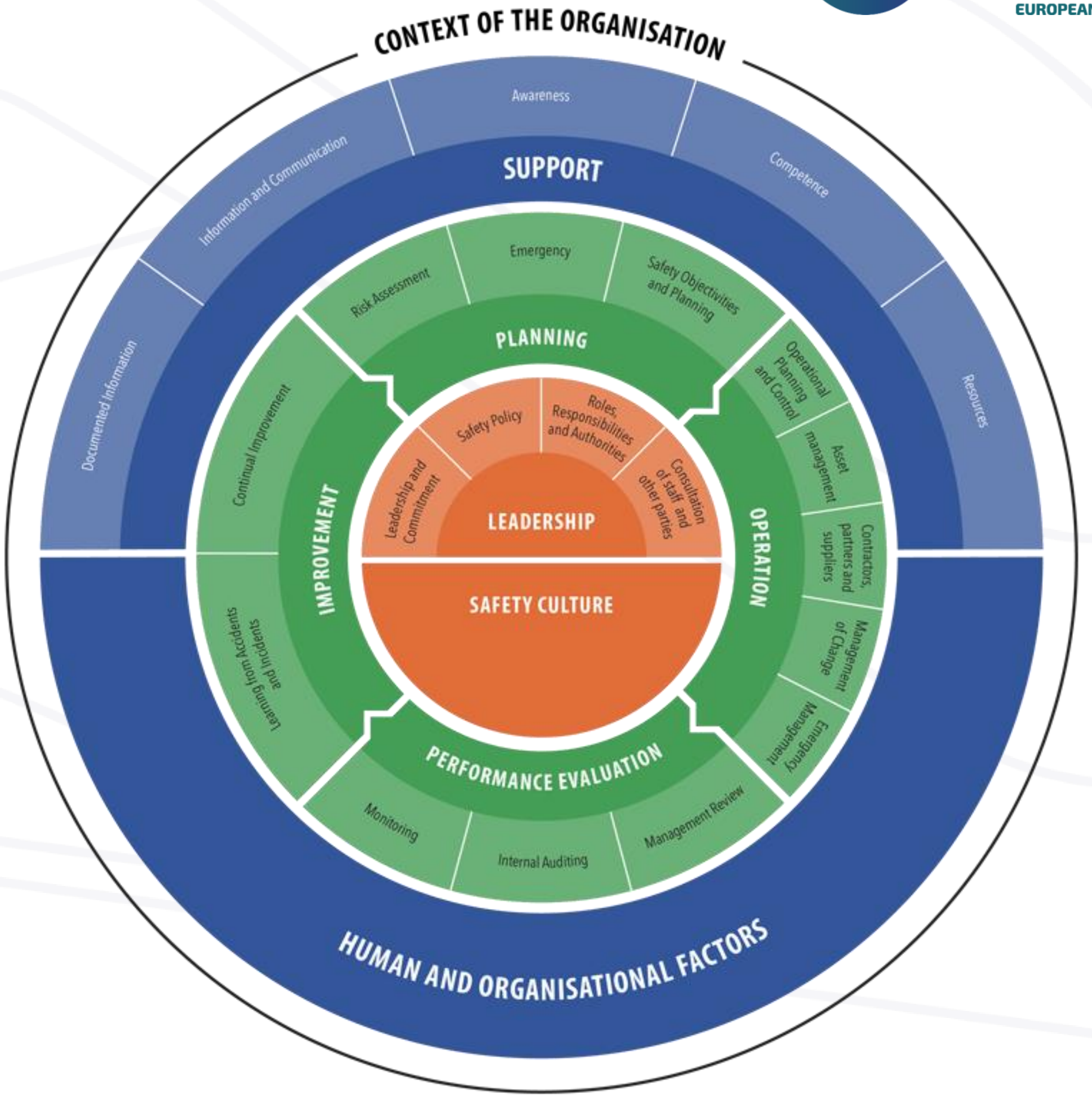
Safety management systems - Concept

ERA – SMS Guide 2018

Contains the diagram, shown alongside, which shows how the PDCA (Plan, Do, Check, Act) management cycle is created by tacking in account the elements of the SMS and integrated by others elements of the SMS:

- **«organizational context» which provides input to the planning phase;**
- **«leadership», as the driving force of the PDCA cycle;**
- **various "support" functions that support all elements of the SMS.**



SMS - General principles

- The adequate implementation of an SMS constitutes the basis on which the Agency and the National Safety Authorities issue safety certificates and authorizations.
- The implementation of an SMS is a legally binding obligation under Directive (EU) 2016/798 and national transposition laws.
- The SMS must monitor and improve risk control through a process that considers all the fundamental aspects of the organization with respect to safety:
    - ✓ Technicians
    - ✓ Human (operational)
    - ✓ Organizational

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The SMS – Logical cycle

Policies	=	What to do?	• Define policies
Organization		Who does what?	• Identify roles • Ensure level of preparation • Training of staff at all levels • Identification of responsibility • Resource allocation
Planning Implementation		How to do it?	• Define procedures • Set measurable goals • Define operational plans • Define actions to achieve goals
Monitoring		It has been done?	• Define procedures for data collection and analysis • Specify the type of data • Establish databases • Set up indicator systems that cover the organization, resources, processes and means of work • Define reporting procedures
Review - Audit		Could be done better?	

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The SMS – Typical flowchart

- Safety policy
- Responsibilities, skills and delegations for safety
- Resource involvement
- Definition of objectives and planning of safety initiatives
- Risks: identification, assessment, minimization, reporting and analysis
- Skills, training, updating and supervision of resources
- Internal monitoring: data collection and analysis
- Internal Audit
- Corrective actions

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The SMS – Essential elements

a) a **safety policy**;

b) qualitative and quantitative organizational objectives for maintaining and improving safety, as well as plans and procedures to achieve these objectives;

c) procedures designed to satisfy the technical and operational standards in force;

d) procedures aimed at ensuring compliance with standards and other requirements during the life cycle of equipment and operations;

e) procedures and methods **for risk identification, risk assessment and implementation of risk control measures**;

f) offering **staff training programs and systems to ensure staff maintain their skills**;

g) provisions to ensure a sufficient level of information within the body and, where appropriate, between the bodies of the railway system;

h) procedures and formats for documenting safety information;

i) procedures aimed at ensuring that accidents, incidents, "near misses" and other dangerous events are reported, investigated and analyzed and that the necessary preventive measures are adopted;

j) intervention, alarm and information plans in case of emergency, agreed with the competent public authorities;

k) regular internal audits of the safety management system.

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Common Safety Methods (CSMs)

- The CSMs are directly applicable and enforceable in the Member States. Depending on their scope, they are applied either by authorities or bodies, or by specific actors of the railway system (e.g. railway undertakings, infrastructure managers, entities in charge of maintenance), or even by both.
- The CSMs are established in accordance with Article 6 of Directive (EU) 2016/798 and include:
  1. the CSM for risk evaluation and assessment methods
  2. the CSM on Safety Management System Requirements
  3. the CSM method for supervision (to be applied by National Safety Authorities)
  4. the CSM for monitoring (to be applied by Railway Undertakings, Infrastructure Managers and Entities in Charge of Maintenance
  5. the CSM for assessing the safety level and the safety performance of railway operators at national and Union level
  6. the CSM for assessing the achievement of safety targets at national and Union level.

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1. CSM for risk evaluation and assessment methods

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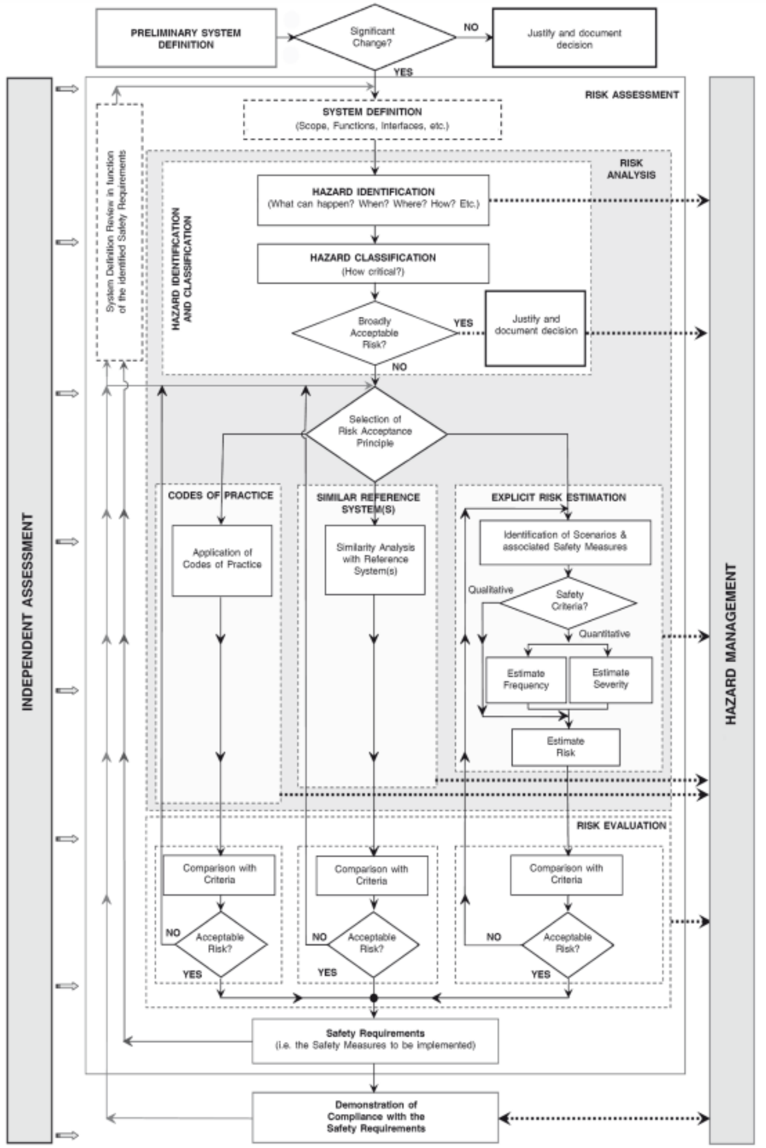

Implementing Regulation (EU) 402/2013 of 30 April 2013

Describes the methods for risk evaluation and assessment.

It applies to the proposer, when he makes any change to the railway system in a Member State, which has repercussions (impacts) on safety.

Such changes may be of a technical, operational or organizational nature. Among the organizational changes, only those capable of impacting operational or maintenance processes are taken into consideration.

If the change is considered significant,

the acceptability of the risks of the system to be evaluated is defined on the basis of one or more of the following criteria:

a) application of codes of good practice;

b) comparison with similar systems;

c) accurate risk estimation.

2. CSM on Safety Management System Requirements

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Delegated Regulation (EU) 2018/762 of 8 March 2018

establishing common safety methods relating to safety management system requirements in accordance with Directive (EU) 2016/798 of the European Parliament and of the Council.

It takes up the concepts, already present in Directive (EU) 2016/798, of the development of a positive safety culture, «in which personnel are encouraged to contribute to the development of safety by reporting dangerous events and providing safety-related information » and attention to the human factor, through «the use of experts and the use of recognized methods to identify behavioral problems affecting the various parts of the SMS».

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2. CSM on Safety Management System Requirements

Commission Delegated Regulation (EU) 2018/ 762 - of 8 March 2018

The SMS requirements are contained in the following paragraphs of Annex I with regard to RUs and Annex II with reference to IMs:

1. **CONTEXT OF THE ORGANISATION**
2. **LEADERSHIP**
   - 2.1 Leadership and commitment
   - 2.2 Safety policy
   - 2.3 Organizational roles, responsibilities, accountabilities and authorities
   - 2.4 Consultation of staff and other parties
3. **PLANNING**
   - 3.1 Actions to address risks
   - 3.2 Safety objectives and planning
4. **SUPPORT**
   - 4.1 Resources
   - 4.2 Competenze
   - 4.3 Awareness

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2. CSM on Safety Management System Requirements

Commission Delegated Regulation (EU) 2018/ 762 - of 8 March 2018

4.4 Information and communication

4.5 Documented information

4.6 Integration of human and organizational factors

5. OPERATION

5.1. Operational planning and control

5.2. Asset management *(veicoli per le IF, infrastruttura per i GI, ndr)*

5.3. Contractors, partners and suppliers

5.4. Management of change

5.5. Emergency management

6. PERFORMANCE EVALUATION

6.1. Monitoring

6.2. Internal auditing

6.3. Management review

7. IMPROVEMENT

7.1. Learning from accidents and incidents

7.2. Continual improvement

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3. CSM for supervision by NSAs

Delegated Regulation (EU) 2018/761 of 16 February 2018

establishing common safety methods for supervision by national safety authorities following the issuing of a single safety certificate or safety authorization in accordance with Directive (EU) 2016/798 of the European Parliament and of the Council.

The annex I defines the supervision process that national safety authorities must apply, consisting of the following elements:

- development of a strategy and a supervision plan or plans;
- communication of the strategy and supervisory plan(s);
- carrying out supervisory activities;
- results of supervision activities;
- review of supervisory activities.

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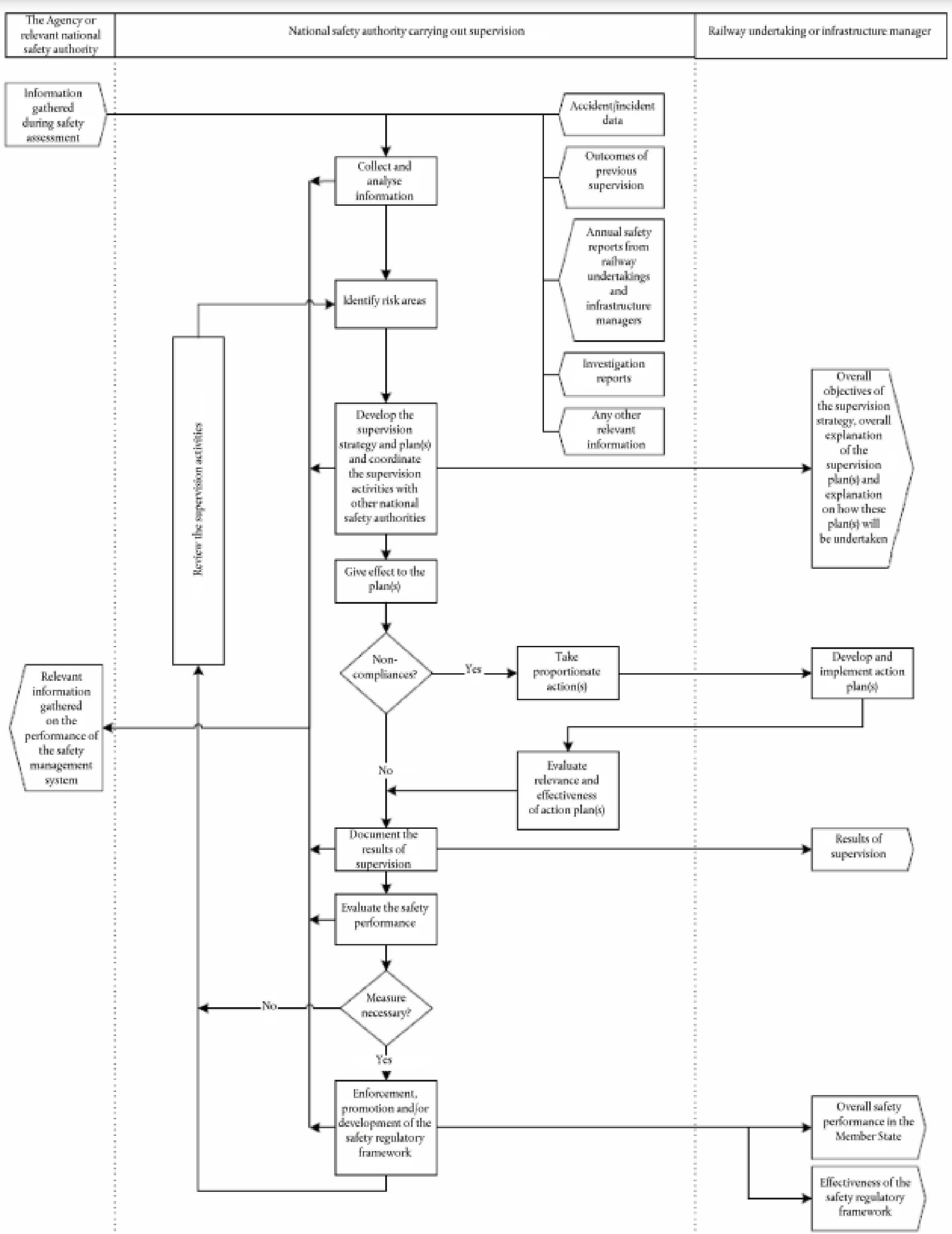
3. CSM for supervision by NSAs



[Delegated Regulation (EU) 2018/761 of 16 February 2018]

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4. CSM for monitoring to be applied by RUs, IMs and entities in charge of maintenance

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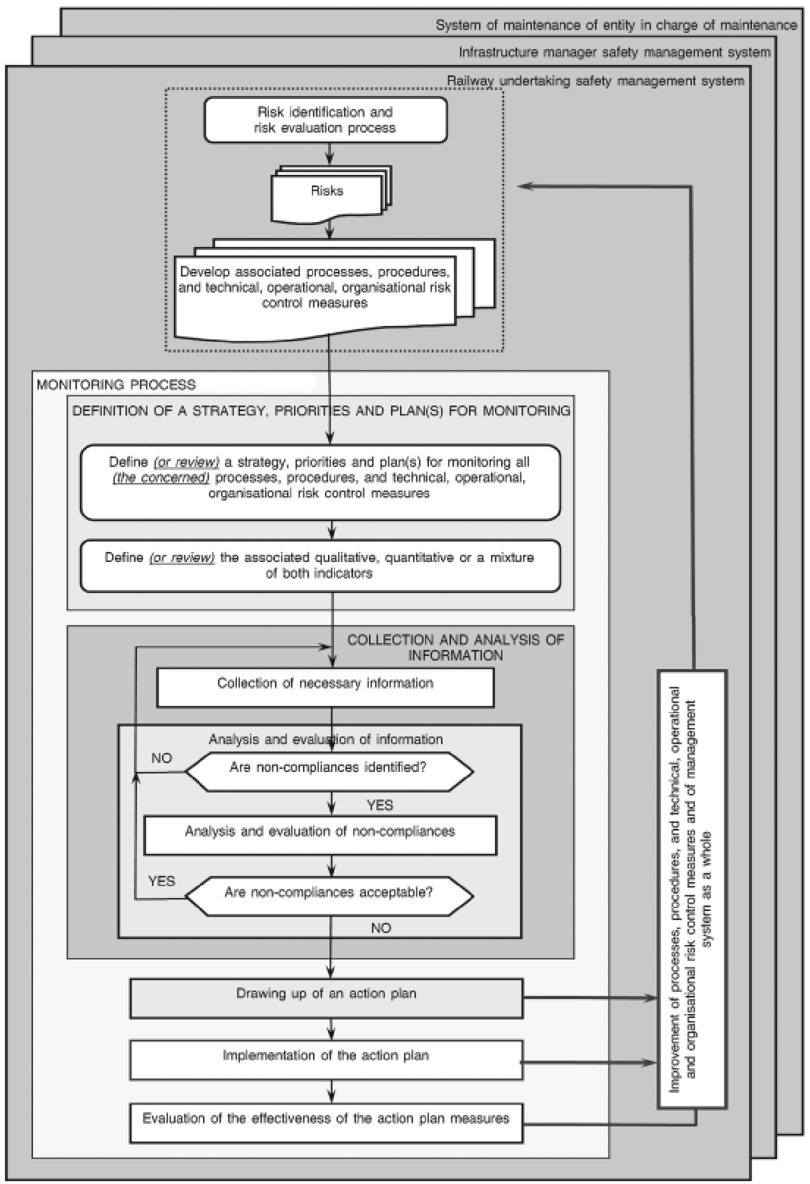
Framework for the monitoring process



Regulation (EU) 1078/2012 of 16 November 2012

on a common safety method for monitoring to be applied by railway undertakings, infrastructure managers having obtained a safety certificate or safety authorization and entities responsible for maintenance

It establishes a common safety method (CSM) relating to monitoring, to enable effective management of safety in the railway system during operation and maintenance activities and, where appropriate, improve the management system.

5. Draft of CSM

Draft Delegated Regulation establishing Common Safety Methods for the assessment of the safety level and performance of railway operators at national and European Union level

(Common Safety Methods on the assessment of Safety Level and Safety Performance of railway operators at national and Union level (CSM ASLP) – published on 17/12/2020 – consultation closed on 17/03/2021

Annex IV of the draft Regulation proposes the relationship structure between:

- accidents that can directly cause casualties or damage (**category A events**),
- dangerous events (**category B events, which can directly generate category A events**);
- primary causes (**category C events which, formulated as deviations during the execution of a railway process, can directly or indirectly cause a category B event**).

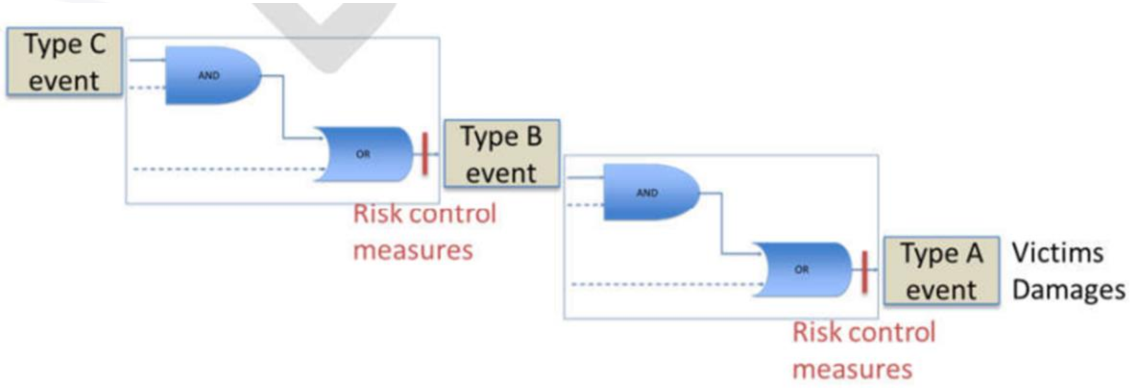


Figure: Example of a scenario description using building blocks.

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5. Draft of CSM

- Appendix A – Part A of the draft Regulation contains the list of events belonging to the three categories mentioned above, as well as a list of "contributing factors", defined as "actions, omissions, events or conditions that affect an event by increasing its the probability, accelerating the effect over time or increasing the severity of the consequences, but whose elimination would not have prevented the event".

Category A events

-

Accidents with a potential to directly result in victims or damages

Code of event type	Name of the event type	Definitions	By default allocation of related occurrences (see Annex IV for details)
A1	**Collisions**		
A1.1	**Collision of a train with rail vehicle**	RSD AppAnnexI	RU / RU+IM
A1.2	**Collision of a train with obstacle within the clearance gauge**	RSD AppAnnexI	RU / RU+IM
A1.3	**Collision of one or more rail vehicle with another rail vehicle**	Same as A1.1 but concerning one or more rail vehicle not forming a train.	RU / RU+IM
A1.4	**Collision of one or more rail vehicle with obstacle within the clearance gauge**	Same as A1.2 but concerning one or more rail vehicle not forming a train.	RU / RU+IM
A1.5	**Other**	A reporting of information in accordance with Article 3.2.1. of this Appendix shall apply.	
A2	**Derailments**		
A2.1	**Derailment of a train**	RSD AppAnnexI	

Category B events

-

Incidents with the potential to directly cause a category A event

Code of event type	Name of the event type	Definitions	By default allocation of related occurrences (see Annex IV for details)
B.1	**Operation failures**		
B.1.1	**Failure to operate the infrastructure**		
B.1.1.1	Improper routing	Any occasion when a train/vehicle is directed on an inappropriate track.	IM
B.1.1.2	On track plant incorrectly outside possession	Note: on track plant refers to on track machine(s) or other object(s) used during infrastructure works.	IM
B.1.1.3	Pushed switch	Any occasion when a switch is run over in a wrong setting.	RU or IM
B.1.1.4	Other	A reporting of information in accordance with Article 3.2.1. of this Appendix shall apply.	RU or IM
B.1.2	**Failure to operate a train or rail vehicle(s)**		
B.1.2.1	Signal passed at danger when passing a danger point	RSD AppAnnexI	RU
B.1.2.2	Signal passed at danger without passing a danger point	RSD AppAnnexI	RU
B.1.2.3	Runaway	Any uncontrolled movement of a rail vehicle over a distance of at least one meter.	RU

Category C events

-

Incidents, formulated as variations while performing a railway function, with the potential to directly or indirectly cause a category B event

Code of event type	Name of the event type	Definitions	By default allocation of related occurrences (see Annex IV for details)
C.1	**Human Performance**		
C.1.1	**To provide power for train (or vehicle) operations in normal operations, or situations where there are disruptions or engineering work**		
C.1.1.1	Variation in function 'Take up power control duties'		
C.1.1.2	Variation in function 'Monitor power'		
C.1.1.3	Variation in function 'Provision of traction supply'		
C.1.1.4	Variation in function 'Detect irregularity'		
C.1.1.5	Variation in function 'Agreement of isolation'		
C.1.1.6	Variation in function 'Formal agreement for control of the line'		
C.1.1.7	Variation in function 'Apply isolation'		

Contributing factors

-

Actions, omissions, events or conditions that affect an occurrence by increasing its likelihood, accelerating the effect in time or increasing the severity of the consequences, but the elimination of which would not have prevented the occurrence

Code of event type	Name of the event type	Definitions	By default allocation of related occurrences (see Annex IV for details)
F.2	**Performance relevant factor**		
F.2.1	**Dynamic staff factors**		
F.2.1.1	Expectation / Intention while acting / Decision model / Error type		
F.2.1.2	Vigilance/ concentration		
F.2.1.3	Fatigue		
F.2.1.4	Stress (incl. emotions & psychosocial factors)		
F.2.1.5	Situational awareness (incl. self-awareness - situational self-knowledge)		
F.2.1.6	Other	A reporting of information in accordance with Article 3.2.1. of this Appendix shall apply.	
F.2.2	**Dynamic tasks factors**		

6. CSM for determining and evaluating the achievement of CSTs

Decision 2009/460/EC of the European Commission of 5 June 2009

The new European approach to safety objectives is based on the principle that the safety levels of the community rail system are generally high, in particular compared to those of road transport.

In the liberalization process it was therefore considered important to maintain at least the pre-existing safety performance levels, aiming if anything at a further improvement of them through technical progress.

Decision 2009/460/EC introduced the Common Safety Targets (CST) and the common method (Common Safety Method - CSM) for determining and evaluating the achievement of these objectives.

To quantitatively define the CSTs, it was necessary to preliminarily identify the National Reference Values (NRV), i.e. the safety levels present in the individual railway systems of the Member States, and therefore "deemed acceptable".

It refers to groups of people, called "risk categories", who interact differently with the railway system (passengers, staff, users of level crossings, unauthorized persons, others).

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6. CSM for determining and evaluating the achievement of CSTs

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Decision 2009/460/EC of the European Commission of 5 June 2009

Measurement units for NRVs and CSTs

Risk category	Measurement units	Scaling bases
1. Passengers	1.1 Number of passenger FWSIs per year arising from significant accidents/Number of passenger train-km per year	Passenger train-km per year
	1.2 Number of passenger FWSIs per year arising from significant accidents/Number of passenger-km per year	Passenger-km per year
2. Employees	Number of employee FWSIs per year arising from significant accidents/Number of train-km per year	Train-km per year
3. Level crossing users	3.1 Number of level-crossing user FWSIs per year arising from significant accidents/Number of train-km per year	Train-km per year
	3.2 Number of level-crossing user FWSIs per year arising from significant accidents/[(Number of Train-km per year * Number of level crossings)/Track-km)]	(Train-km per year * Number of level crossings)/Track-km
4. Others	Yearly number of FWSIs to persons belonging to the category 'others' arising from significant accidents/Number of train-km per year	Train-km per year
5. Unauthorised persons on railway premises	Number of FWSIs to unauthorised persons on railway premises per year arising from significant accidents/Number of train-km per year	Train-km per year
6. Whole society	Total number of FWSIs per year arising from significant accidents/Number of train-km per year	Train-km per year

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Different types of safety indicators

- UIC indicators (historical note)
- Common Safety Indicators (CSIs)
- National safety indicators (e.g. Italy)
- Safety Management System Indicators

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UIC indicators

The first classification of railway accidents at international level was made by the **UIC (Union Internationale des Chemins de Fer)**, which was established on 17 October 1922 with the principal aim of standardising practices across the railway industry and expanding international cooperation in the sector.

The UIC has classified railway accidents into:

- **'Typical' accidents**: events more closely related to the railway system, occurring in traffic, shunting, special vehicles and level crossings; they include collisions between trains or rolling stock, derailments, accidents to level crossings, train break-ups, fires, etc.
- **'Atypical' accidents**: occurring individually to persons in connection with the movement of rolling stock; they include people falling from trains, injuries sustained while boarding or alighting from coaches, suspected suicides, etc.

The accidents that conventionally best characterise railway traffic in the narrower sense are the 'typical' accidents.

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UIC indicators

1926 1950 1995 2001 2010

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The UIC then classified railway accidents, according to severity, into:

- **'Significant accidents'**: are the most serious ones, the definition of which coincides with the definition of 'significant accidents' in the Safety Directive, which we will see below
- **'Minor accidents'**: accidents resulting in only minor injuries, damage of less than € 150,000 or traffic disruptions of less than six hours
- **'Incidents'**: abnormal events that did not generate consequences, but which could have caused even serious damage to persons or property

The UIC annually collects accident data from the railways of the member states in the UIC Safety Report.

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Accident definitions (RSD art. 3)

'**Accident**' means an unwanted or unintended sudden event or a specific chain of such events which have harmful consequences; accidents are divided into the following categories:

1. collisions
2. derailments
3. level crossing accidents
4. accidents to persons involving rolling stock in motion
5. fires
6. others

"By 'others' is meant all accidents that do not fall under the above categories (e.g. derailments and collisions in manoeuvres or of special vehicles, loss of dangerous goods, etc.)" *(source: Italian National Safety Authority)*

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Accident definitions (RSD art. 3)

'Serious accident' means any train collision or derailment of trains resulting in the **death of at least one person** or **serious injuries to five or more persons** or **extensive damage to rolling stock, the infrastructure or the environment**, and any other accident with the same consequences which has an obvious impact on railway safety regulation or the management of safety

'Extensive damage' means damage that can be immediately assessed by the investigating body to cost at least EUR 2 million in total

'Incident' means any occurrence, other than an accident or serious accident, affecting the safety of railway operations

'Investigation' means a process conducted for the purpose of accident and incident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the **determination of causes** and, when appropriate, the making of **safety recommendations**

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Accident definitions (RSD Appendix)

'Significant accident' means any accident involving at least one rail vehicle in motion, resulting in **at least one killed or seriously injured person**, or in **significant damage** to stock, track, other installations or environment, or extensive disruptions to traffic, excluding accidents in workshops, warehouses and depots

'**Significant damage to stock, track, other installations or environment**' means damage that is **equivalent to EUR 150 000 or more**

'**Extensive disruptions to traffic**' means that train services on a main railway line are suspended for **six hours or more**

'**Death (killed person)**' means any person killed immediately or dying within 30 days as a result of an accident, excluding any suicide

'**Serious injury (seriously injured person)**' means any person injured who was hospitalised for more than 24 hours as a result of an accident, excluding any attempted suicide

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Common Safety Indicators (CSIs)

- They are listed in the Annex I of the Directive (EU) 2016/798 on railway safety and shall be reported annually by the national safety authorities.

1. **Indicators relating to accidents**

   1.1 Total and relative (to train-kilometres) number of serious accidents and a break-down for the following types of accidents:

   - collision of train with rail vehicle
   - collision of train with obstacle within the clearance gauge
   - derailment of train
   - level crossing accident, including accident involving pedestrians at level crossing, and a further break-down for the five types of level crossings defined in point 6.2
   - accident to persons involving rolling stock in motion, with the exception of suicides and attempted suicides
   - fire in rolling stock
   - other

- Each significant accident shall be reported under the type of the primary accident, even if the consequences of the secondary accident are more severe (e.g. a derailment followed by a fire).

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Common Safety Indicators (CSIs)

- They are listed in the Annex I of the Directive (EU) 2016/798 on railway safety and shall be reported annually by the national safety authorities.

1. **Indicators relating to accidents**

   1.1 Total and relative (to train-kilometres) number of serious accidents and a break-down for the following types of accidents:

   - collision of train with rail vehicle
   - collision of train with obstacle within the clearance gauge
   - derailment of train
   - level crossing accident, including accident involving pedestrians at level crossing, and a further break-down for the five types of level crossings defined in point 6.2
   - accident to persons involving rolling stock in motion, with the exception of suicides and attempted suicides
   - fire in rolling stock
   - other

- Each significant accident shall be reported under the type of the primary accident, even if the consequences of the secondary accident are more severe (e.g. a derailment followed by a fire).

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Common Safety Indicators (CSIs)

1. **Indicators relating to accidents**

   1.2 Total and relative (to train-kilometres) number of persons seriously injured and killed by type of accident divided into the following categories:
   - passenger (also relative to total passenger-kilometres and passenger train-kilometres)
   - employee or contractor
   - level crossing user
   - Trespasser
   - other person at a platform
   - other person not at a platform

2. **Indicators relating to dangerous goods**

   Total and relative (to train-kilometres) number of accidents involving the transport of dangerous goods by rail divided into the following categories:
   - accident involving at least one railway vehicle transporting dangerous goods, as defined in the Appendix
   - number of such accidents in which dangerous goods are released

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Common Safety Indicators (CSIs)

3. **Indicators relating to suicides**
   - Total and relative (to train-kilometres) number of suicides and attempted suicides

4. **Indicators relating to precursors of accidents**

   Total and relative (to train-kilometres) number of precursors to accidents and a break down on the following types of precursor
   - broken rail
   - track buckle and other track misalignment
   - wrong-side signalling failure
   - signal passed at danger when passing a danger point
   - signal passed at danger without passing a danger point
   - broken wheel on rolling stock in service
   - broken axle on rolling stock in service.

   All precursors are to be reported, both those resulting and those not resulting in accidents. (A precursor resulting in a significant accident shall also be reported under indicators relating to precursors; a precursor not resulting in a significant accident shall only be reported under indicators relating to precursors).

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Common Safety Indicators (CSIs)

5. **Indicators to calculate the economic impact of accidents**

   Total in euro and relative (to train-kilometres):
   - number of deaths and serious injuries multiplied by the Value of Preventing a Casualty (VPC),
   - cost of damages to environment
   - cost of material damages to rolling stock or infrastructure
   - cost of delays as a consequence of accidents.

   National safety authorities shall report the economic impact of significant accidents. The VPC is the value society attributes to the prevention of a casualty and as such shall not form a reference for compensation between parties involved in accidents.

6. **Indicators relating to technical safety of infrastructure and its implementation**

   6.1 Percentage of tracks with Train Protection Systems (TPSs) in operation and percentage of train-kilometres using on- board TPSs, where these systems provide:
   - warning
   - warning and automatic stop
   - warning and automatic stop and discrete supervision of speed
   - warning and automatic stop and continuous supervision of speed

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Common Safety Indicators (CSIs)

6. **Indicators relating to technical safety of infrastructure and its implementation**

   6.2 Number of level crossings (total, per line kilometre and track kilometre) by the following five types:

   (a) passive level crossing

   (b) active level crossing:

      i. manual

      ii. automatic with user-side warning

      iii. automatic with user-side protection

      iv. rail-side protected

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Common Safety Indicators (CSIs)

Definitions of different types of level crossings

Item	Definition

Active level crossings	A level crossing where, when a train arrives, users are protected or warned by the activation of devices when it is dangerous to cross the crossing.
	• Protection by the use of physical devices includes:
	    • complete or half-barriers
	    • gates
	• Warning through the use of fixed equipment at level crossings:
	    • visible devices: lights
	    • audible devices: bells, horns, claxons, etc.
	Active level crossings are classified as follows:
	a) "manual": a level crossing where the user-side protection or alarm is manually activated by a railway employee
	b) "automatic with user-side alarm": a level crossing where the user-side alarm is activated by the approach of the train
	c) "automatic with user-side protection": a level crossing where the user-side protection is activated by the approach of the train. This includes a level crossing with both user-side protection and user-side alarm
	d) "protected rail-side" means a level crossing where a signal or other train protection system allows a train to proceed if the level crossing is fully protected user-side and is free from obstacles

Passive level crossing	A level crossing without any form of alarm or protection system that is activated when it is dangerous for the user to cross the crossing

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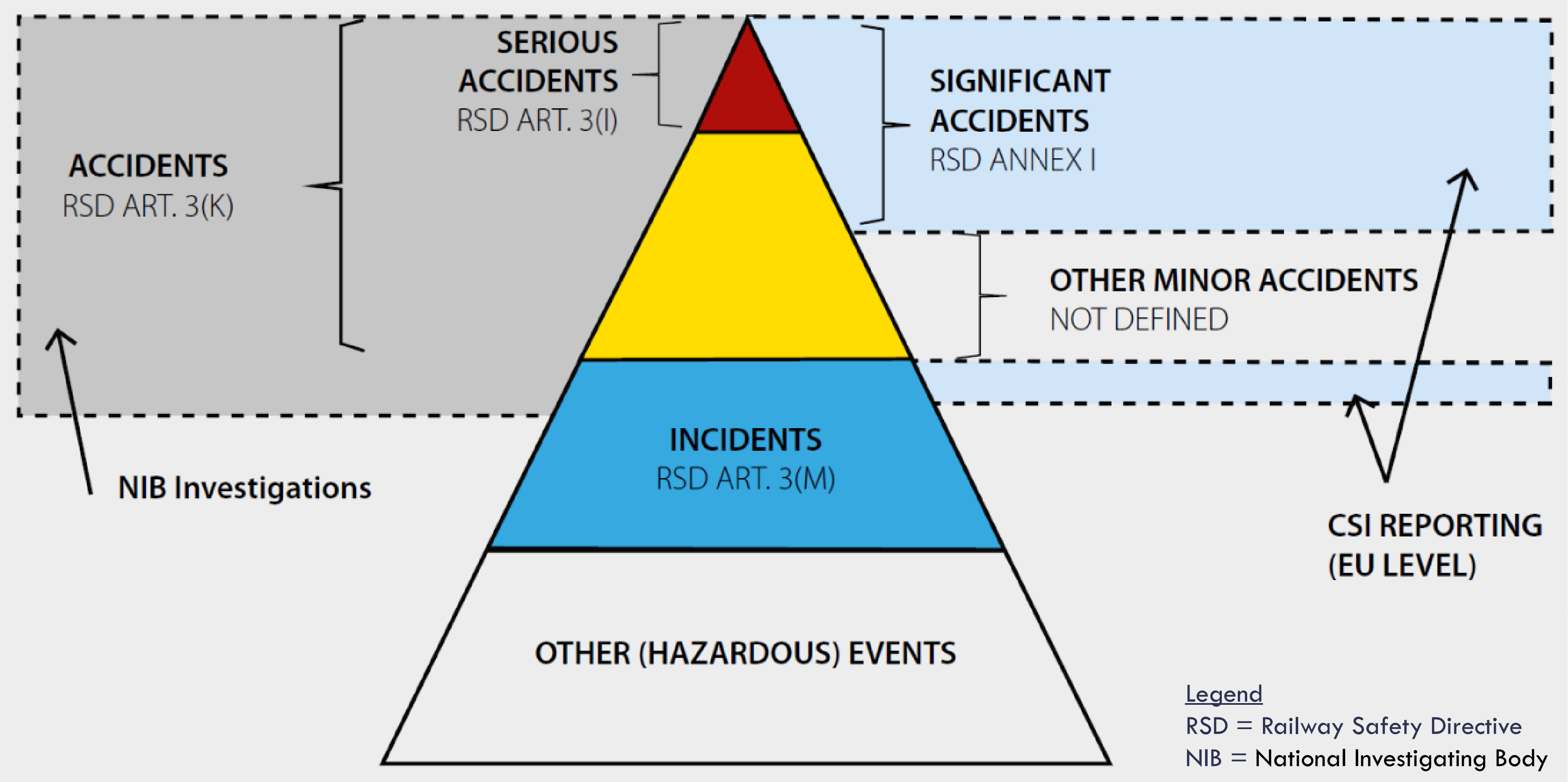
Summary of events covered by CSIs and investigations



Source: European Union Agency for Railways - Report on Railway Safety and Interoperability in the EU 2020 – June 2020

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Accident statistics

- Types of accidents defined by the ERA:
  1. collisions
  2. derailments
  3. level crossing accidents
  4. accidents to persons involving rolling stock in motion
  5. fires in rolling stock
  6. others

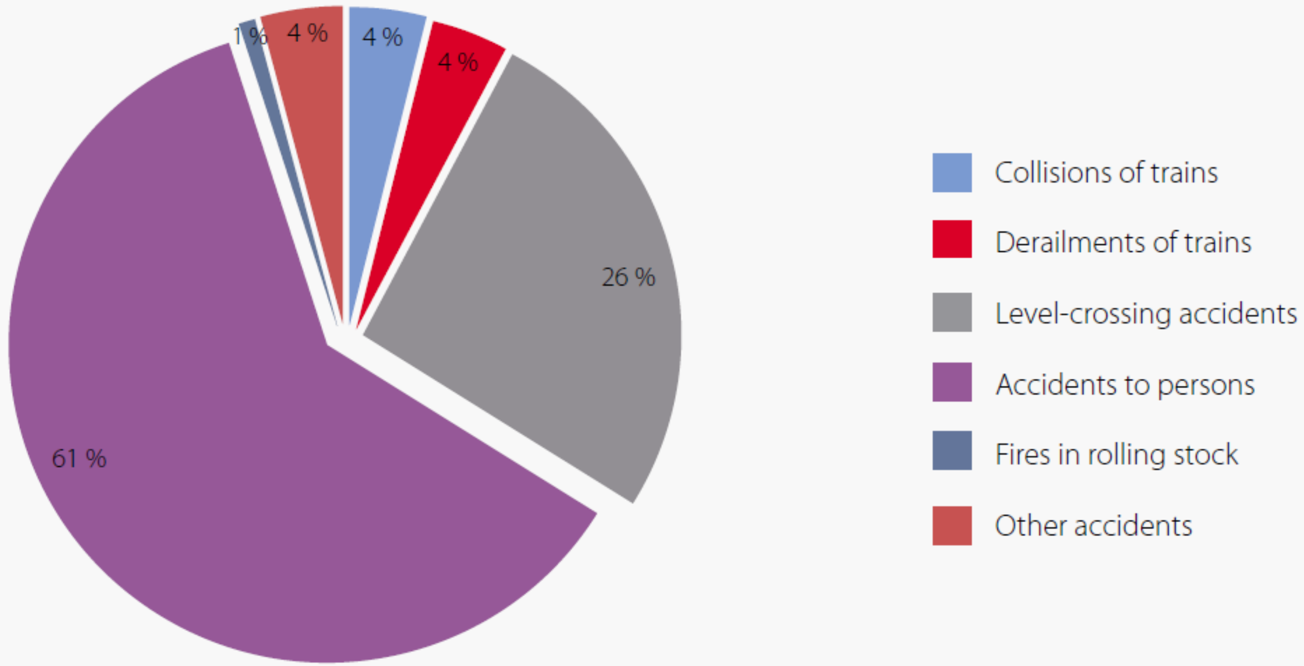

Figure 8: Breakdown of significant accidents per type (EU-28: 2010–2012)

Source: European Railway Agency - RAILWAY SAFETY PERFORMANCE IN THE EUROPEAN UNION, 2014

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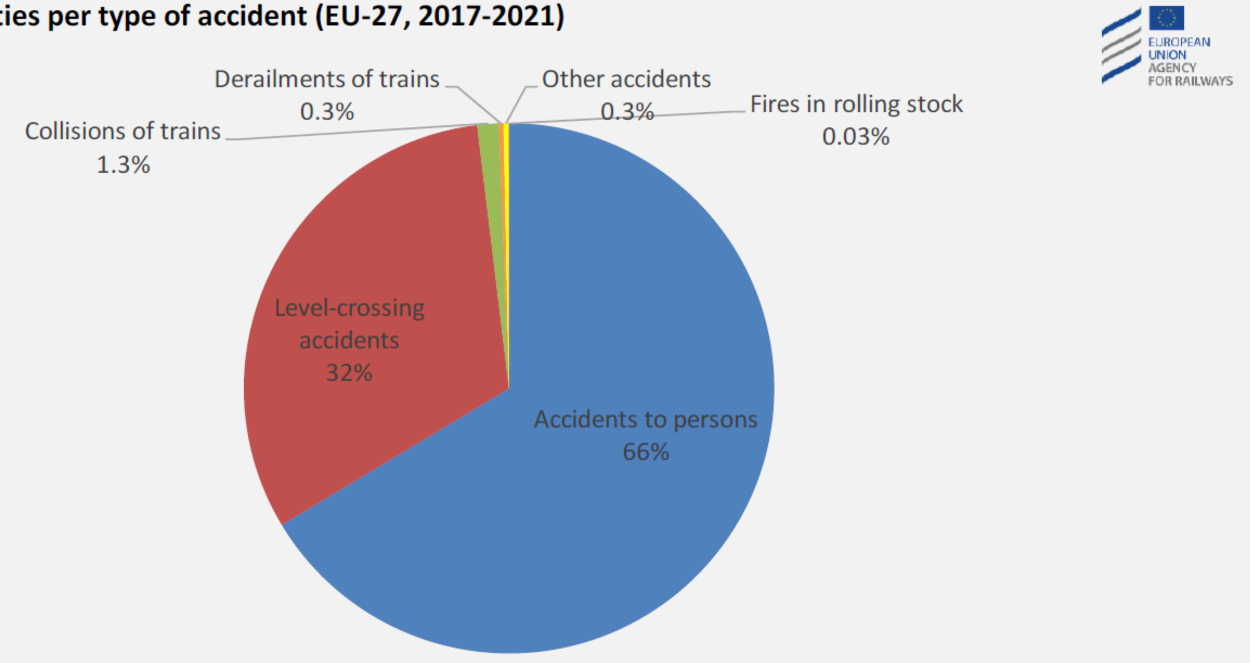
Accident statistics

- Types of accidents defined by the ERA:
  1. collisions
  2. derailments
  3. level crossing accidents
  4. accidents to persons involving rolling stock in motion
  5. fires in rolling stock
  6. others

Figure 10 - Fatalities per type of accident (EU-27, 2017-2021)



Source: Common Safety Indicators (CSIs) as reported by National Safety Authorities (NSAs) to the Agency.

Source: European Union Agency for Railways - Safety Overview 2023: Main figures based on CSI data (up to 2021) - March 2023

National safety indicators (e.g. Italy)

- Individual EU member states can define and collect other safety indicators. For example, Italy with a notified national standard (RFI Disp. 13/2001) has defined two sets of national safety indicators, one for **Railway Undertakings** (e.g. train driver's compliance with
  - brake test execution
  - maximum speeds
  - signals
  - safe operation in degraded conditions
  - correct train immobilization
  - correct compilation of technical documentation, etc.)
- and one for **Infrastructure Managers** (e.g. failures of the following infrastructure elements:
  - switches
  - level crossings
  - track circuits, etc.)

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Safety Management System Indicators

- They arise from the need to control the system implemented by the company (Railway Undertaking or Infrastructure Manager)
- They must derive from the design of the service and thus be based on an analysis of company's specific risks.
- They constitute one of the elements of the SMS review phase (check)
- They cover a broader area than the CSIs and National Safety Indicators (they refer to all company processes related to safety)
- May include CSIs and National Safety Indicators (NSIs)
- They unbundle CSIs and National Safety Indicators (see example on next slide)

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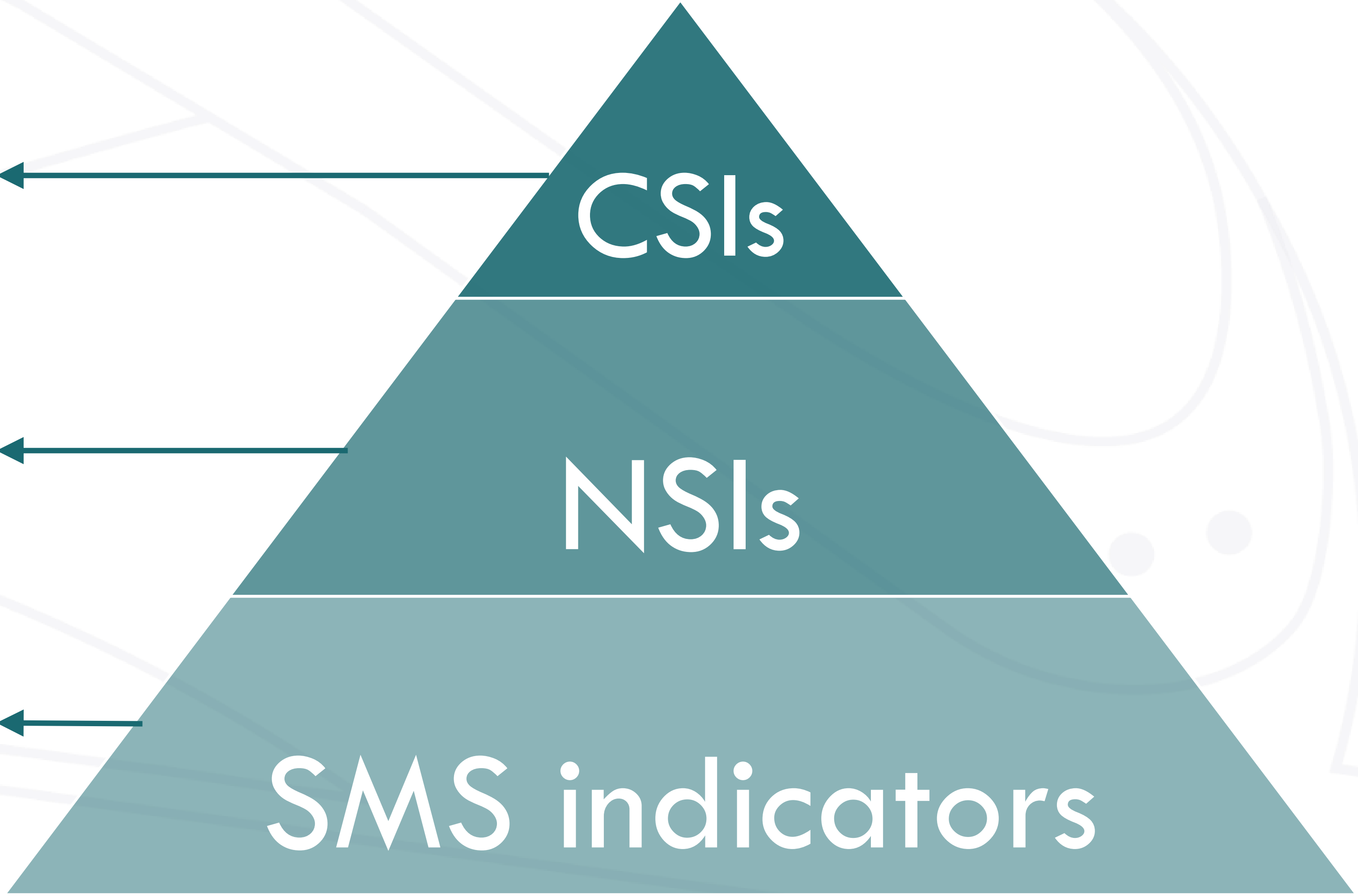
Example of comparison between indicators

Significant derailments of trains (and a few precursors)

Any derailment of trains or rolling stock (and a few precursors)

All events that can be considered as precursors or root causes of derailments



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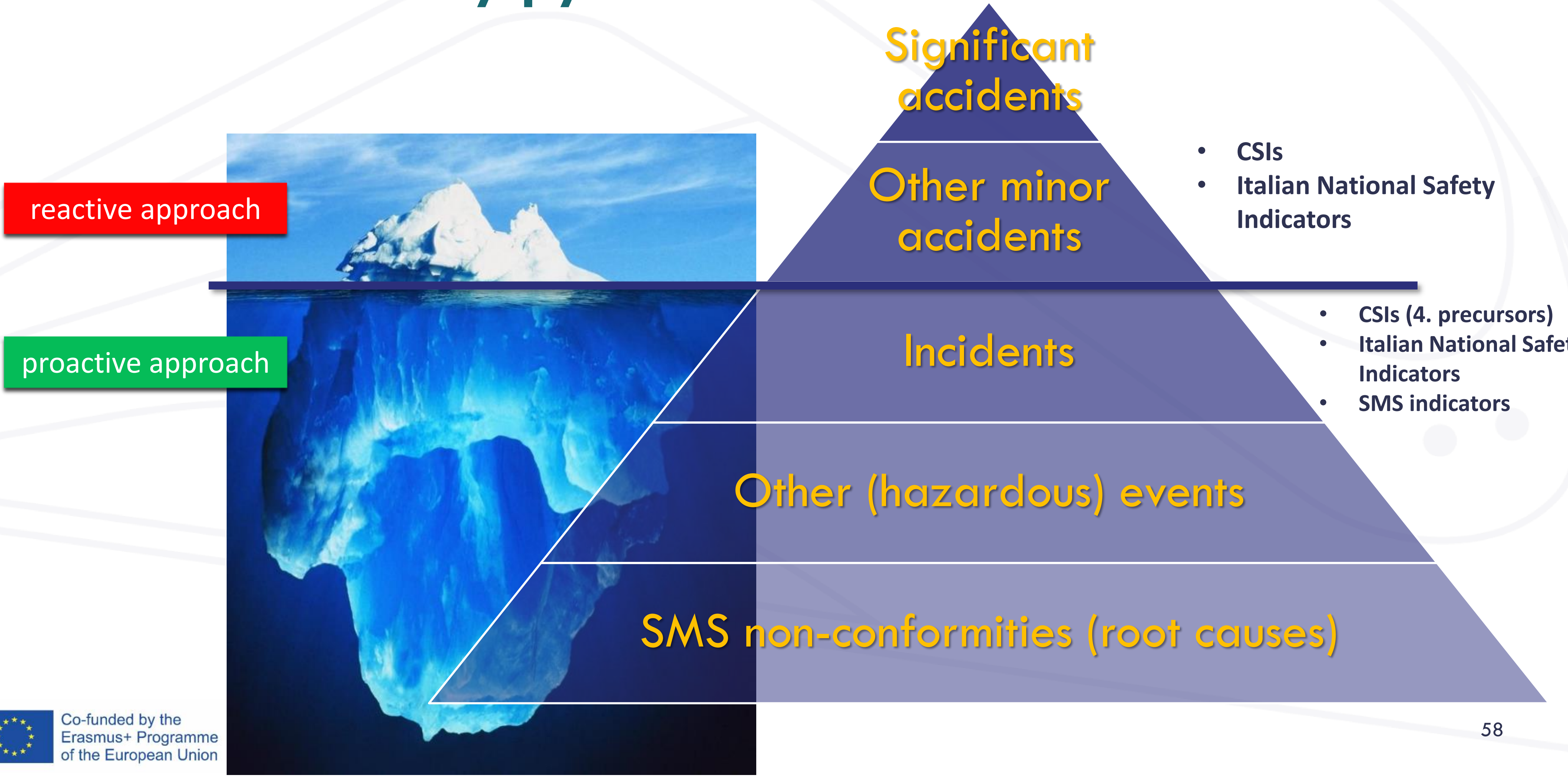
Heinrich's safety pyramid



- CSIs
- Italian National Safety Indicators

- CSIs (4. precursors)
- Italian National Safety Indicators
- SMS indicators

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Common Safety Targets (CSTs)

- Decision 2009/460/EC introduced the Common Safety Targets (CST) and the Common Safety Method (CSM) for determining and evaluating the achievement of these targets.
- European approach to safety targets is based on the principle that the **safety levels of the EU railway system are generally high**, particularly **in comparison to road transport**.
- In the liberalisation process it was therefore considered important **to maintain at least the pre-existing safety performance levels** and, if anything, to aim for a further improvement of these through technical progress.
- In order to define CST quantitatively, it was first necessary to identify the National Reference Values (NRVs), i.e. the safety levels present in the individual railway systems of the Member States, and therefore 'considered acceptable'.
- This refers to **5 groups of people**, called **'risk categories'**, who interact differently with the railway system (**passengers, staff, level-crossing users, unauthorised persons, others**) and to **society as a whole**.

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Measurement units for NRVs and CSTs

APPENDIX 1

Measurement units for NRVs and CSTs

Risk category	Measurement units	Scaling bases
1. Passengers	1.1 Number of passenger FWSIs per year arising from significant accidents/Number of passenger train-km per year	Passenger train-km per year
	1.2 Number of passenger FWSIs per year arising from significant accidents/Number of passenger-km per year	Passenger-km per year
2. Employees	Number of employee FWSIs per year arising from significant accidents/Number of train-km per year	Train-km per year
3. Level crossing users	3.1 Number of level-crossing user FWSIs per year arising from significant accidents/Number of train-km per year	Train-km per year
	3.2 Number of level-crossing user FWSIs per year arising from significant accidents/[(Number of Train-km per year * Number of level crossings)/Track-km)]	(Train-km per year * Number of level crossings)/Track-km
4. Others	Yearly number of FWSIs to persons belonging to the category 'others' arising from significant accidents/Number of train-km per year	Train-km per year
5. Unauthorised persons on railway premises	Number of FWSIs to unauthorised persons on railway premises per year arising from significant accidents/Number of train-km per year	Train-km per year
6. Whole society	Total number of FWSIs per year arising from significant accidents/Number of train-km per year	Train-km per year

'fatalities and weighted serious injuries (FWSIs)' means a measurement of the consequences of significant accidents combining fatalities and serious injuries, where 1 serious injury is considered statistically equivalent to 0,1 fatalities

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Methodology for calculating NRVs

- For each Member State and for each of the risk categories the NRV shall be calculated by applying in sequential order the following process:

a) calculation of the values returned by the corresponding measurement units listed in the previous slide;

b) analysis of the results of the process described in point (a), to check presence and recurrence of zero values for the FWSIs in the observed safety performances for the years concerned;

c) if the zero values referred to in point (b) are no more than two, the calculation is made of the **weighted average of the values** referred to in point (a), and the returned value is taken as the NRV;

d) if the zero values referred to in point (b) are more than two, the Agency shall attribute to the NRV a discretional value to be identified by consulting the Member State concerned.

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Weighted averaging process for the calculation of NRVs

- For each Member State and for each of the risk categories to which the weighted averaging can be applied, the following steps shall be applied for calculating, during year Y (where Y = 2009 and 2011), the NRV_Y:

a) calculation of the annual observations OBS_i (where i is the considered year of observation) returned by the corresponding measurement units listed above, after providing as input the data for the most recent reported n years [initially n = 4; from 2011 onwards n = 6];

b) calculation of the arithmetic n-year average (AV) of annual observations OBS_i;

c) calculation of the absolute value of the difference $ABSDIFF_i$ between each annual observation OBS_i and the AV. If $ABSDIFF_i<0{,}01*AV$, to $ABSDIFF_i$ is attributed a constant value equal to 0,01*AV;

d) calculation of the weight (W_i) for each single year i, by taking the inverse of $ABSDIFF_i$;

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Weighted averaging process for the calculation of NRVs

e) calculation of the NRV_Y in the form of weighted average, as follows:

$$NRV_Y = \frac{\sum_{i=x}^{N} W_i \times OBS_i}{\sum_{i=x}^{N} W_i};$$

where i is a natural number and $\begin{cases} if\ Y = 2009: x = Y - 5; N = Y - 2 \\ if\ Y = 2011: x = Y - 7; N = Y - 2 \end{cases}$

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Methodology for deriving CSTs from NRVs

- **For each of the risk categories,** once the NRV has been calculated for each Member State, the corresponding **CST** shall be assigned a value equal to the lower of:

a) **the value of the NRV which is the highest amongst the Member States;**

b) **the value equal to 10 times the European average value** of the risk to which the considered NRV refers.

Ultimately, the target value for each country, thus representing its acceptable level of risk in terms of human consequences, was calculated based on the historical damage series recorded in that country.

This is consistent with one of the fundamental principles of the first Railway Safety Directive 49/2004/EC, according to which safety performance at the time of the introduction of the regulatory framework was in itself acceptable and the Safety Management Systems of the various operators must be designed and implemented to maintain this.

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Common Safety Targets (CSTs)

- The table **shows the first set of NRVs** (maximum, minimum and average of EU countries) and the **first set of CSTs (CST1)** calculated by them in **2009** (Decision 2010/409/EU).

Risk Category	Range of NRV values (xE-09)		EURV (xE-09)	Measurement units
Risk to passengers	NRV 1.1	4,91 ÷ **250**	34,4	Number of passenger FWSIs per year arising from significant accidents / Number of passenger train-km per year
	NRV 1.2	0,0557 ÷ **2,01**	0,288	Number of passenger FWSIs per year arising from significant accidents / Number of passenger-km per year
Risk to employees	NRV 2	1,5 ÷ **77,9**	14	Number of employee FWSIs per year arising from significant accidents / Number of train-km per year
Risk to level crossing users	NRV 3.1	21 ÷ **743**	117	Number of level-crossing user FWSIs per year arising from significant accidents / Number of train-km per year
	NRV 3.2	Not available	Not available	Number of level-crossing user FWSIs per year arising from significant accidents / [(Number of Train-km per year * Number of level crossings)/ Track-km]
Risk to "others"	NRV 4	1,90 ÷ **18,5**	4,93	Yearly number of FWSIs to persons belonging to the category "others" arising from significant accidents / Number of train-km per year
Risk to unauthorized persons on railway premises	NRV 5	22,6 ÷ **2030**	234	Number of FWSIs to unauthorised persons on railway premises per year arising from significant accidents / Number of train-km per year
Risk to the whole society	NRV 6	55,2 ÷ **2510**	395	Total number of FWSIs per year arising from significant accidents / Number of train-km per year

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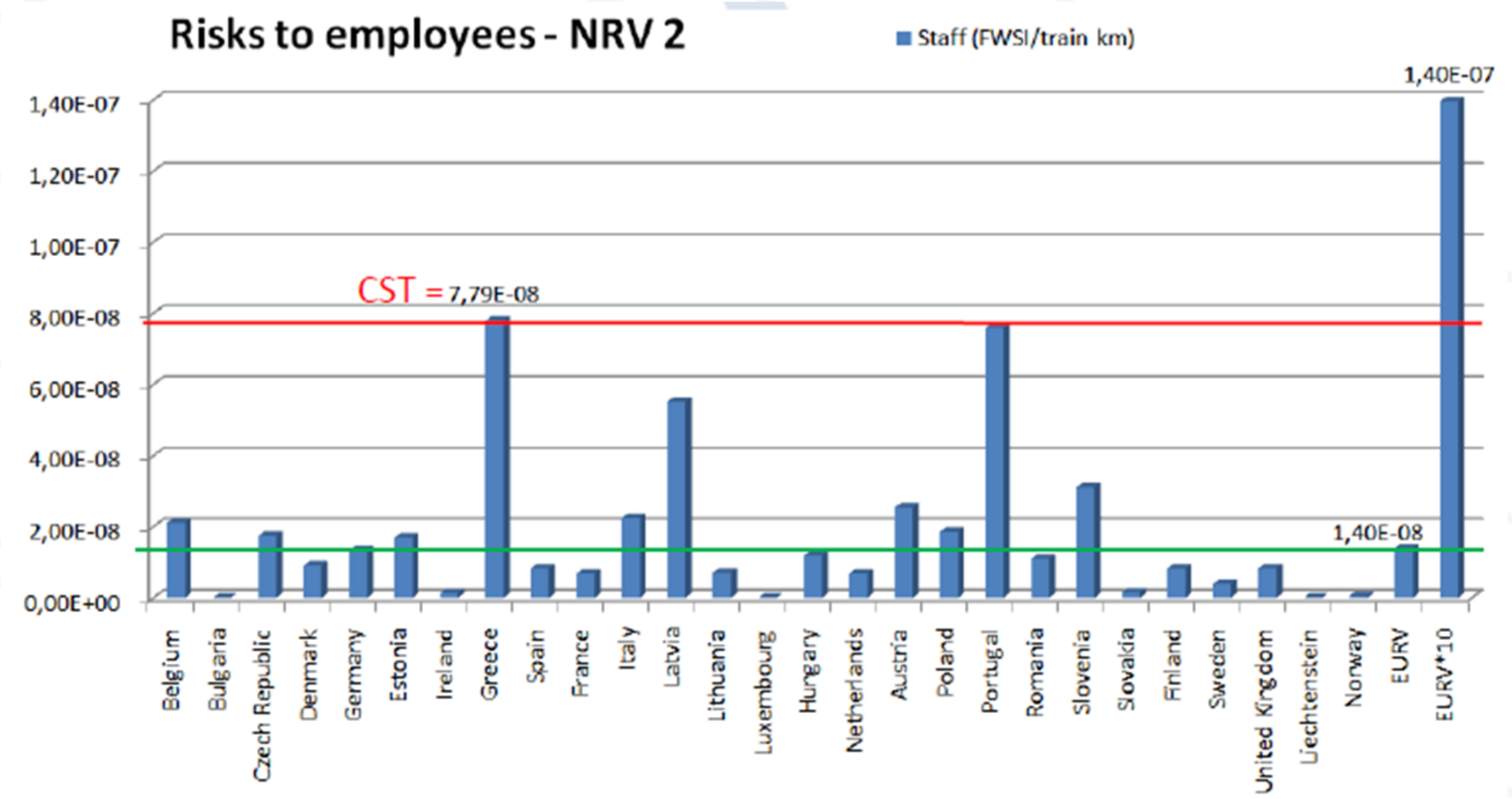
Common Safety Targets (CSTs)

- **CST1 and NRVs** for the **second risk category (employees):**
  2. Number of FWSI employees per year resulting from serious accidents/Number of train-km per year



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Common Safety Targets (CSTs)

- The first set of CSTs **(CST1)** was calculated in **2009 (Decision 2010/409/EU)**, based on data from the time period **2004-2007** and was subsequently recalculated **(CST2)** in **2011 (Decision 2012/226/EU)** based on data from the time period **2004-2009.**

Risk category			CST1 value (× E-06)	CST2 value (× E-06)
CSTs based on Eurostat data for			2004–07	2004–09
Risk to passengers	...per train-km	CST 1.1	0.25	0.17
	...per passenger-km	CST 1.2	0.00201	0.00165
Risk to employees		CST 2	0.0779	0.0779
Risk to level-crossing users		CST 3.1	0.743	0.710
		CST 3.2	n.a.	n.a.
Risk to 'others'		CST 4	0.0185	0.0145
Risk to unauthorised persons on railway premises		CST 5	2.03	2.05
Risk to the whole society		CST 6	2.51	2.59

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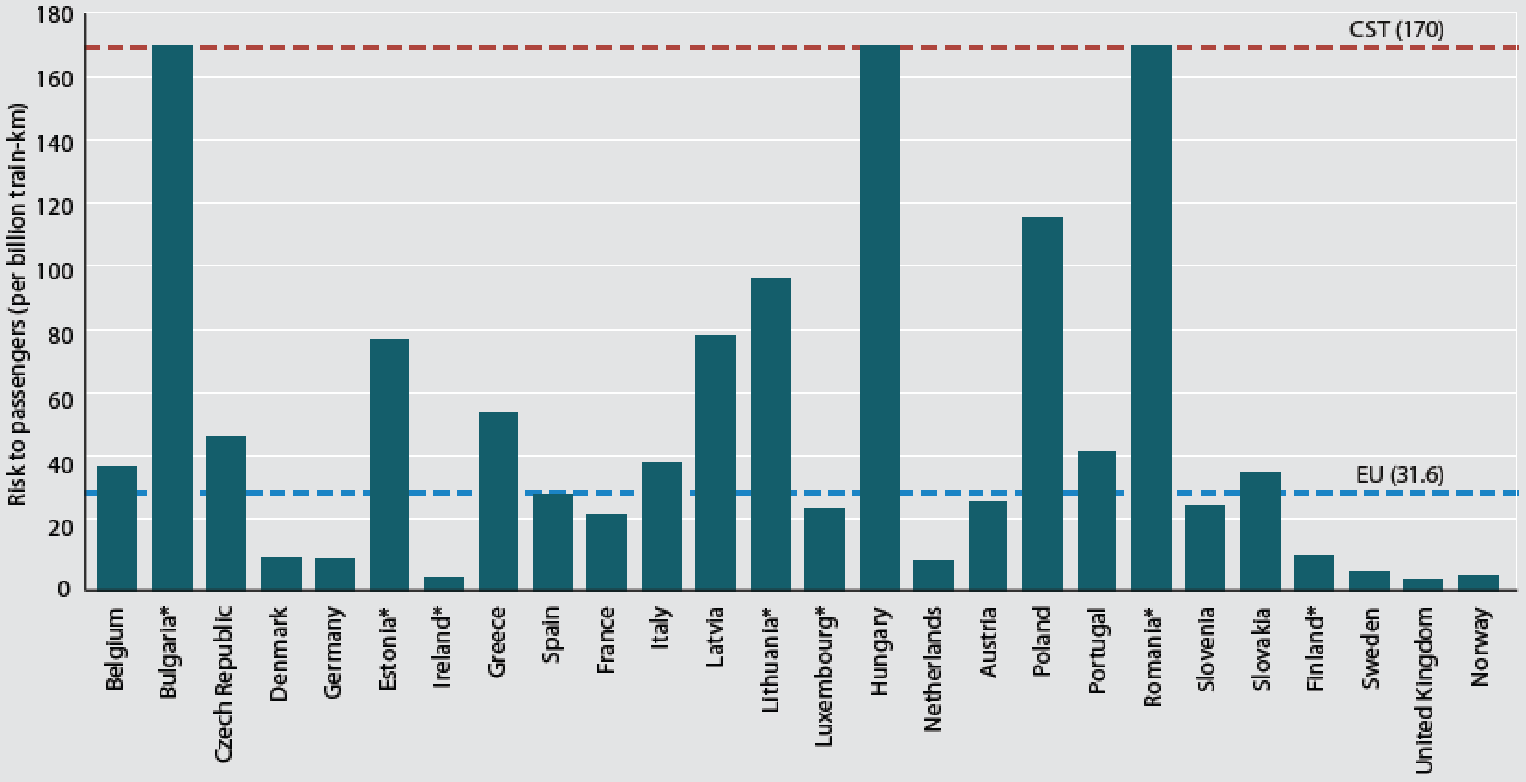
Common Safety Targets (CSTs)

- **CST2 and NRVs** values for the **first risk category (passengers):**
  1.1 Number of FWSI passengers per year resulting from serious accidents/Number of passenger train-km per year

Figure 17 _ CST and NRVs (risks caused) for the passenger - CST 1.1
(second set based on 2004–2009 data)



Methodology for assessing the achievement of NRVs

- Decision 2009/460/EC also defined an algorithm to assess the achievement of NRVs by individual Member States.
- The following principles apply to assessing the achievement of NRVs and CSTs
  - for each Member State and for each of the risk categories whose respective NRV is equal to or lower than the corresponding CST, **the achievement of the NRV automatically implies that of the CST.**
  - for each Member State and for each of the risk categories whose respective NRV is higher than the corresponding CST, **the CST represents the maximum tolerable level of the risk to which it refers.**

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Methodology for assessing the achievement of NRVs

- Starting in **2010**, for each Member State and for each of the risk categories, the Agency (ERA) started to assess annually the NRV and CST achievement, taking into account the declarations of the previous **four years**.
- By 31 March each year, the Agency reports to the Commission on the overall results of the NRV and CST achievement assessment.
- As of **2012**, the evaluation of the achievement of NRVs and CSTs is carried out annually by the Agency, taking into account the declarations of the last **five years**.
- The outcome of the performance assessment is classified as follows:
  a) acceptable safety performance
  b) possible deterioration of the safety performance
  c) probable deterioration of the safety performance

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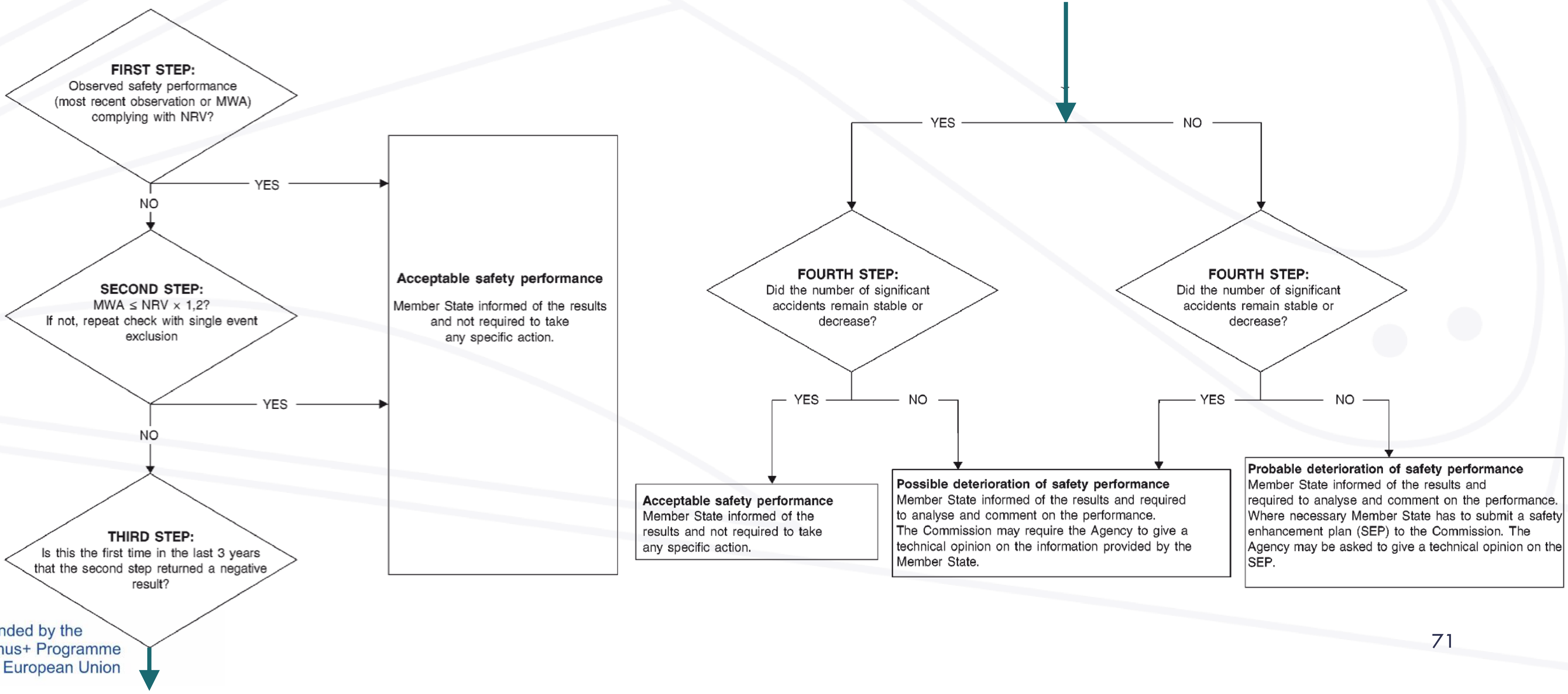
Methodology for assessing the achievement of NRVs

- The procedure for the evaluation of NRV implementation consists of **four different steps.**



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Example of NRV achievement assessment for Italy

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- Risk category 5. Unauthorised persons on railway premises

The results of all assessments carried out by the Agency are summarized in the table below.

Risk category	*Passengers*		*Employees*	*Level crossing users*	*Others*	*Unauthorised persons*	*Whole society*
	1.1[6]	*1.2*[7]	*2*	*3.1*	*4*	*5*	*6*
2010			*Romania*	*Romania*	*Romania*	*Romania*	
2011			*Lithuania*			*Romania* *Slovakia*	
2012						*Sweden*	
2013	*Slovakia*	*Slovakia*	*Romania* *Slovakia* **Bulgaria**		*Romania*	*Romania* *Slovakia* *Sweden*	*Romania*
2014			*Bulgaria* *Romania* *Slovakia* *Sweden*	*Bulgaria*	*(Croatia*[8]*)* *(Romania)*		*[Norway]*
2015			*Romania* *Slovakia*	*Bulgaria*		*Italy* *[Norway]*	*Slovakia* *[Norway]*
2016			*Hungary* *Romania* *Sweden* **Slovakia**	*Bulgaria* *[Norway]*	*Hungary*	*France* *Italy* *[Norway]*	**Slovakia**
2017			*Bulgaria* *Slovakia* *Sweden*	*[Norway]*		*Italy* *[Norway]*	*Slovakia* *[Norway]*

Note: For countries in **bold**, the result of "probable deterioration", for countries in *italic* "possible deterioration" of safety performance. In all other cases, the result was "acceptable safety performance".

Conclusion for Italy in 2015, 2016 and 2017: possible deterioration of safety performance in category 5.

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Example of NRV achievement assessment for Italy

- Risk category 5. Unauthorised persons on railway premises

NRV achievement assessment		Year 2018	Year 2019	Year 2020	Year 2021	Year 2022	Year 2023
	NRV ($*10^{-9}$) [2004-2009]	119,25	119,25	119,25	119,25	119,25	119,25
	OSP ($*10^{-9}$) [Y-2]	140,8	122,0	167,01	99,12	113,94	146,23
	MWA ($*10^{-9}$) [(Y-6)-(Y-2)]	145,25	138,41	141,18	-	-	125,37
1^ STEP passed?	OSP ($*10^{-9}$) [Y-2] o MWA ($*10^{-9}$) [(Y-6)-(Y-2)] < NRV ($*10^{-9}$) [2004-2009] ?	NO	NO	NO	YES	YES	NO
2^ STEP passed?	MWA [(Y-6)-(Y-2)] ≤ NRV * 1,2	NO	YES	YES	-	-	YES
3^ STEP passed?	Is this the first time in the last three years that the 3^ step returns a negative result?	NO	-	-	-	-	-
4^ STEP	Did the number of significant accidents per train*km remain stable (or decreased) compared to previous years?	YES	-	-	-	-	-
NRV = National Reference Value, OSP = Observed Safety Performance, MWA = Moving Weighted Average, Y = Year							
Fonte: ERA – 2018, 2019, 2020 and 2021 Assessment of achievements of Common Safety Targets							

Conclusion for the year 2018: possible deterioration of safety performance in category 5.
Conclusion for the years 2019 to 2023: acceptable safety performance.

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General concepts of risk analysis

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- *Definitions from the **REGULATION (EU) No 402/2013** on the common safety method for risk evaluation and assessment and repealing Regulation (EC) No 352/2009*
- **‘hazard’** means a condition that could lead to an accident
- **‘risk’** means the frequency of occurrence of accidents and incidents resulting in harm (caused by a hazard) and the degree of severity of that harm
- **‘risk estimation’** means the process used to produce a measure of the level of risks being analysed, consisting of the following steps: estimation of frequency, consequence analysis and their integration
- **‘risk analysis’** means systematic use of all available information to identify hazards and to estimate the risk
- **‘risk evaluation’** means a procedure based on the risk analysis to determine whether an acceptable level of risk has been achieved
- **‘risk assessment’** means the overall process comprising a risk analysis and a risk evaluation

risk analysis = hazards identification + risk estimation

risk assessment = risk analysis + risk evaluation

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General concepts of risk analysis

- *Definitions from the **REGULATION (EU) No 402/2013** on the common safety method for risk evaluation and assessment and repealing Regulation (EC) No 352/2009*
- **‘hazard record’** means the document in which identified hazards, their related measures, their origin and the reference to the organisation which has to manage them are recorded and referenced
- **‘risk acceptance principle’** means the rules used in order to arrive at the conclusion whether or not the risk related to one or more specific hazards is acceptable
- **‘risk acceptance criteria’** means the terms of reference by which the acceptability of a specific risk is assessed; these criteria are used to determine that the level of a risk is sufficiently low that it is not necessary to take any immediate action to reduce it further
- **‘safety’** means freedom from unacceptable risk of harm
- **‘safety measures’** means a set of actions either reducing the frequency of occurrence of a hazard or mitigating its consequences in order to achieve and/or maintain an acceptable level of risk

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General concepts of risk analysis

In summary:

- DANGER and **RISK** are two different concepts
- DANGER can be considered as the intrinsic property of a situation, object, substance, factor to lead to a hazardous event and potentially create harm
- HARM is any negative consequence resulting from the occurrence of an accident caused by a hazardous event (hazard), characterised by a given potential level or severity
- RISK can therefore be defined as a combination of the **PROBABILITY** of occurrence of a hazard and the **SEVERITY** of the harm it may cause. In formulae:

$$R = P \times S$$

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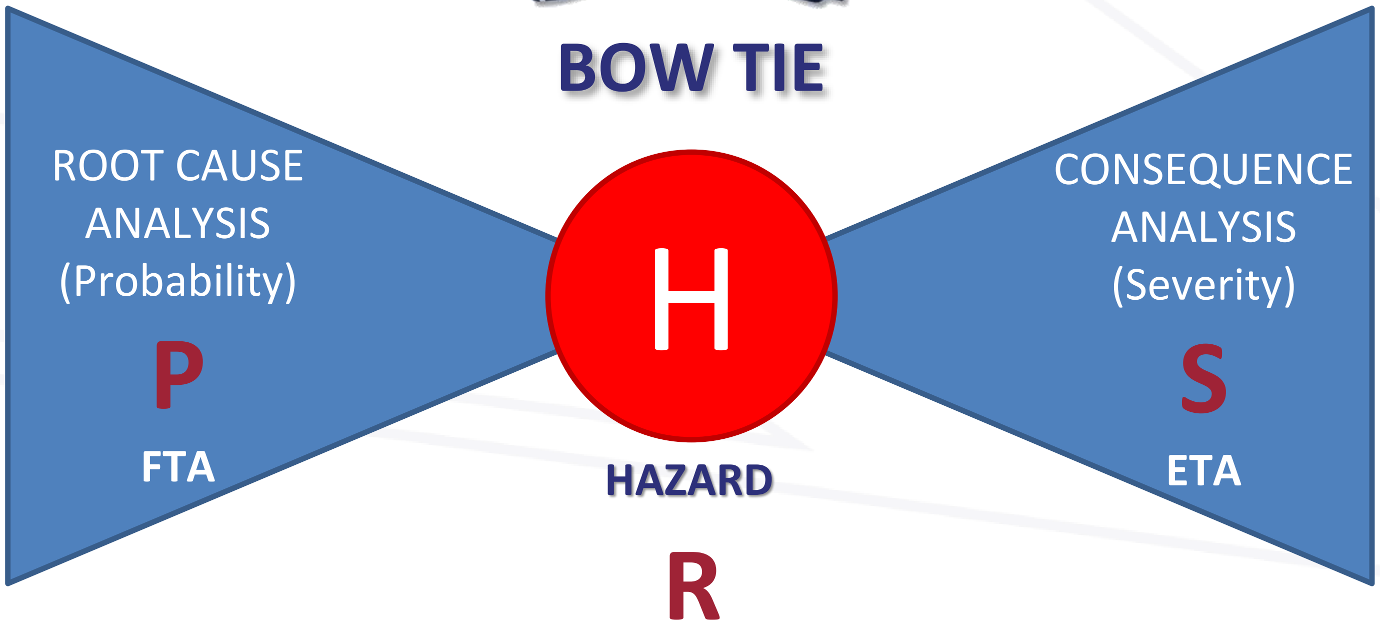
General concepts of risk analysis

- **RISK** can be defined as the combination of the **PROBABILITY** of occurrence of an accident caused by a hazard and the SEVERITY of the harm it may cause. In formulae:

$$R = P \times S$$

BOW TIE



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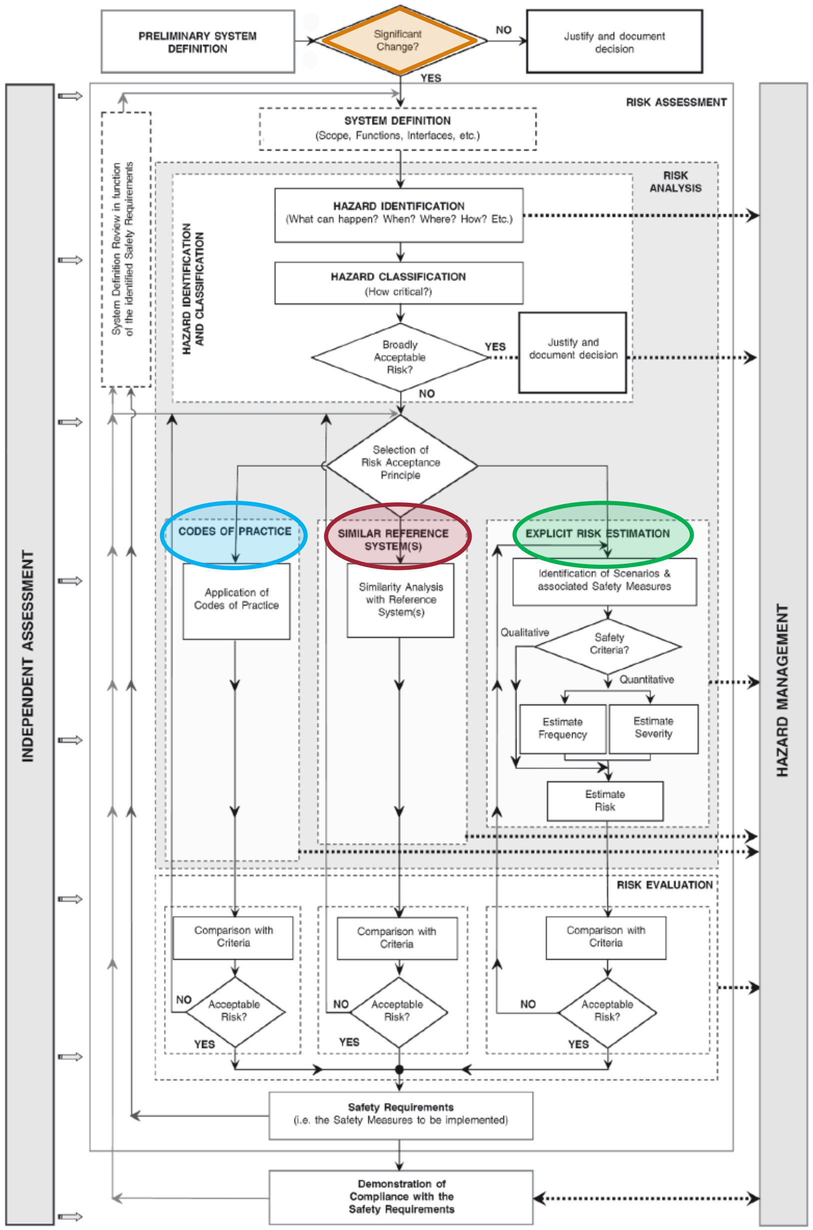
Regulation (EU) 402/2013



- This Regulation shall apply to the **proposer** when making **any change to the railway system** in a Member State.
- Such changes may be of a **technical, operational** or **organisational** nature. As regards organisational changes, only those changes which could impact the **operational or maintenance processes** shall be subjected to consideration.
- If the change is considered **significant**, The risk acceptability of the system under assessment shall be evaluated by using one or more of the following risk acceptance principles:
  a) **the application of codes of practice**
  b) **a comparison with similar systems**
  c) **an explicit risk estimation**

Regulation (EU) 402/2013
Scope of application

- It is the **same of the Safety Directive**. Therefore, it shall not apply to:

a) metros

b) trams and light rail vehicles, and infrastructure used exclusively by those vehicles; or

c) networks that are functionally separate from the rest of the Union rail system and intended only for the operation of local, urban or suburban passenger services, as well as undertakings operating solely on those networks.

- Member States may exclude from the scope of the measures implementing the Safety Directive:

a) privately owned railway infrastructure, including sidings, used by the owner or by an operator for the purpose of their respective freight activities or for the transport of persons for non-commercial purposes, and vehicles used exclusively on such infrastructure

b) infrastructure and vehicles reserved for strictly local, historical or tourist use

c) light rail infrastructure occasionally used by heavy rail vehicles under the operational conditions of the light rail system, where it is necessary for the purposes of connectivity of those vehicles only; and

d) vehicles primarily used on light rail infrastructure but equipped with some heavy rail components necessary to enable transit to be effected on a confined and limited section of heavy rail infrastructure for connectivity purposes only.

- Notwithstanding the firs point, Member States may decide to apply, where appropriate, provisions of the Safety Directive to metros and other local systems in accordance with national law.

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Regulation (EU) 402/2013
Actors involved in its application

- Proposer
- Assessment Body (AsBo) or CSM Assessor
- National Safety Authority (in Italy: ANSFISA)
- ERA (Eupean Union Agency for Railways)

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Regulation (EU) 402/2013
Actors involved in its application

‘Proposer’ means one of the following:

a) a **railway undertaking** or an **infrastructure manager** which implements risk control measures in accordance with Article 4 of Directive 2004/49/EC

b) an **entity in charge of maintenance** which implements measures in accordance with Article 14a(3) of Directive 2004/49/EC

c) a **contracting entity** or a **manufacturer** which invites a **notified body** to apply the ‘EC’ verification procedure in accordance with Article 18(1) of Directive 2008/57/EC or a **designated body** according to Article 17(3) of that Directive

d) an **applicant for an authorisation for the placing in service of structural sub-systems**

The **proposer** is responsible for the implementation of the regulation; he ensures the correct classification of the change and the proper application of the change risk management process. It is responsible for the **‘safety acceptance’** of the change based on the safety assessment report provided by the assessment body.

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Regulation (EU) 402/2013
Actors involved in its application

- The assessment body is the independent and competent external or internal individual, organisation or entity which undertakes investigation to provide a **judgement,** based on evidence, **of the suitability of a system to fulfil its safety requirements.** The conclusions of its assessment are contained in the **'safety assessment report'**. The assessment body shall be either:
- **accredited** by the national accreditation body; or
- **recognised** by the recognition body; or
- **the national safety authority.**
- *e.g., In Italy, the assessment body is accredited by the national accreditation body (ACCREDIA) and the NSA (ANSIFSA) does not offer the service of assessment body.*
- The National Safety Authority shall supervise the application of this Regulation by railway undertakings and infrastructure managers.
- The Agency (ERA) shall collect all information on the experience of the application of this Regulation and shall, when necessary, make recommendations to the Commission with a view to improving this Regulation.

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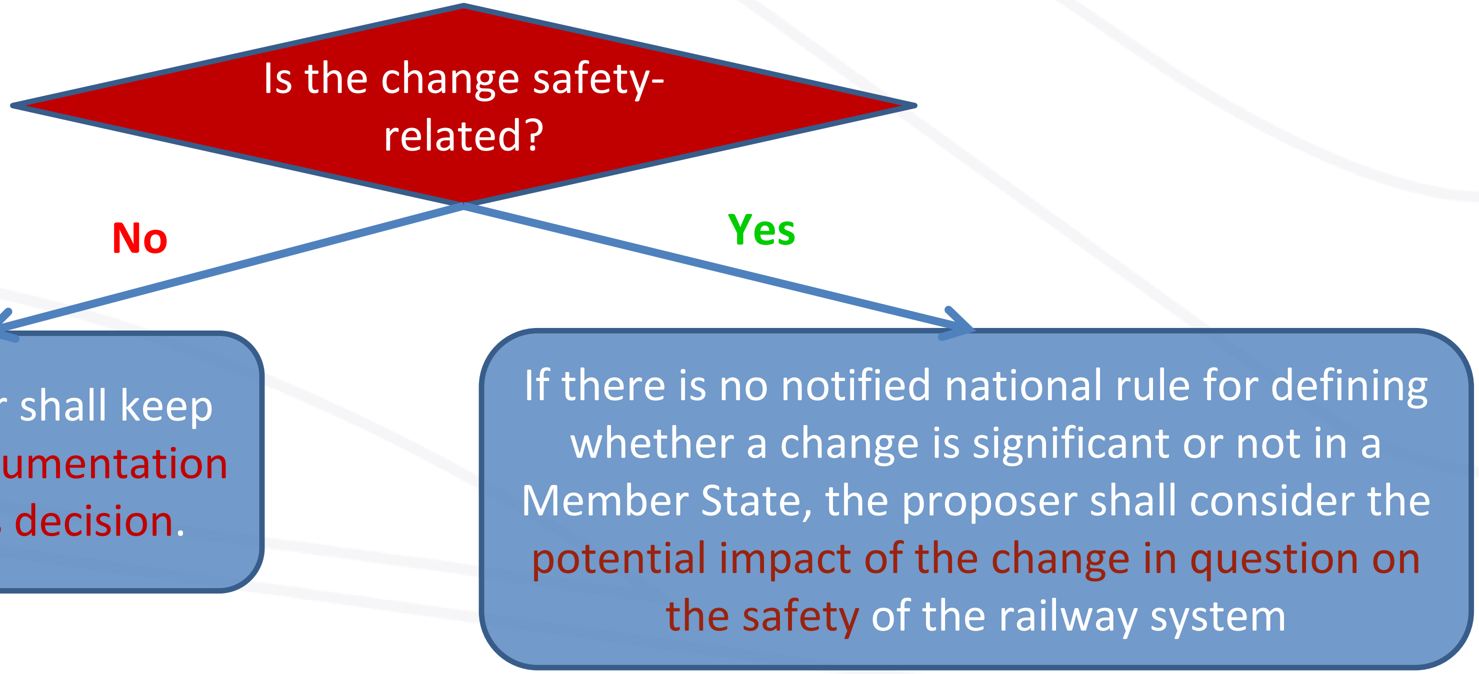
Risk management process

1. Is the change SAFETY-RELATED?

The proposer first considers the potential effect of the change on the safety of the railway system. If the proposed change does not affect safety, the risk management process need not be applied. The proposer keeps the documentation necessary to justify the decision taken.



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Risk management process

2. Is the change SIGNIFICANT?

If the proposed change has an impact on safety, the proposer shall decide, by expert judgement, on the **significance of the change** based on the **following criteria**:

a) **failure consequence**: credible worst-case scenario in the event of failure of the system under assessment, taking into account the existence of safety barriers outside the system under assessment;

b) **novelty used in implementing the change**: this concerns both what is innovative in the railway sector, and what is new for the organisation implementing the change;

c) **complexity** of the change;

d) **monitoring**: the inability to monitor the implemented change throughout the system life-cycle and intervene appropriately;

e) **reversibility**: the inability to revert to the system before the change;

f) **additionality**: assessment of the significance of the change taking into account all recent safety-related changes to the system under assessment and which were not judged to be significant.

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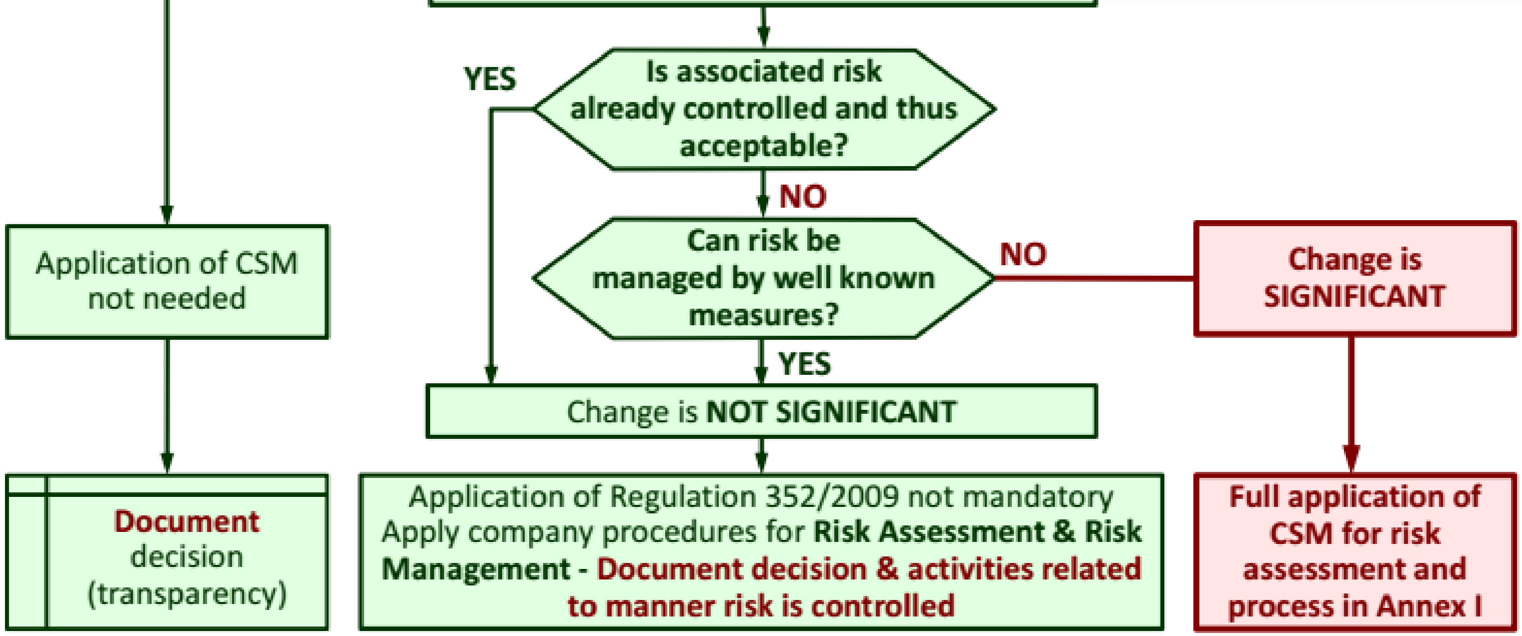
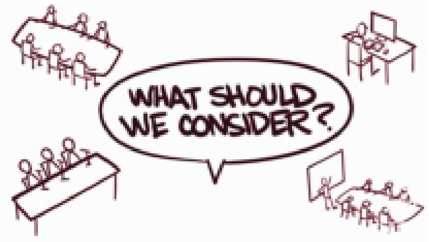
Risk management process

2. Is the change SIGNIFICANT?

"Seventh criterion": a change can be judged **NOT SIGNIFICANT** when the risks introduced by the change "**can be managed by well-known safety measures**".





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Source: *CSM for risk assessment - Revision of Regulation 352/2009 – ERA Workshop on RAC-TS, 25th & 26th June 2013*

Risk management process

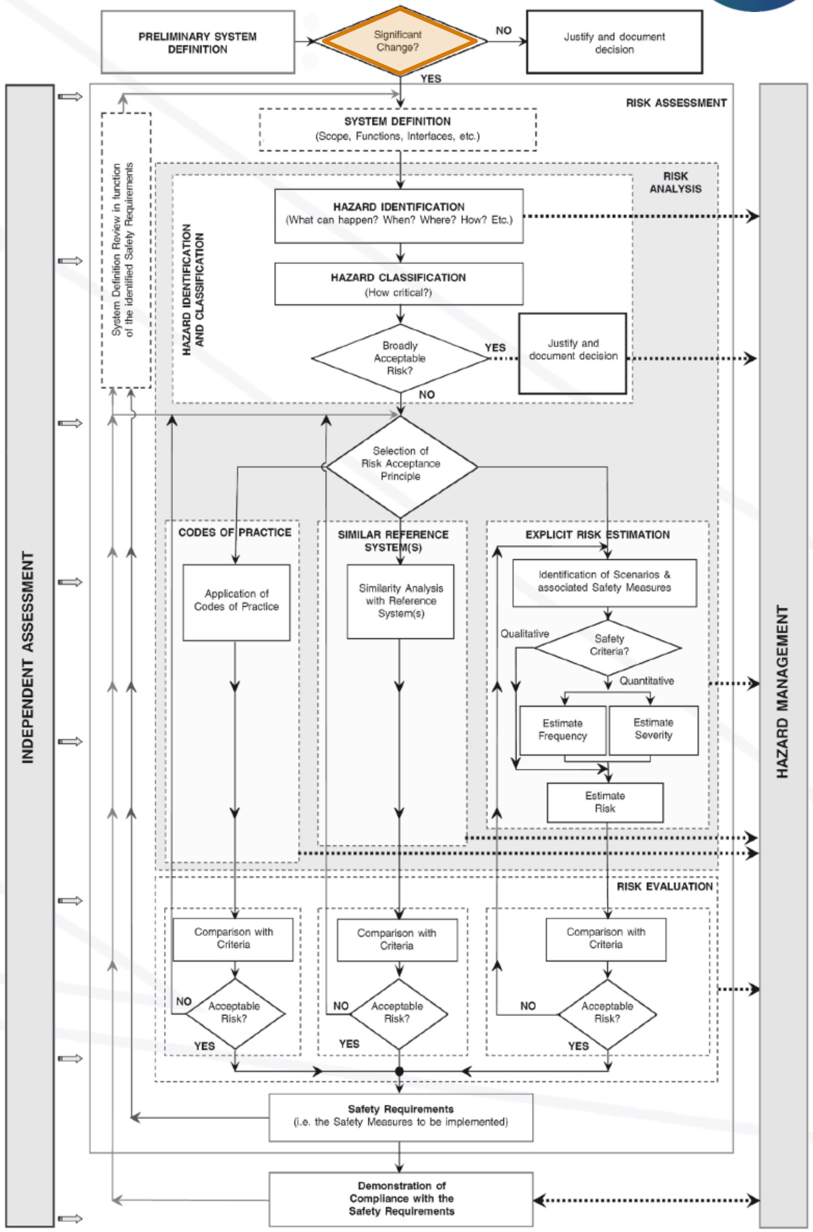
Is the change SIGNIFICANT?

No

The proposer shall keep adequate documentation to justify its decision

Yes

The Proponent must apply the risk management process (CSM) as set out in Annex I



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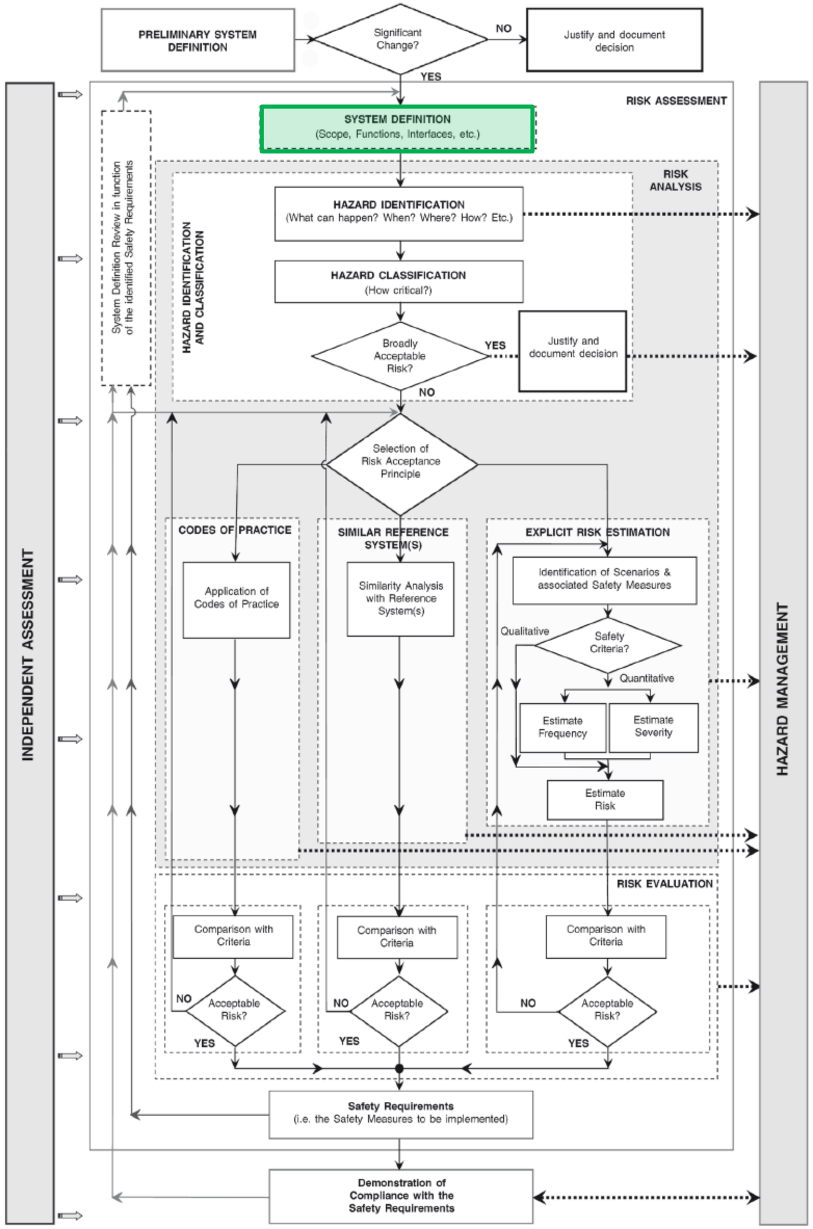
Risk management process



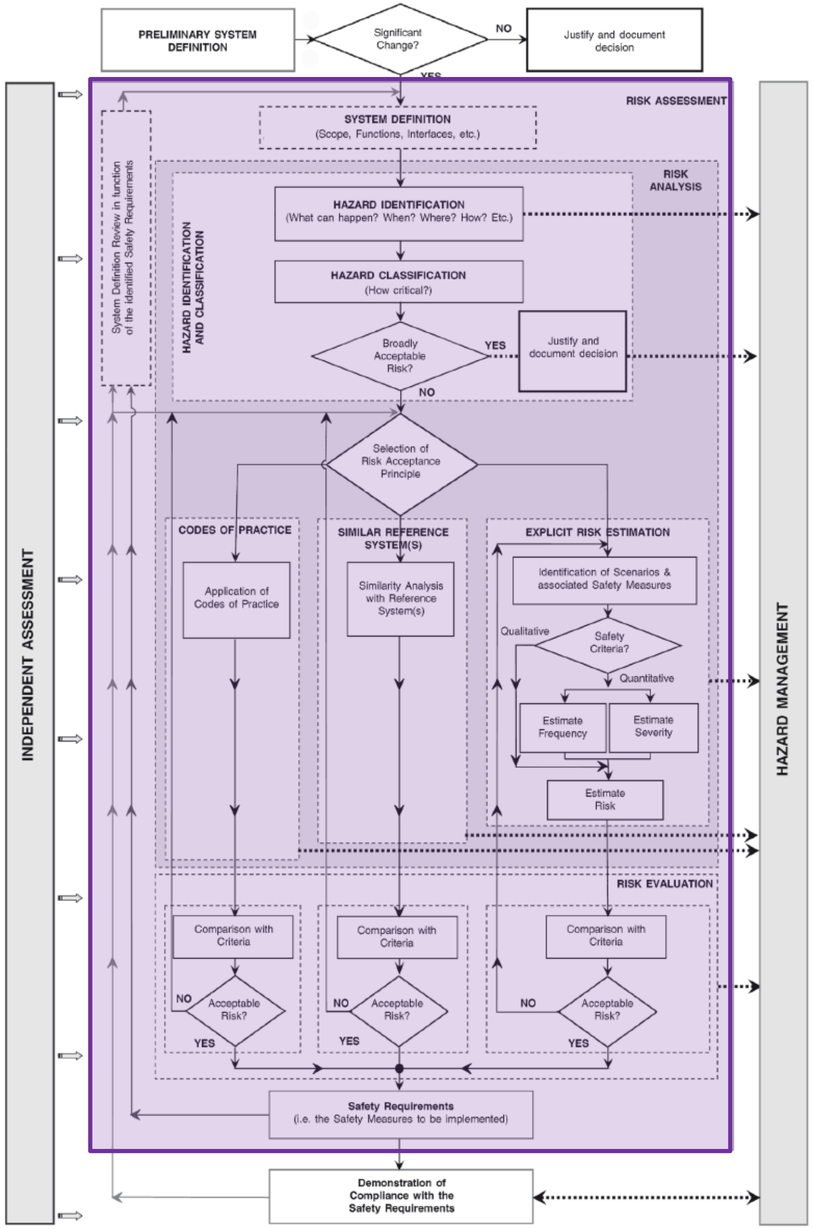
- According to Annex I of Reg. 402/2013, risk management must take place through an **iterative process**, which begins with the **definition of the system** to be assessed and includes the following activities:

a) the **risk assessment** process, which shall identify the hazards, the risks, the associated **safety measures** and the resulting **safety requirements** to be fulfilled by the system under assessment;

b) demonstration of the **compliance** of the system with the identified safety requirements; and

c) **management of all identified hazards** and the associated safety measures.

Risk management process



- The **risk assessment** process is the overall iterative process that comprises:

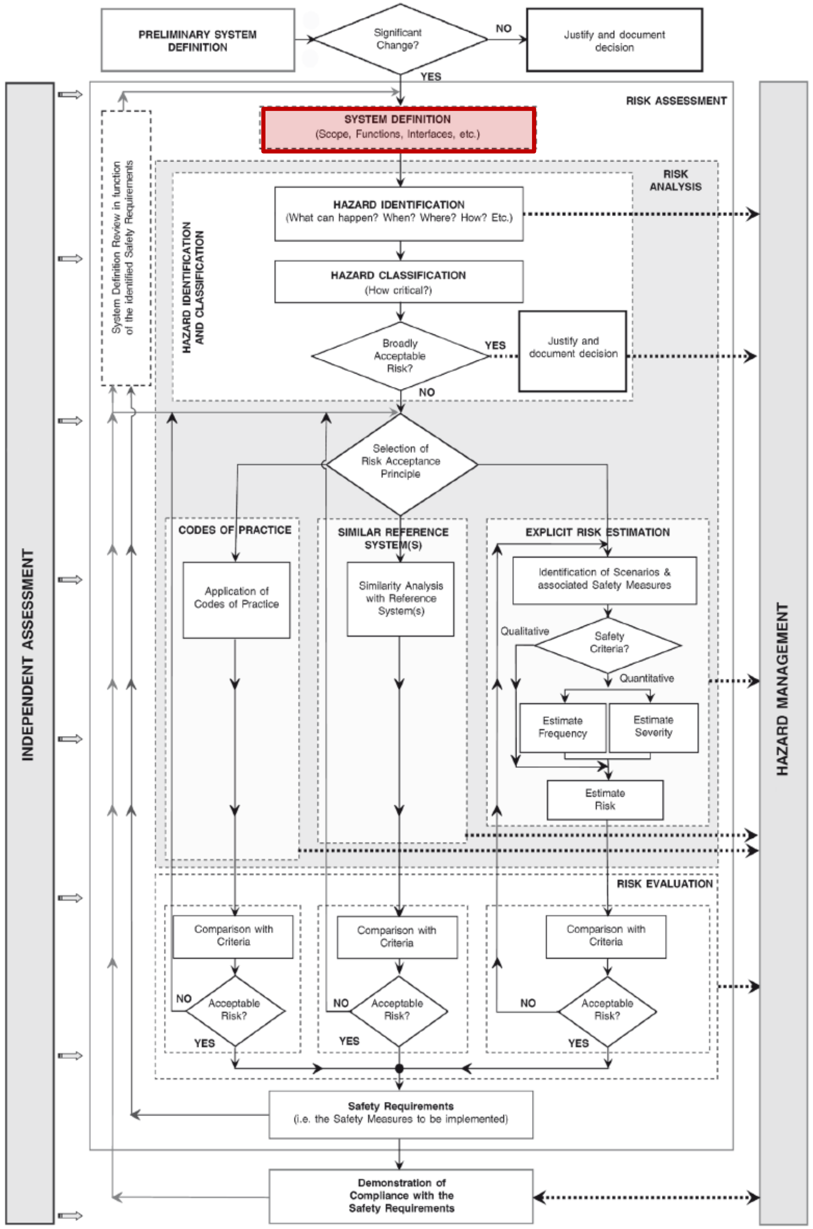
a) the **system definition**;

b) the **risk analysis** including the hazard identification;

c) the **risk evaluation** (*means a procedure based on the risk analysis to determine whether an acceptable level of risk has been achieved*).

- The risk assessment process shall interact with hazard management (*as shown in the flow chart on the left*).

Risk management process



1. SYSTEM DEFINITION

The system definition shall address at least the following issues:

a) system objective (intended purpose);

b) system functions and elements, where relevant (including human, technical and operational elements);

c) system boundary including other interacting systems;

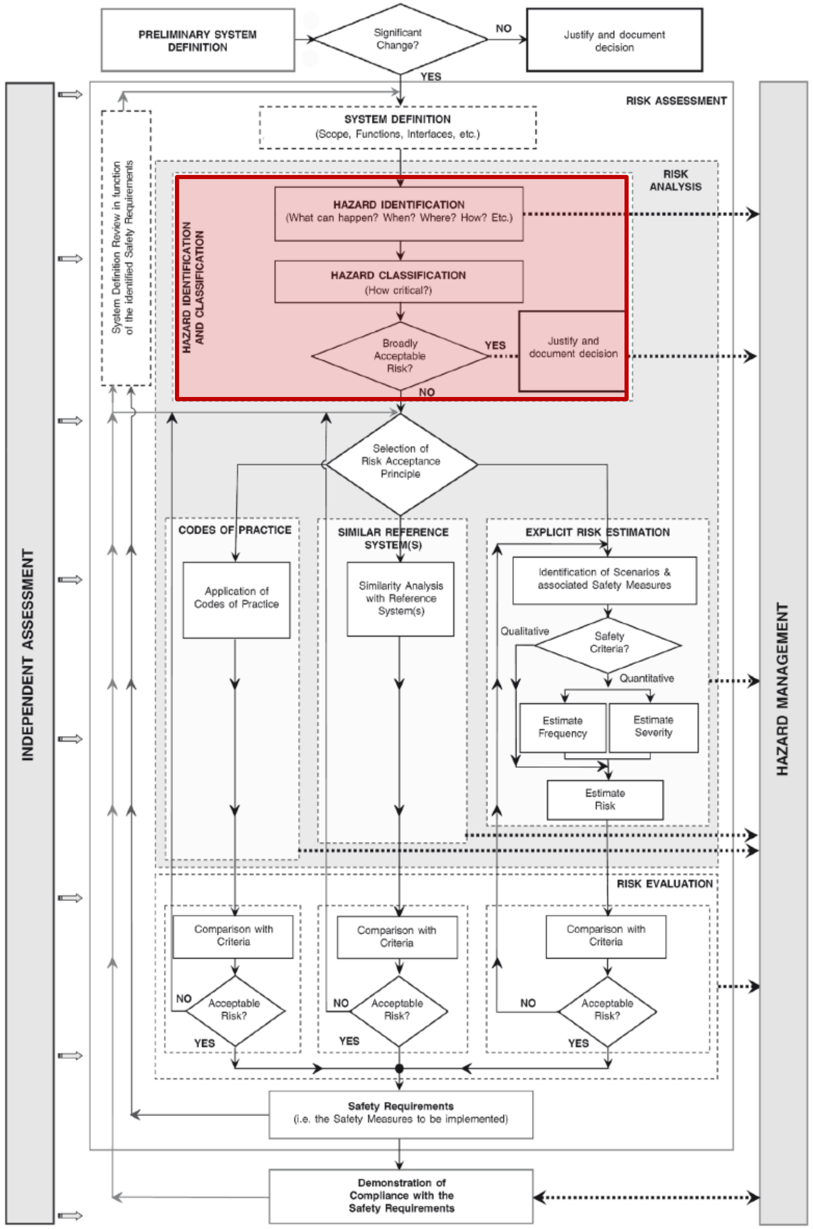
d) physical (interacting systems) and functional (functional input and output) interfaces;

e) system environment (for example energy and thermal flow, shocks, vibrations, electromagnetic interference, operational use);

f) existing safety measures and, after the necessary relevant iterations, definition of the safety requirements identified by the risk assessment process;

g) assumptions that determine the limits for the risk assessment

Risk management process



2. HAZARD IDENTIFICATION AND CLASSIFICATION

The proposer shall systematically identify, using **wide-ranging expertise from a competent team,** all reasonably foreseeable hazards for the whole system under assessment, its functions where appropriate and its interfaces.

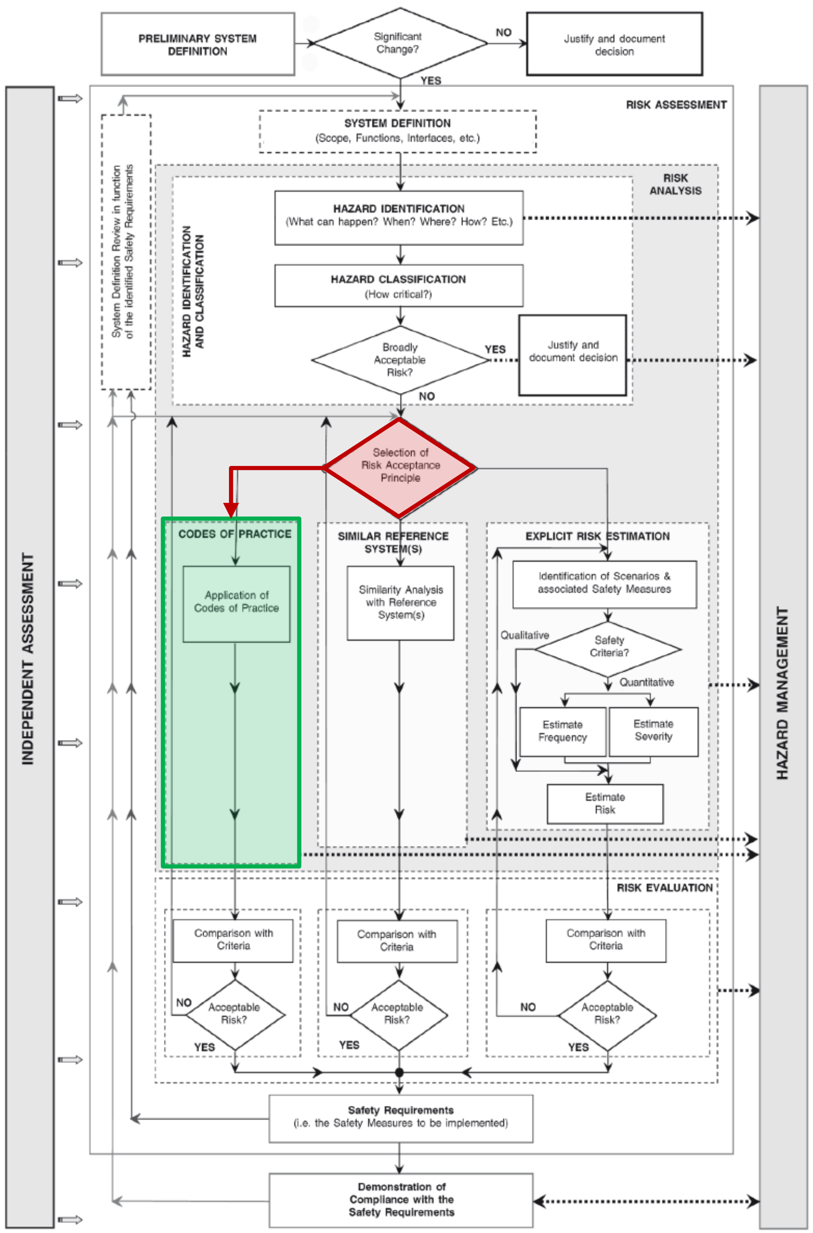
All hazards identified in this way are entered in the **HAZARD RECORD**.

To focus the risk assessment efforts upon the most important risks, the **hazards shall be classified** according to the estimated risk arising from them.

Based on expert judgement, hazards associated with a **broadly acceptable risk** need not be analysed further but shall be registered in the hazard record.

Their classification shall be justified in order to allow independent assessment by an **assessment body**.

Risk management process



3. RISK ACCEPTANCE PRINCIPLES

1. CODES OF PRACTICE

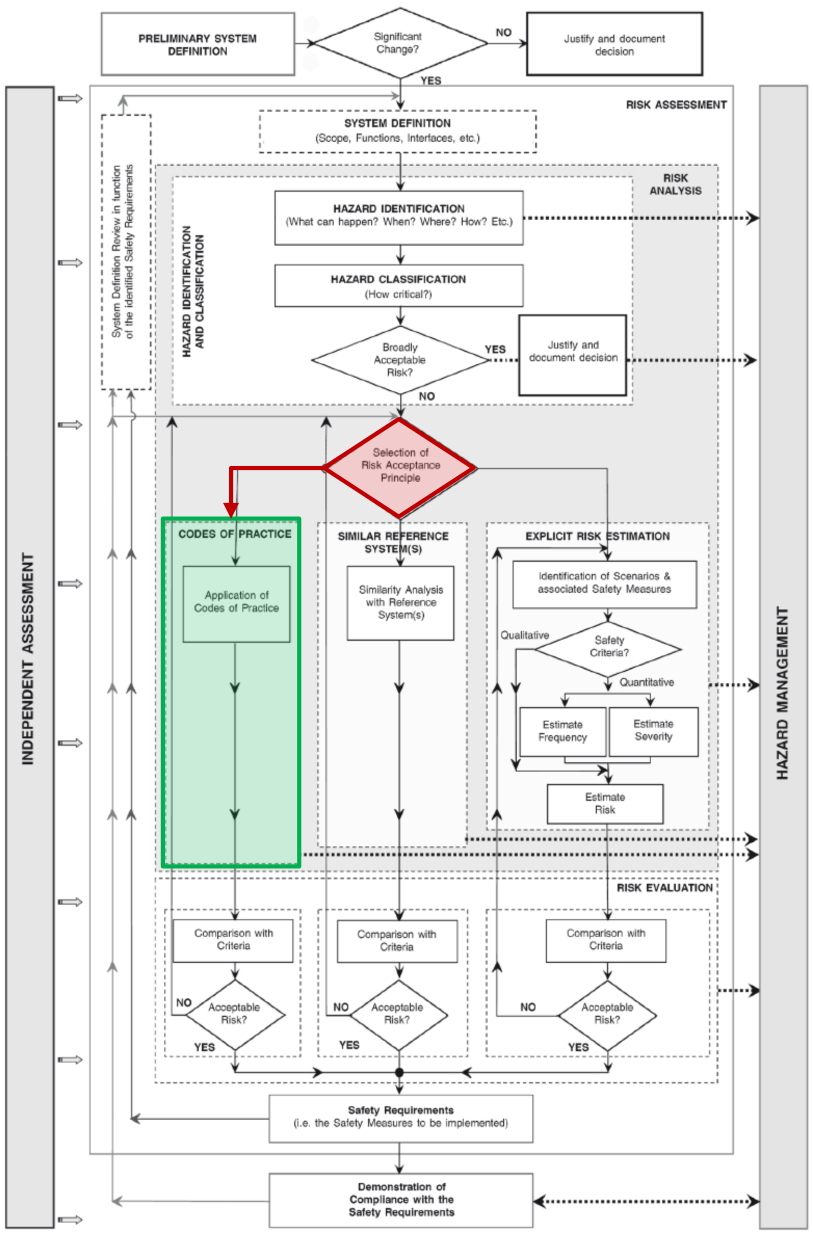
The codes of practice shall satisfy at least the following requirements:

a) They must be **widely recognised** in the railway domain. If this is not the case, the codes of practice will have to be justified and be acceptable to the assessment body;

b) They must be **relevant for the control of the considered hazards** in the system under assessment. Successful application of a code of practice for similar cases to manage changes and control effectively the identified hazards of a system in the sense of this Regulation is sufficient for it to be considered as relevant;

c) Upon request, **they must be available to assessment bodies** for them to either assess or, where relevant, mutually recognize the suitability of both the application of the risk management process and of its results.

Risk management process



3. RISK ACCEPTANCE PRINCIPLES

1. CODES OF PRACTICE

- Where compliance with TSIs is required by Directive 2008/57/EC and the relevant TSI does not impose the risk management process established by this Regulation, the **TSIs may be considered as codes of practice for controlling hazards** provided that requirement (b) of the previous slide (relevance) is fulfilled.
- National rules notified in accordance with Article 8 of Directive 2004/49/EC and Article 17(3) of Directive 2008/57/EC may be considered as codes of practice provided the requirements (a, b, c) of the previous slide are fulfilled.

Risk management process

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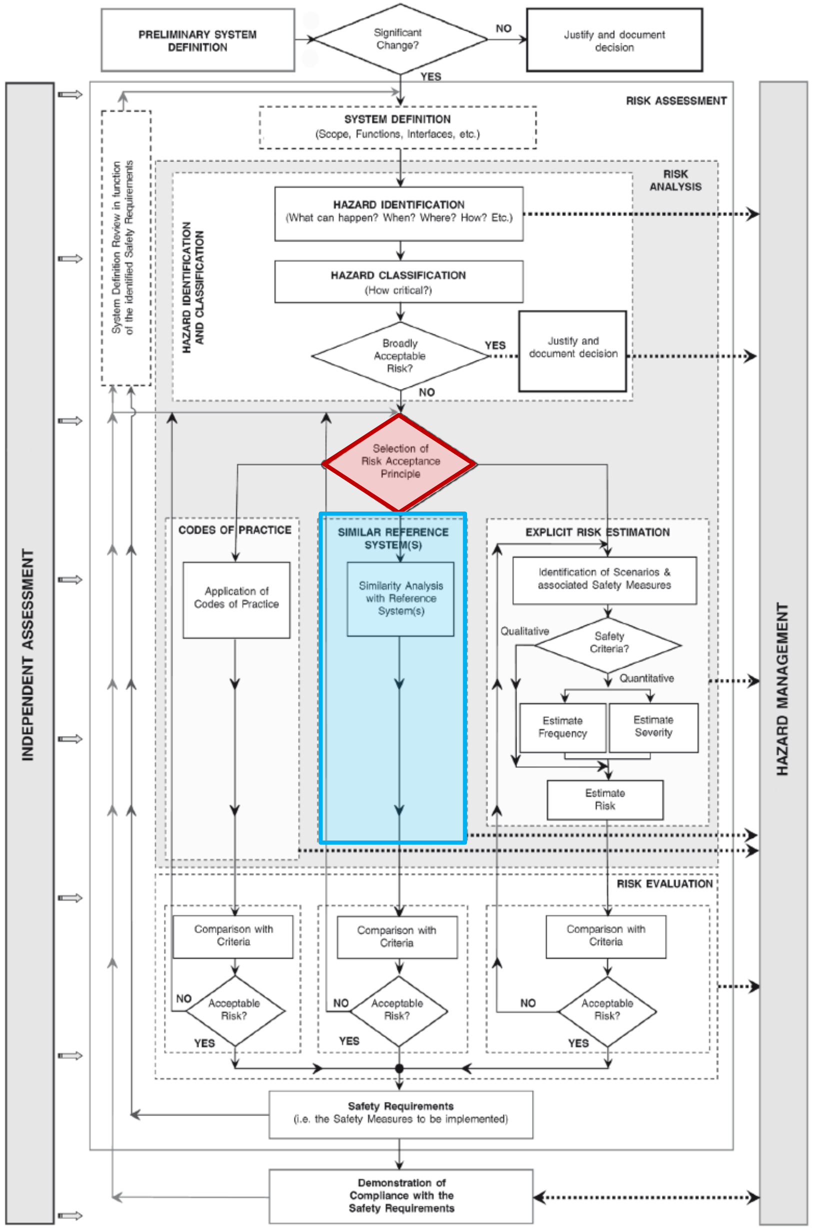


3. RISK ACCEPTANCE PRINCIPLES

2. SIMILAR REFERENCE SYSTEM(S)

A reference system shall satisfy at least the following requirements:

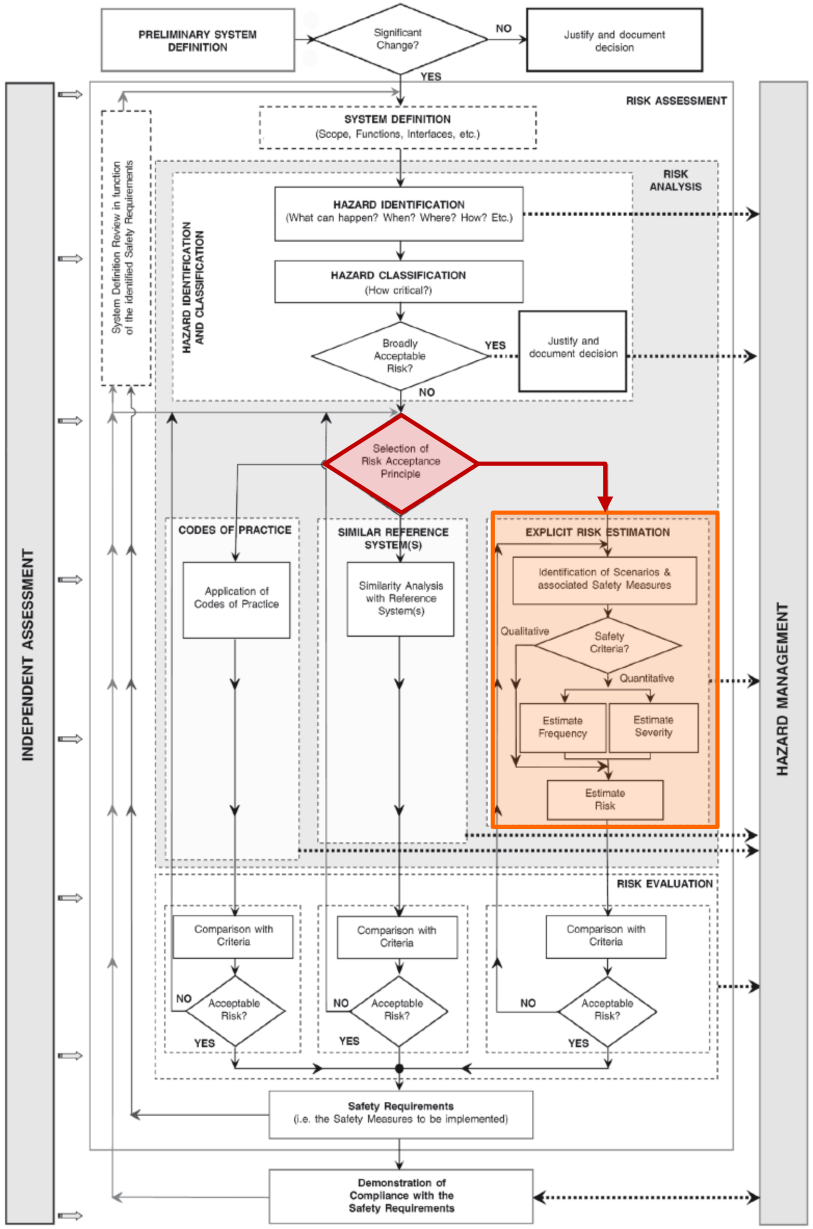
a) it has already **been proven in-use to have an acceptable safety level** and would therefore still qualify for approval in the Member State where the change is to be introduced;

b) it has **similar functions and interfaces** as the system under assessment;

c) it is used under **similar operational conditions** as the system under assessment;

d) it is used under **similar environmental conditions** as the system under assessment.

Risk management process



3. RISK ACCEPTANCE PRINCIPLES

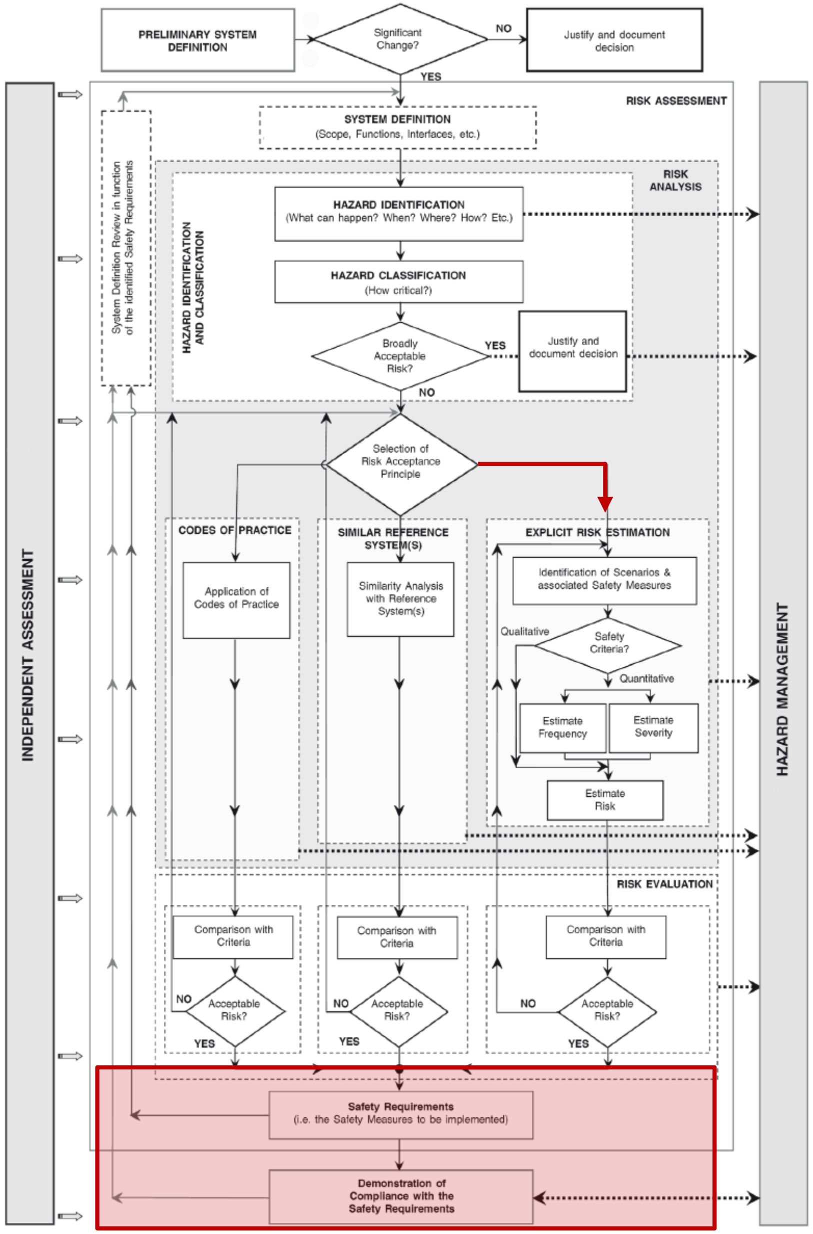
3. EXPLICIT RISK ESTIMATION

If the hazards are not covered by one of the two previous risk acceptance principles, the demonstration of risk acceptability shall be performed by explicit risk estimation and evaluation.

Risks resulting from these **hazards shall be estimated either quantitatively or qualitatively**, taking existing safety measures into account.

Depending on the risk acceptance criteria, the acceptability of the risk may be evaluated either individually for each associated hazard or the combination of all hazards as a whole considered in the explicit risk estimation.

Risk management process



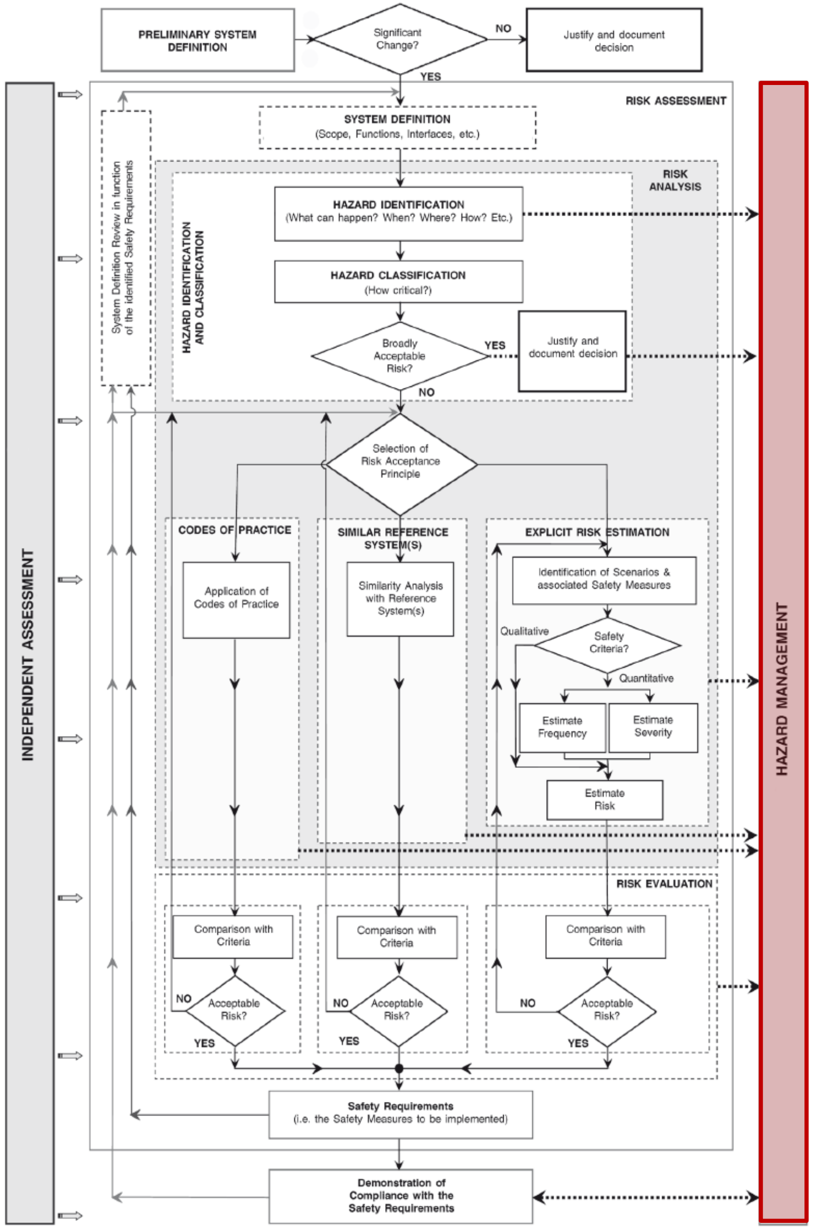
4. DEMONSTRATION OF COMPLIANCE WITH SAFETY REQUIREMENTS

Prior to the safety acceptance of the change, **fulfilment of the safety requirements** resulting from the risk assessment phase shall be demonstrated under the supervision of the proposer.

This demonstration shall be carried out **by each of the actors responsible for fulfilling the safety requirements.**

The approach chosen for demonstrating compliance with the safety requirements as well as the demonstration itself shall be **independently assessed by an assessment body.**

Risk management process



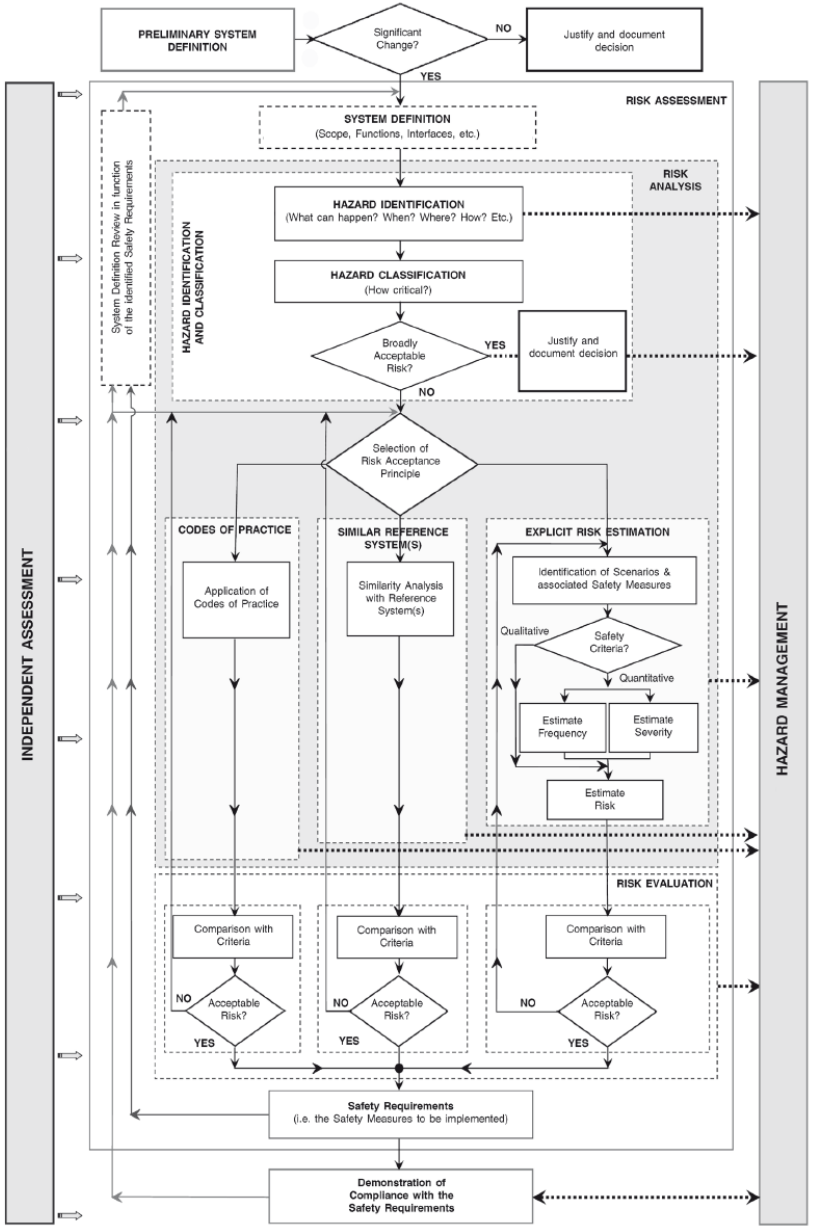
5. HAZARD MANAGEMENT

Hazard record(s) shall be created or updated (where they already exist) by the proposer during design and implementation until acceptance of the change or delivery of the safety assessment report.

A hazard record shall track the progress in monitoring risks associated with the identified hazards.

Once the system has been accepted and is in operation, the **hazard record** shall be **further maintained** by the **infrastructure** manager or the **railway undertaking** in charge of the operation of the system under assessment **as an integrated part of its safety management system.**

Risk management process



6. EVIDENCE FROM THE APPLICATION OF THE RISK MANAGEMENT PROCESS

The risk **management process** used to assess the safety levels and compliance with safety requirements shall be **documented by the proposer** in such a way that all the necessary evidence showing the suitability of **both the application of the risk management process and of its results are accessible to an assessment body.** The documentation produced by the proposer shall at least include:

a) a description of the organisation and the experts appointed to carry out the risk assessment process;

b) results of the different phases of the risk assessment and a list of all the necessary safety requirements to be fulfilled in order to control the risk to an acceptable level;

c) evidence of compliance with all the necessary safety requirements;

d) all assumptions relevant for system integration, operation or maintenance, which were made during system definition, design and risk assessment.

The **assessment body** shall establish its conclusion in a **safety assessment report.**

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Sustainable Powertrains and Green Mobility in Rail Transport

17 July, 2024

Khaled ITANI

Co-funded by the Erasmus+ Programme of the European Union

Contents

- Energy transition and environmental aspects of rail transport
- Introduction to electrotechnical and energy storage systems in rail
- Sustainable rail energy management

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Energy transition and environmental aspects of rail transport

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The question is:

- What is sustainability ?
- Should we consider it as a necessity?
- Why is it important for humanity ?
- …and in particular for transport?
- … and in particular for rail?

Understanding energy transition and sustainability in the rail sector

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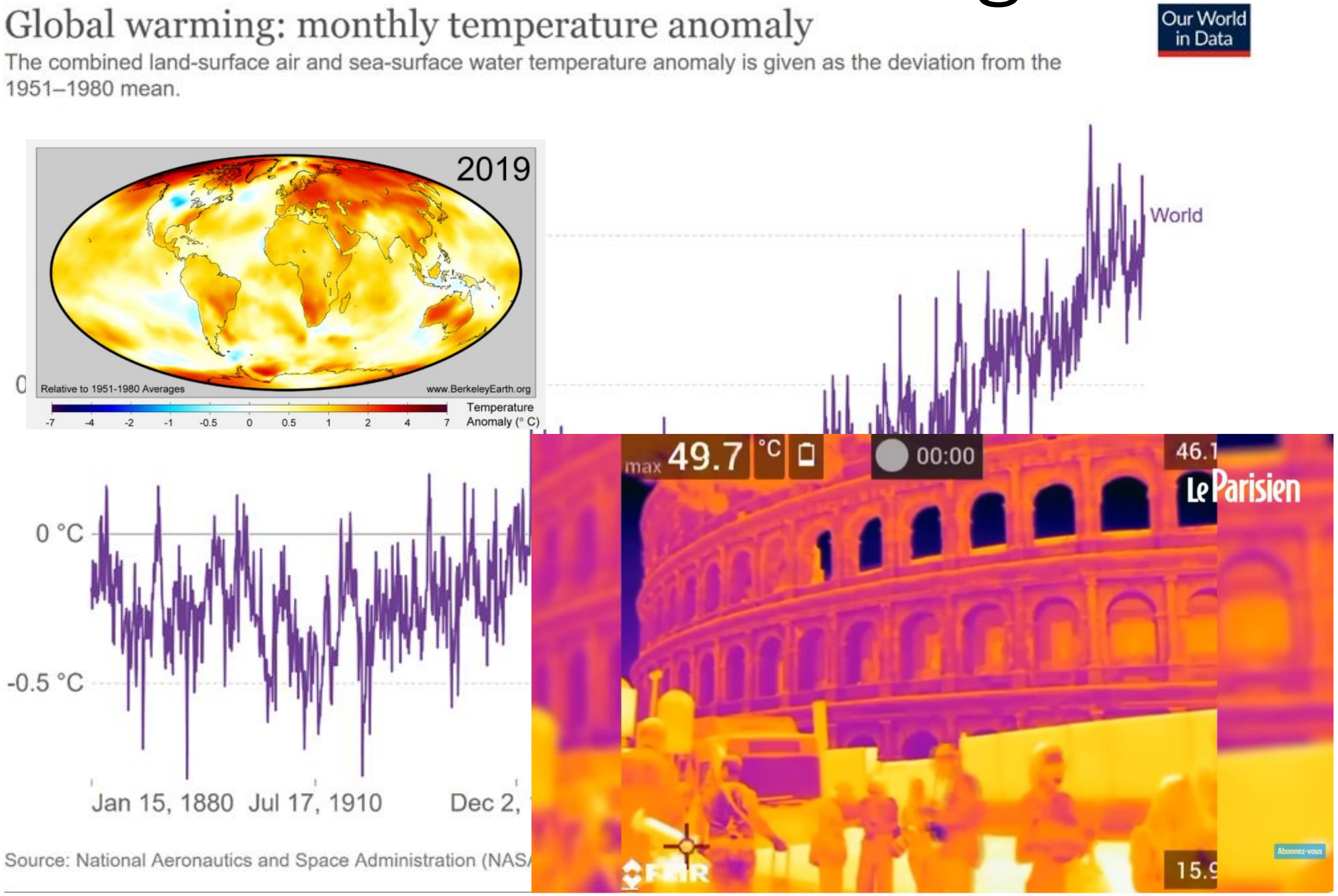
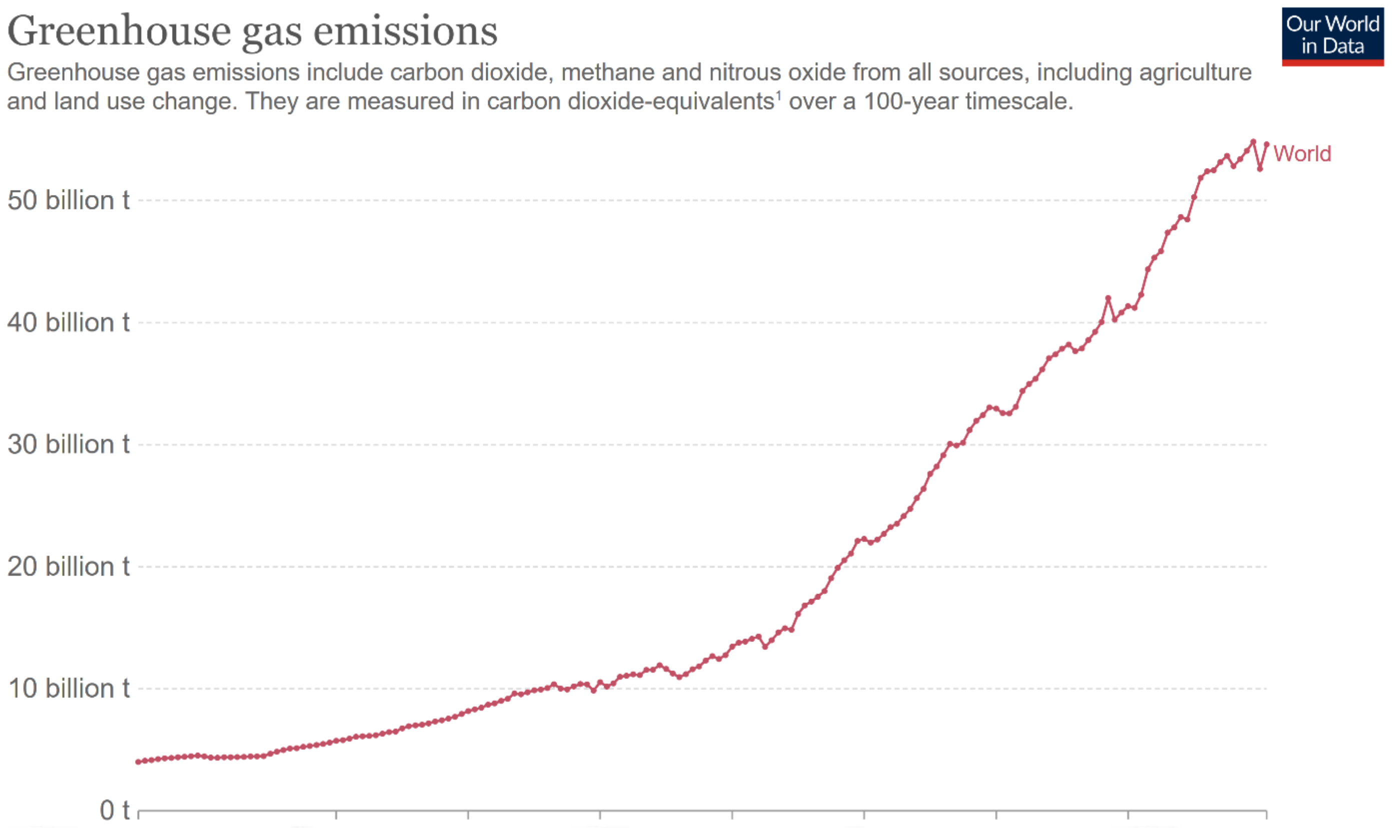
Before that… let's do some investigations.



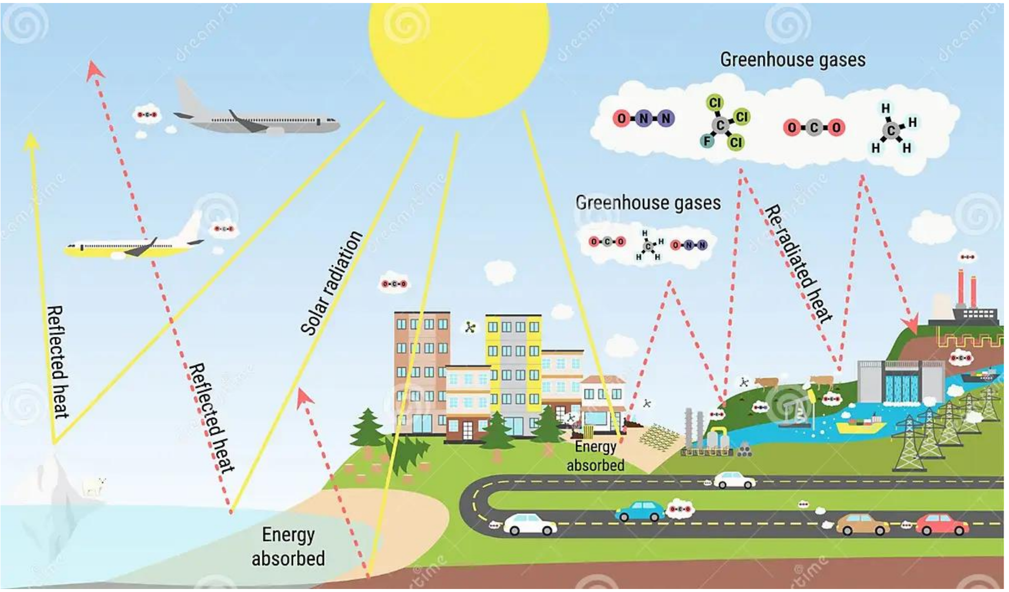
Rome, June 2024

And that.

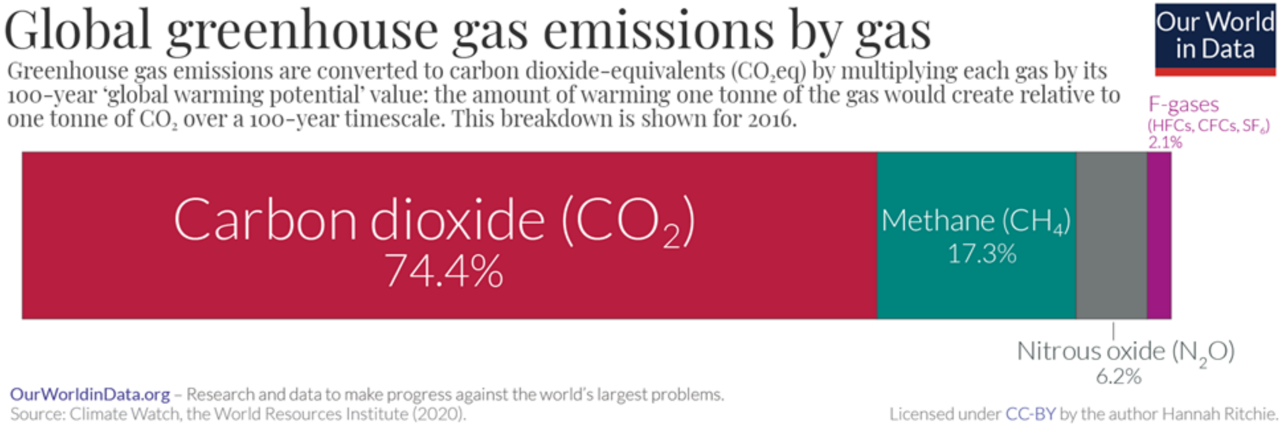

Greenhouse gas emissions
Greenhouse gas emissions include carbon dioxide, methane and nitrous oxide from all sources, including agriculture and land use change. They are measured in carbon dioxide-equivalents[1] over a 100-year timescale.
Our World in Data
World
50 billion t
40 billion t
30 billion t
20 billion t
10 billion t
0 t


N2O
PCFs
CO2
HFCs
CH4
SF6
O3

Greenhouse gas



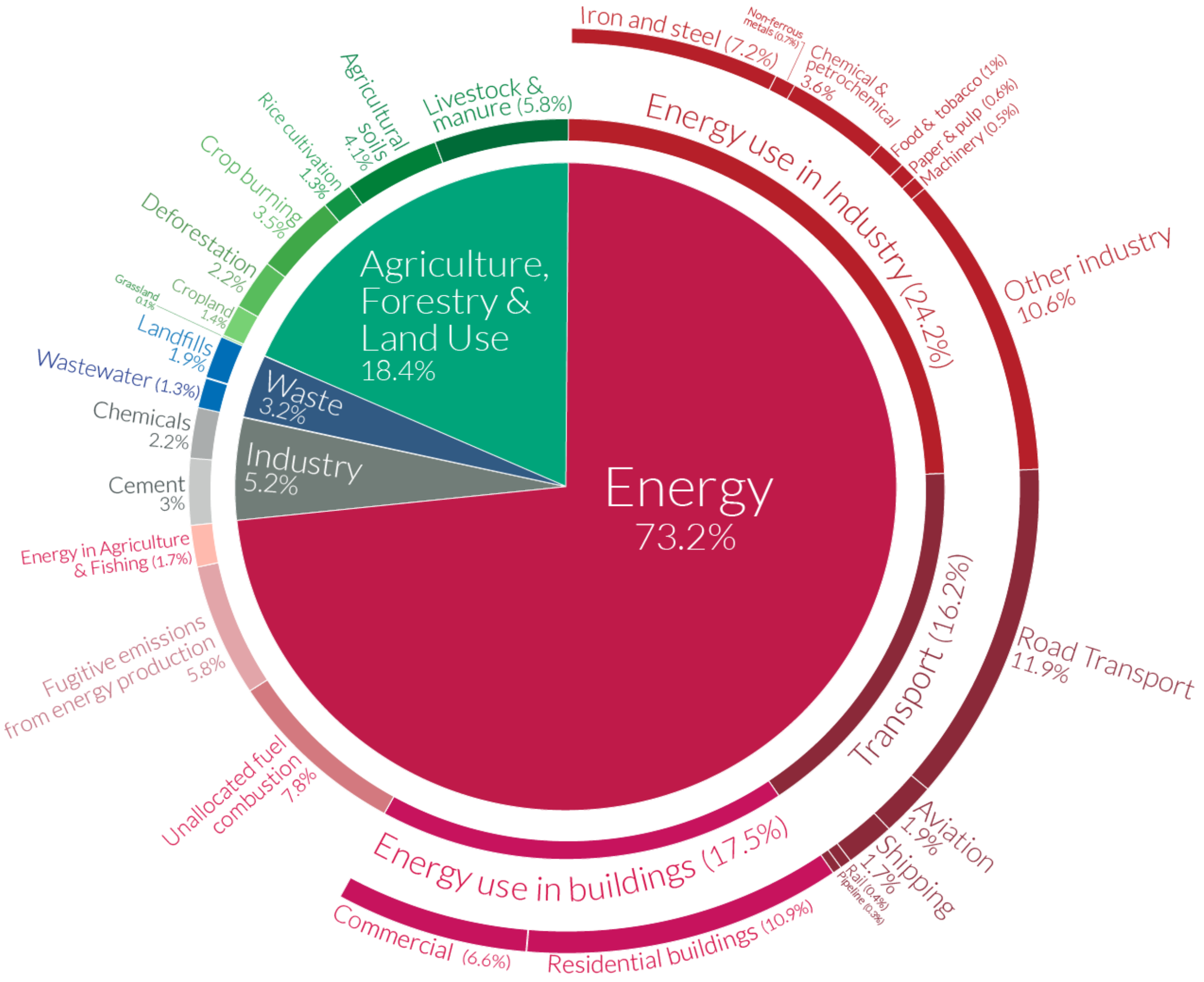
- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Industrial gases: Hydrofluorocarbons (HFCs) Perfluorocarbons (PFCs) Sulfur hexafluoride (SF6) Nitrogen trifluoride (NF3)



Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.

But…
one second.



OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020).

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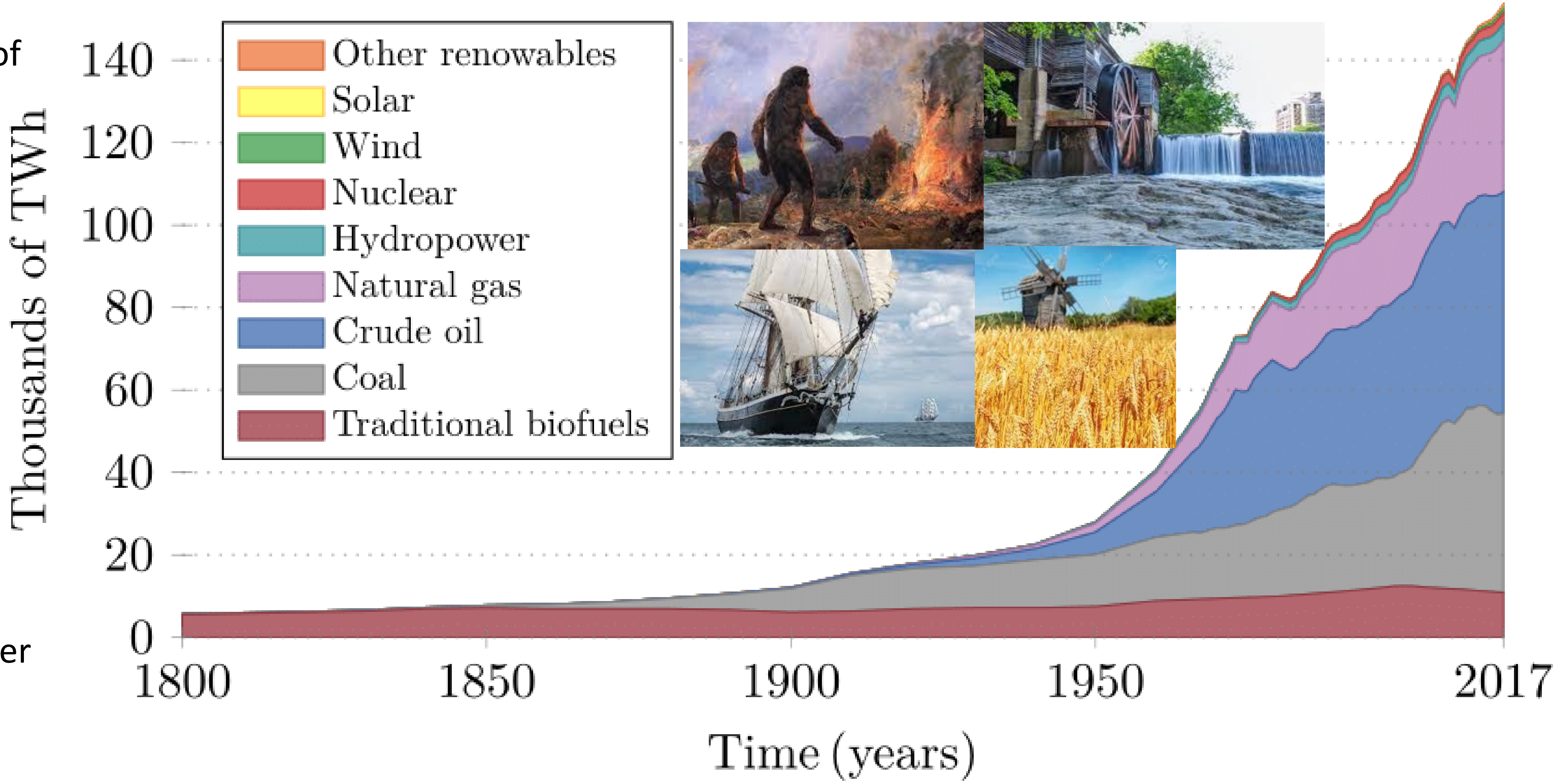
Energy consumption

Time evolution of global primary energy consumption, measured in terawatt-hours (TWh) per year. “Other renewables” represents renewable technologies excluding solar, wind, hydropower and traditional biofuels



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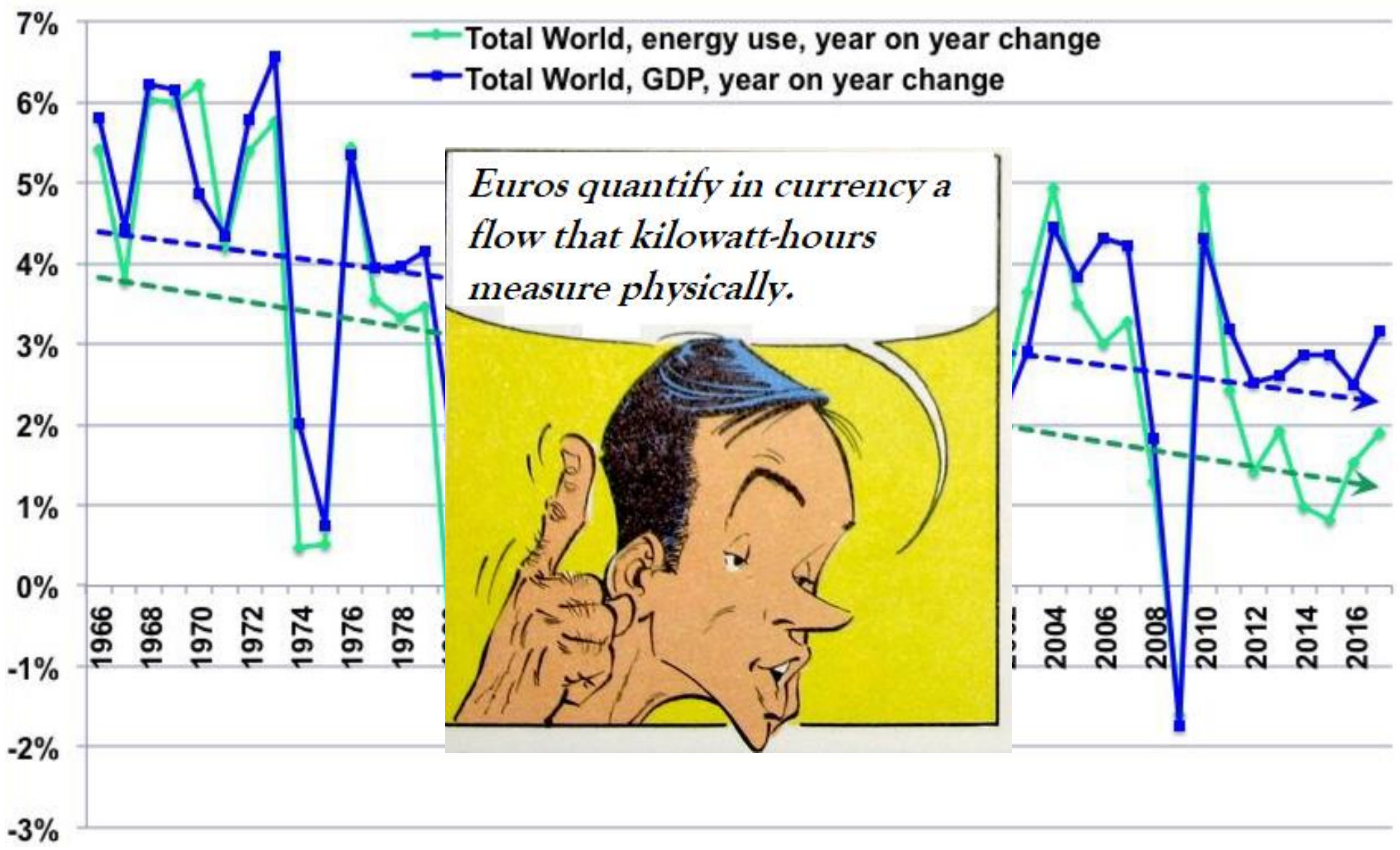
One last thing.



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Some definitions : Sustainability

- Sustainability focuses on developing and utilizing resources in a manner that meets the needs of the present generation without compromising the ability of future generations to meet their own needs in resources.
- It involves the responsible management of resources to ensure their availability in the long term. This includes not only environmental considerations but also social and economic aspects of resource use.

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Some definitions: Energy transition

- Energy transition refers to the process of shifting from the current energy system, which heavily relies on fossil fuels and non-renewable resources, to a more sustainable and low-carbon energy system.
- The objective of an energy transition is to reduce greenhouse gas emissions, mitigate climate change, and promote the adoption of renewable energy sources such as solar, wind, hydro, and geothermal.

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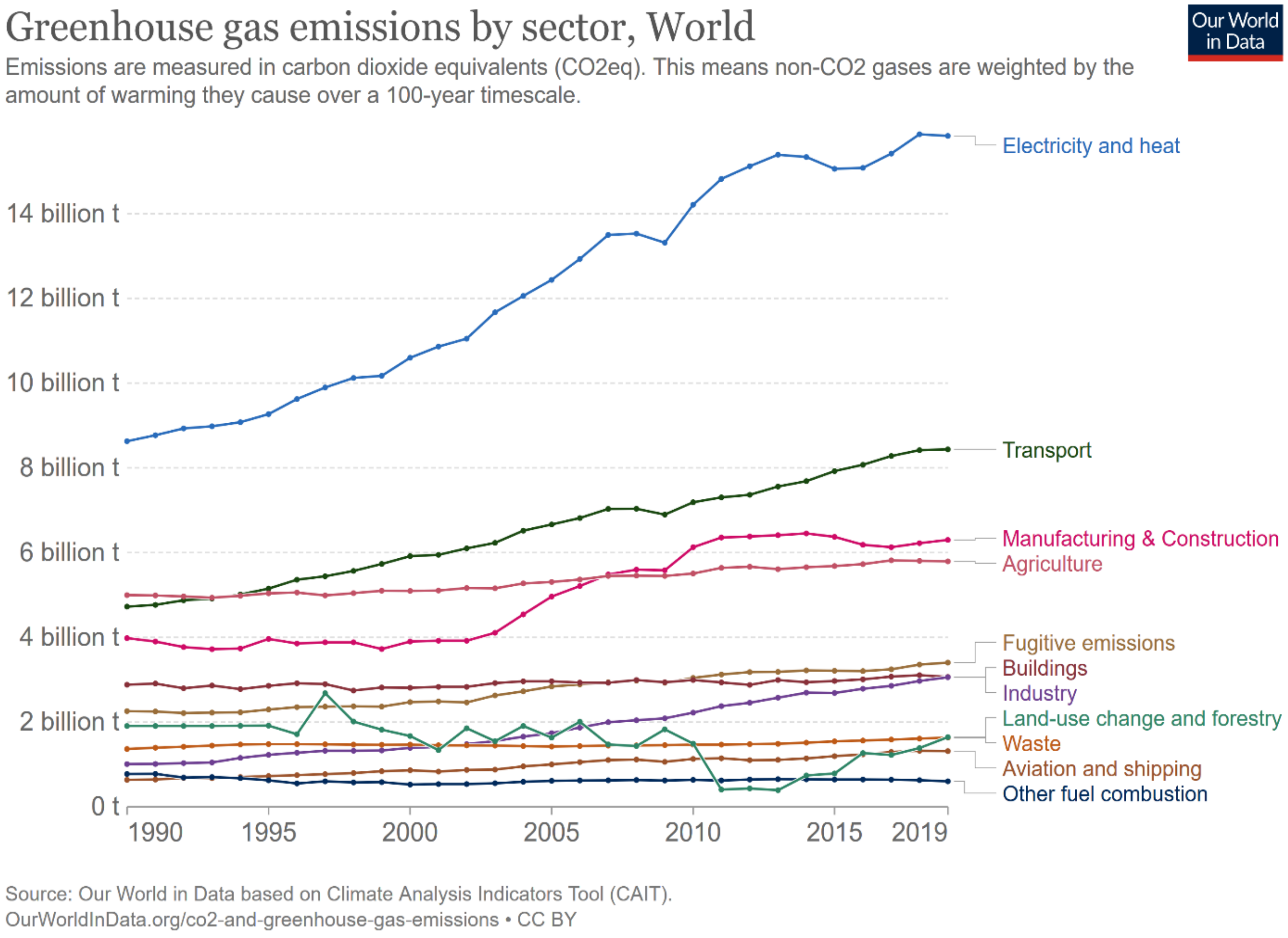
Some definitions : Energy Sobriety

- Energy sobriety refers to the concept of consuming energy in a more measured and restrained manner. It involves reducing energy waste, adopting energy-efficient technologies, and promoting responsible energy consumption practices.
- The goal of energy sobriety is to decrease overall energy demand while still meeting essential needs, thereby contributing to a more sustainable energy future.

Poverty is a kind of forced sobriety !

And the transportation in all this ?



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TRANSPORT in terms of energy use : 16.2 %

- Road transport (11.9%)
- Aviation (1.9 %)
- Shipping (1.7%)
- Rail (0.4%)
- Pipeline (0.3%)

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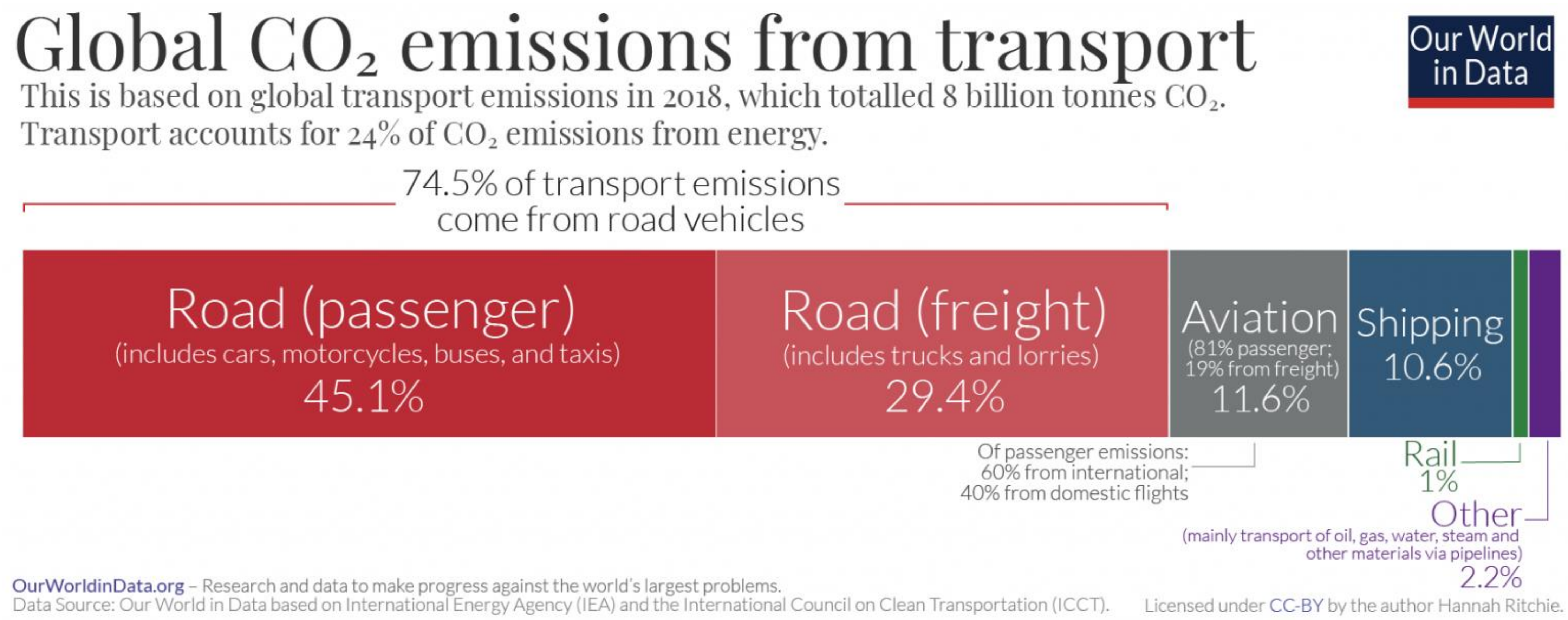
TRANSPORT in terms of CO2 emissions



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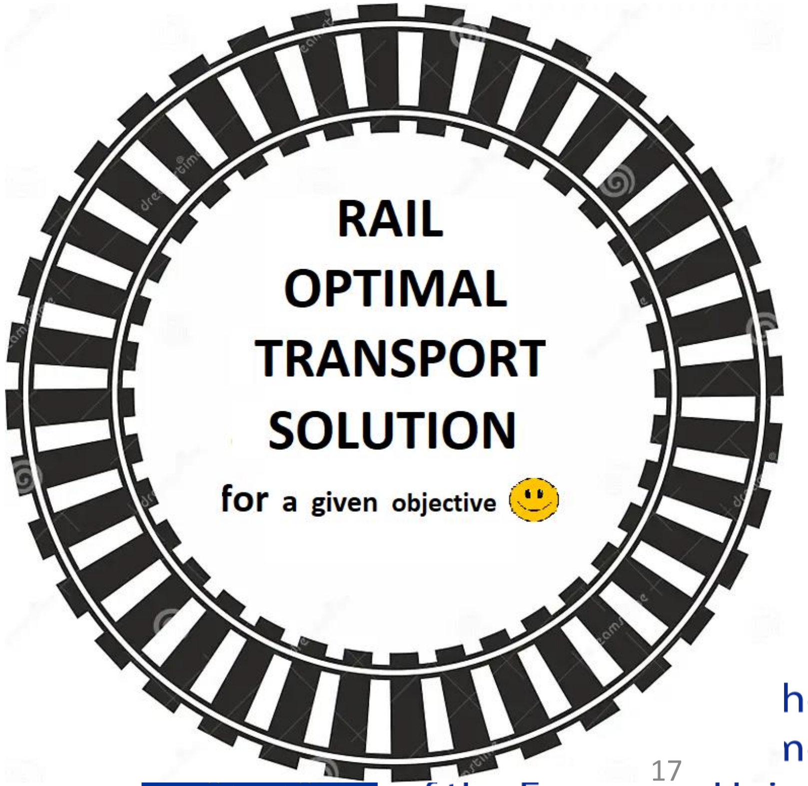
So…

- Rail is the most sustainable mode of transport.
- Increasing its share of passengers and freight is critical to achieving net-zero goals.
- Rail is responsible for 9% of global motorized passenger movement and 7% of freight shipping
- In most countries, rail is underrepresented in

terms of freight carried (measured in

metric-ton-kilometers) and

passenger-kilometers traveled.



Rail in numbers

By 2050 passenger mobility will increase by a staggering 200-300% and freight activity by as much as 150-250%.

4 trillion (10^12!) kilometers travelled by rail passengers in 2017

8% of total transport passenger-kilometers are travelled by rail

2% of total energy use in the transport sector is accounted to rail

1.2 gigatonnes increase in CO_2 if all rail transport was carried out by road vehicles

Rail is the safest mode of land transport, with less than one fatality per billion passenger.km

In terms of urban transport capacity, metro rail can move 20,000 – 70,000 passengers per hour compared to 800 passengers per hour by car

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Introduction to Electrotechnical and energy storage systems in rail

Overview of Electrotechnical systems in rail transportation

Exploration of energy storage and supply systems in railways

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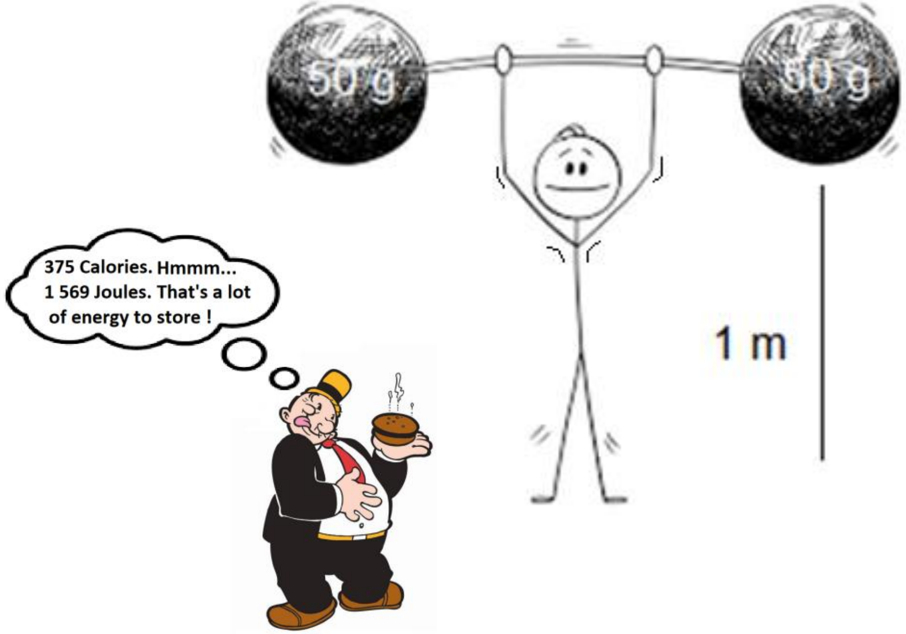
Let’s start simple: Energy Units



1 Joule : The amount of energy needed to lift 100 g by one meter
1 Joule = 1 newton x 1 meter
1 Joule = 1 V x 1 A x 1 second = 1 V x 6,2. 10^18 electrons = 1 V x 1 C
Knowing that 1A = 1C/second

1 calorie :the amount of energy required to raise the temperature of 1 gram of water by 1 degree Celsius at a pressure of 1 atmosphere.
1 cal ≈ 4.184 J
Power is the rate at which energy is transferred or converted per unit of time.
1 Watt : Amount of energy referred to 1 joule per second
1 Watt-hour (Wh) : Amount of energy expended or consumed when 1 watt (1 joule per second) is used for 1 hour(3600 seconds).
1 kWh = 3600 000 J = 3,6 10^6 J (MJ)
1 TWh = 10^9 kWh

k	kilo	10^3
M	Mega	10^6
G	Giga	10^9
T	Tera	10^12
P	Peta	10^15
E	Exa	10^18

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Exemple

To move a car over a distance of 100 km:

- at 100 km/h, the rolling resistance is 400 Newtons, requiring 40 MJ (400 x 100,000) and 11 kW (11 kWh/1h).
- at 130 km/h, the rolling resistance increases to 650 N: requiring 65 MJ and 23.5 kW for 0.77 h (or 18 kW for 1 hour = 18 kWh).

Going faster:
consumes more useful energy
requires a more powerful energy converter (engine), thus making it more expensive.

In terms of an ecological assessment :
•More energy is consumed to provide the service.
•More raw materials are required.
•More embodied energy is needed for the manufacturing of the engine.

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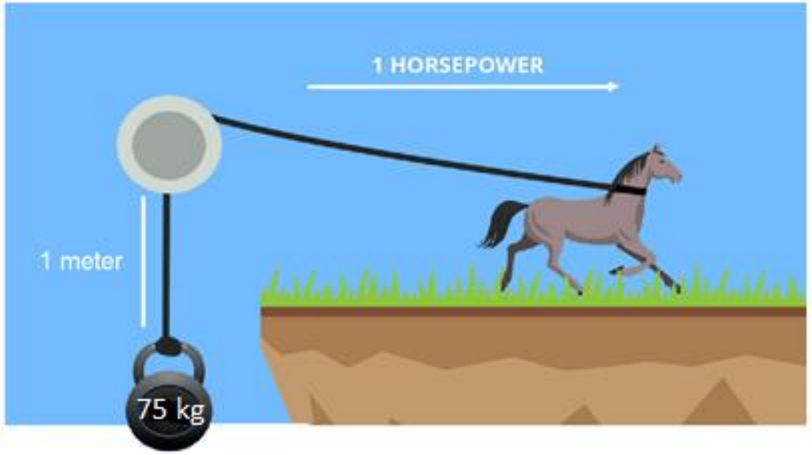
Let’s start simple: Energy Units

1 Horsepower (hp): Amount of work in a given time as a horse can do in lifting a 75-kilogram mass by one meter in one second, or approximately 746 joules per second.



1 L of Diesel oil
10 kWh
0.85 kg
Initial cost : 0.8 $
Energy cost: 2 $

Battery LiFePO4
10 kWh
73 L
102 kg
Initial cost : 4 150 $
Energy cost > 2 $

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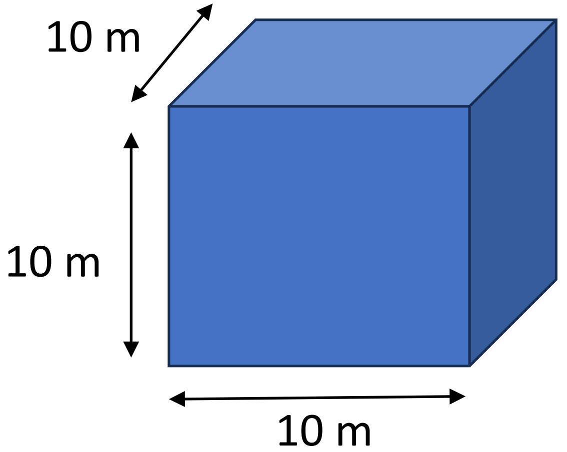
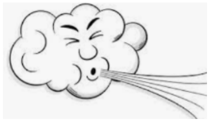
Order of magnitudes





80 km/h

3 mL !

102 kJ

Nuclear Plant of Flamanville in France
2 × 3817 MWth
2 EPR of 1330 MWe each
1 new EPR under commissioning of 1600 MWe
Annual net output : 13 999 GWh (capacity factor 60.08%)

Energy required to climb a mountain of 2000 m for a person of 80 kg + 10 kg (backpack) is 0.5 kWh.
Same amount of energy contained in 50 mL of diesel oil !
Do not forget the mechanical efficiency of 30%, so 160 mL.

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Order of magnitudes

TGV Paris-Ostfrankreich-Süddeutschland (POS)
Manufacturer Alstom
Total power output of 9.6 MW
383 Tonnes – 200.19 m
Max speed of 320 km/h under 25 kV.
Electric system: 25 kV 50 Hz / 15 kV 16.7 Hz Overhead

Tramway of Strasbourg CITADIS
Manufacturer Alstom
Total power output of 720 kW
55.6 Tonnes - 45.50 m
Max Speed of 70 km/h
Electric system : 750 V DC Overhead

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Electrotechnics

A branch of engineering that deals with generating, transmitting, distributing, converting and controlling electrical power for multiple purposes.

Key areas within electrotechnics include:

- Power generation and distribution (power plant, industries, homes…)
- Electro-mobility
- Industry
- Home appliances
- Renewable energy
- …

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Historical Background on Rail Traction

- Disappearance of steam traction in most countries during the 1970s-1980s.
- Distribution of rail tracks between the two sources of energy:
  - Onboard fossil energy (fuel or gas), known as autonomous traction
  - Electric energy distributed via overhead lines
- Autonomous traction is divided into two main technologies:
  - Electric transmission, where the internal combustion engine drives a generator that powers electric traction motors driving the axles.
  - Hydrodynamic transmission, where the internal combustion engine drives a hydraulic converter and coupling unit that drives the axles.

Historical Background on Rail Traction

- Electric traction is not uniform, especially in Europe, due to the juxtaposition of different power supply systems inherited from historical developments:
- Direct current at 750 V (600 V in some cases) is common for urban transport: metro networks and trams.
- Direct current at 1,500 or 3,000 V is used for mainlines. It developed between the World Wars and suited the characteristics of direct current electric motors, with strong torque at start and low speed, and a wide speed range. This system is widespread in countries like France (1,500 V), Belgium, Italy, and Spain (3,000 V).
- Simultaneously, the Germanic countries including Switzerland developed single-phase alternating current at reduced frequency (16.7 Hz) at 15 kV.

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Historical Background on Rail Traction

- France introduced industrial frequency alternating current, 50 Hz at 25 kV, starting in 1951. This electrification was exported to countries worldwide wishing to electrify their railways, including India, Turkey, China, the ex-USSR, Portugal, and more. The "50 Hz Group," consisting of European railway manufacturers, was even created to promote this type of electrification. The French railway network adopted this power supply for all electrified lines. Half of the French network is electrified (1,500 V and 25 kV) and handles over 90% of national traffic.
- This diversity of power supply systems in Europe, and even within individual countries, posed early challenges for network interoperability.
- In the 1960s, multi-voltage or multi-current locomotives were developed.

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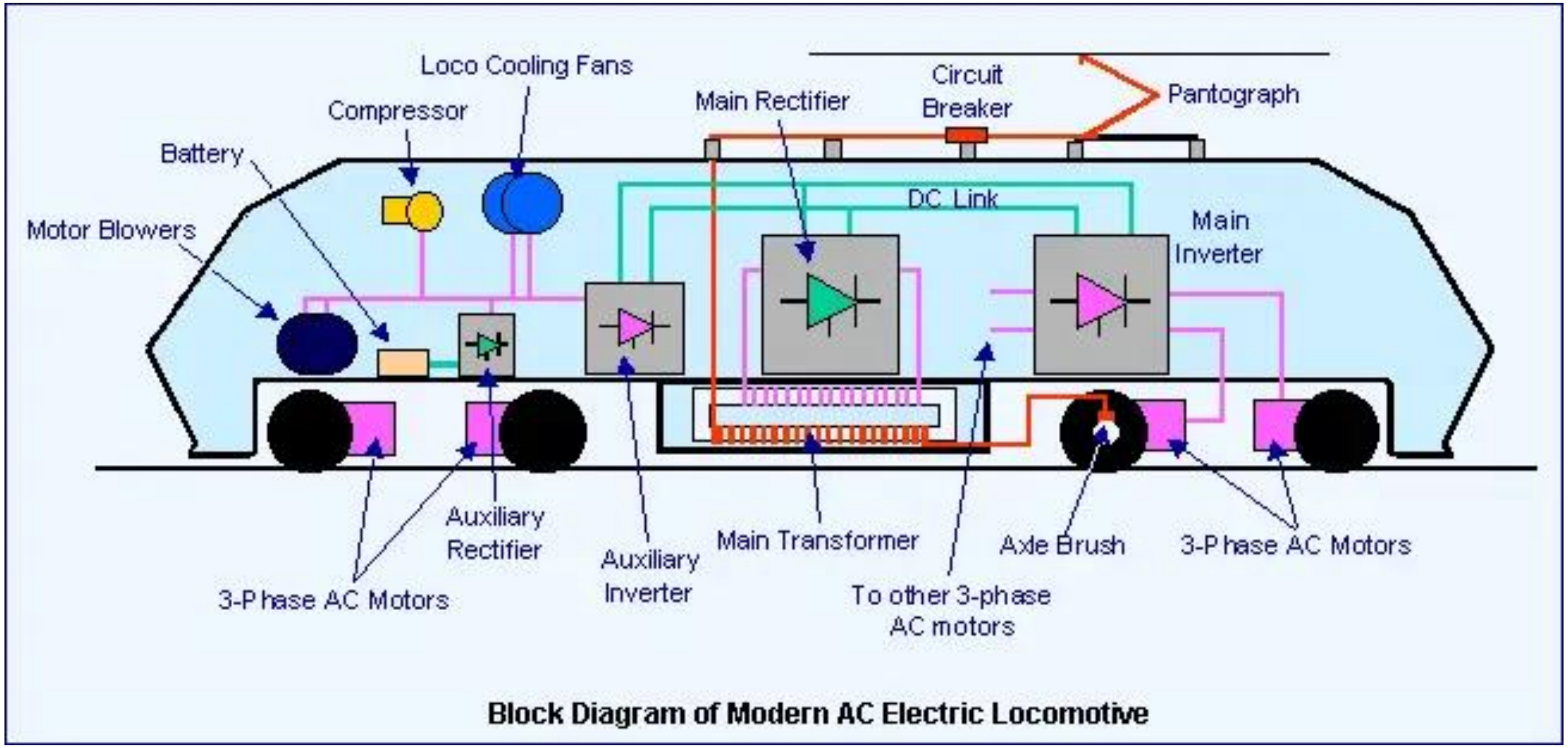
Electrotechnical systems in rail powertrain



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Electrotechnical systems in rail powertrain

Traction transformer LOT 1100
1.5 MW for 16 2/3 Hz high-speed double-deck trains

Traction motor
600 kW for high power applications

Traction motor
1.2 MW for cargo locomotives

Traction transformer LOT 6500/6700
4.5 MW for 50 Hz AC locomotives

Traction generator
2.65 MW for high power applications

Traction transformer
4.8 MW for 16 2/3 Hz and 5.2 MW for
50 Hz high-speed trains

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Electrotechnical systems in rail powertrain

The traditional avenues for improvement

Increasing installed power to enhance speed and load capacity.
Reducing the mass and volume of traction equipment
Reducing heat losses
Less pollution and noise.

Environmental factors

Electromagnetic interference
Noise pollution
Chemical pollution
GHG Emissions

Safety aspects

Dynamic braking for high-speed trains.

Regulation of functions that could generate harmonic currents disrupting signaling circuits.

Energy management

Development of new supply and new traction system architectures

- Traction motors cutting edge technology
- Power conversion cutting edge technology
- Energy storage : lithium-ion batteries, hydrogen, flywheels, or supercapacitors
- Intelligent onboard energy management and hybrid systems
- Renewable energy

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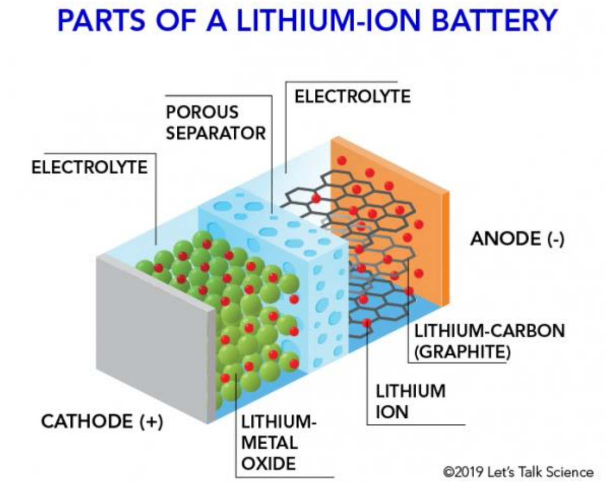
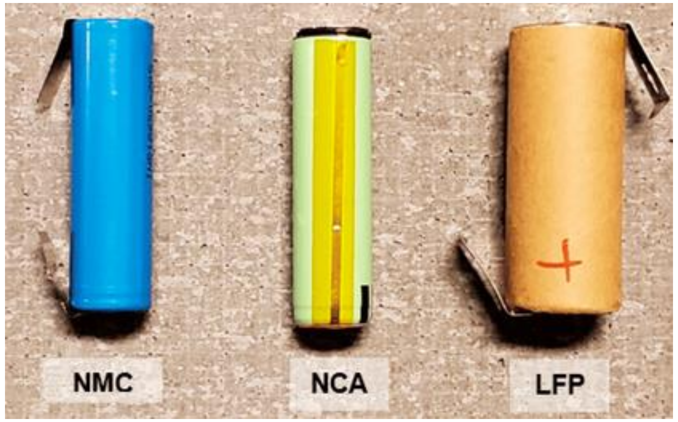
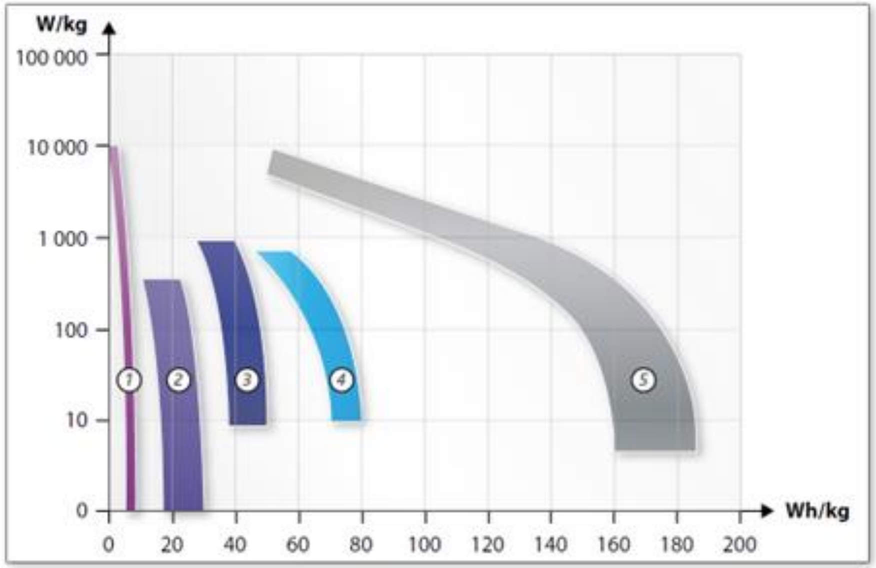
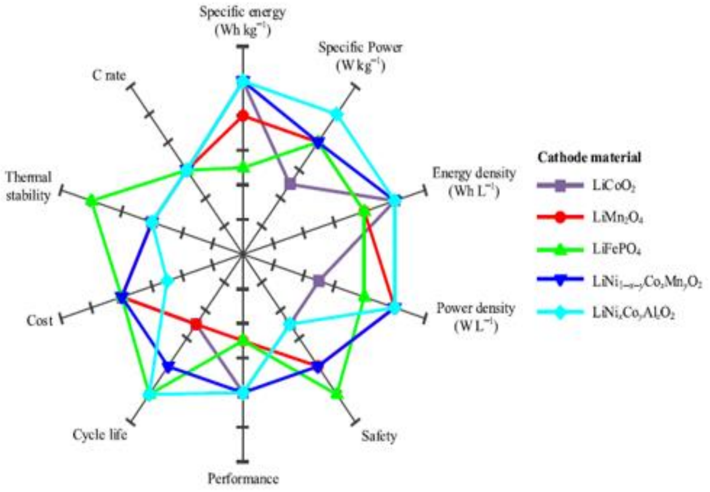
Energy Storage : Batteries

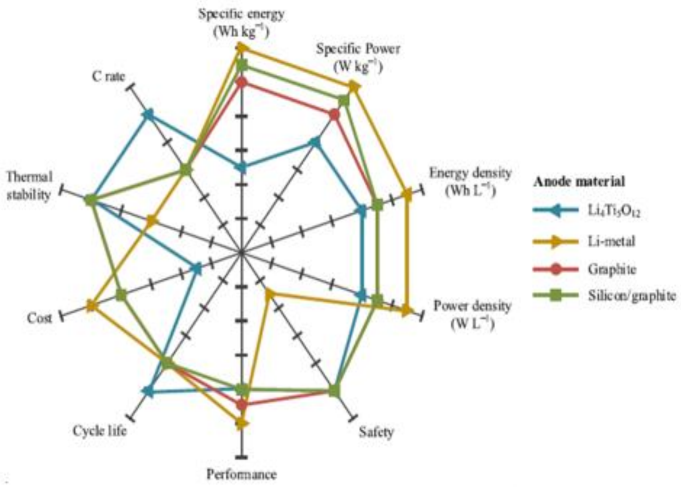






① Supercapacitors ② Lead batteries ③ Nickel Cadmium Batteries NiCd ④ Nickel-metal hydride batteries NiMh ⑤ Li-Ion batteries





From left to right : NiCd, NiMH, lead-acid, Li-Ion, Supercapacitor

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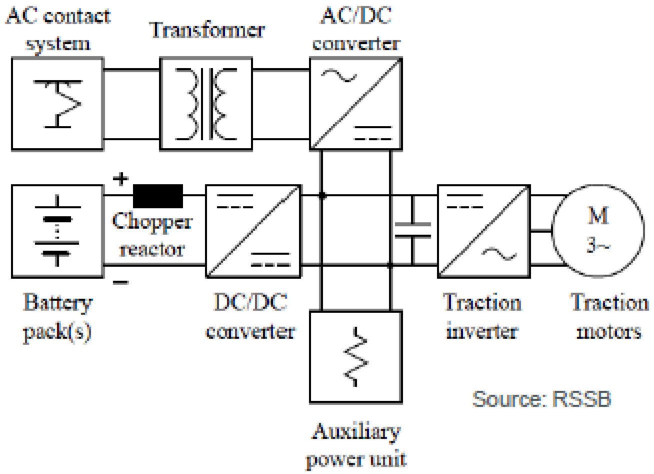
Battery Electric Train

Independent Battery Powered
Independent Battery Powered with hydrogen fuel cell
Bi-mode with AC external pantograph
Bi-mode with DC external pantograph or power rail
Bi-mode with diesel engine



Source: RSSB

Alstom Coradia Continental
Three-car-train, 56 meters long
Equipped with 150 seats
Range under battery power of up to 120 km
Top speed : 160 km/h (100 mph)

Battery-electric freight train - FLXdrive
Hauling capacity : 195 045 kg
Energy capacity : 2.4 MWh from over 20,000 lithium-ion battery cells.
Charging time : 30-40 minutes
Traction Power : 3.2 MW
Top speed : 120 km/h
Travel distance : 563 km
Overhead : 25kV AC/15kV AC/1.5kV DC

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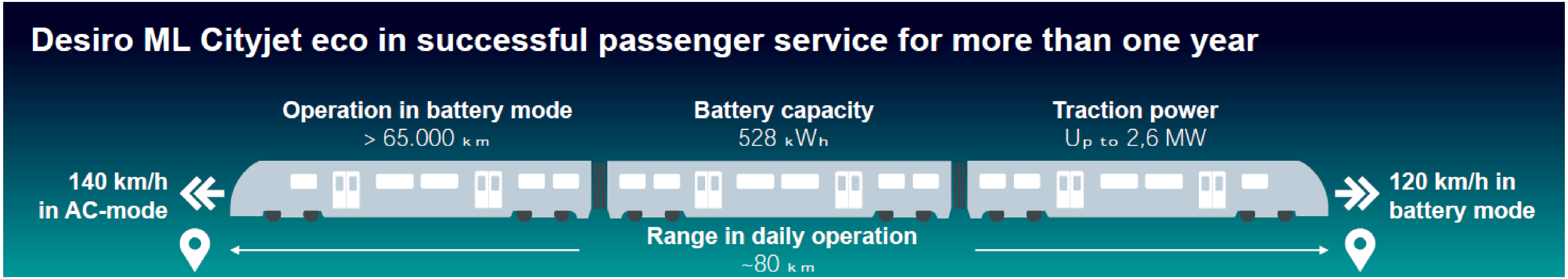
Battery Electric Train – Siemens Mobility



Reduced range due
to active heating (65 km)

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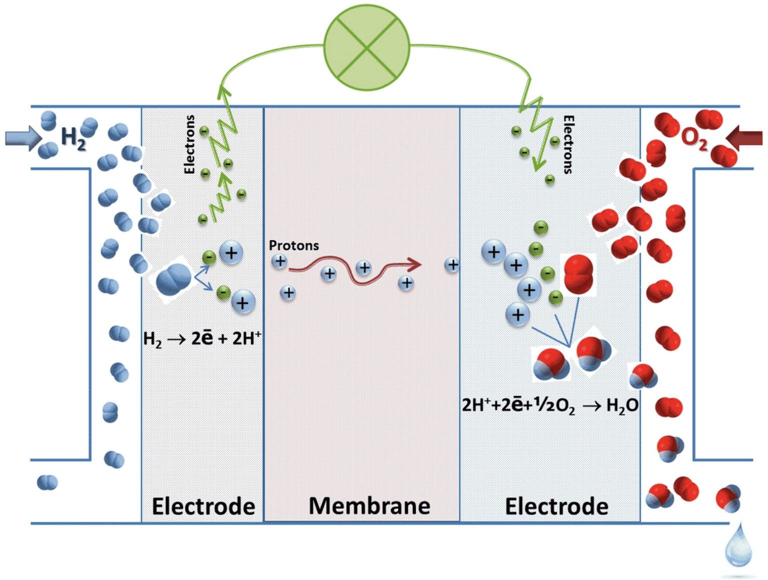
Energy Storage : Hydrogen



Hydrogen does not exist in a pure state !

Advantages:

Refueling time

Emission-free.

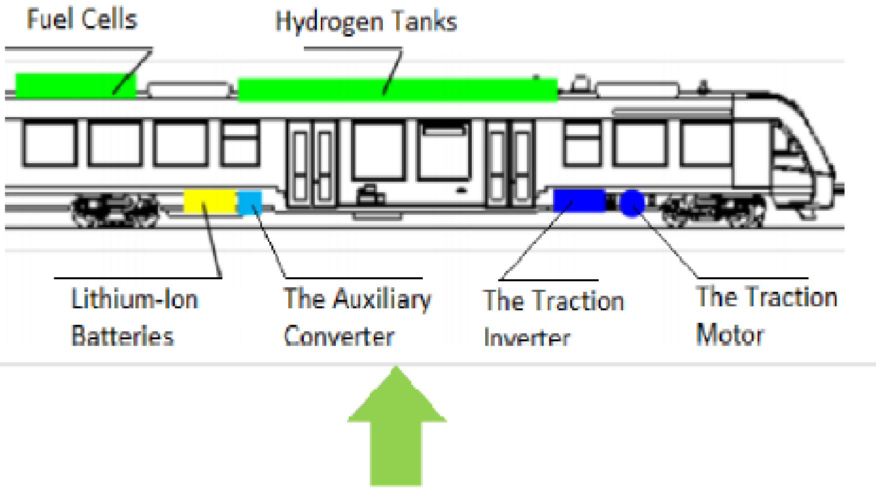
Disadvantages :

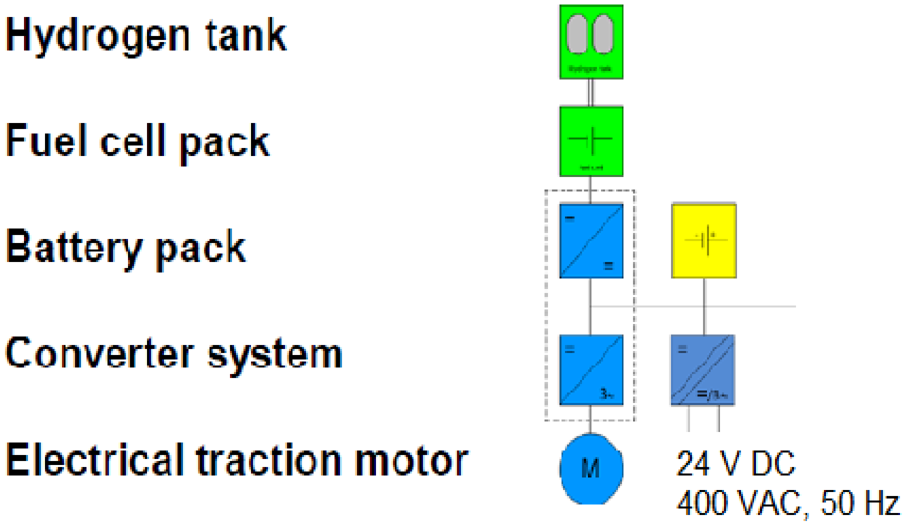
Cost

Bring H2

Performance

Efficiency.





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Hydrogen : Vector of Energy

- Hydrogen can be obtained by separating it either from methane molecules through steam methane reforming (SMR), gasification, methane pyrolysis, or using water molecules by electrolysis.
- The colors of hydrogen can be summarized as follows:

Gray or black: Steam Methane Reforming (SMR) / Gasification - Source: Methane / Coal - Without carbon capture and storage - $CH_4 + H_2O$ (+ heat) → $CO + 3H_2$ / $C + H_2O$ (+ heat) → $CO + H_2$;

Blue: Steam Methane Reforming or Gasification - Source: Methane or Coal - With captured and stored carbon monoxide (85-95%);

Turquoise: Pyrolysis - Source: Methane derived from natural gas. The process is driven by heat produced with electricity rather than the combustion of fossil fuels. CH_4 (+heat) → $C + 2\,H_2$, and

Green Hydrogen: Electrolysis - Source: Electricity generated from renewable energy - $2H_2O \rightarrow 2\,H_2 + O_2$.

There is also **pink**, yellow and **brown** hydrogen.

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Powertrain conversion

Coradia iLint

THE PRINCIPLE

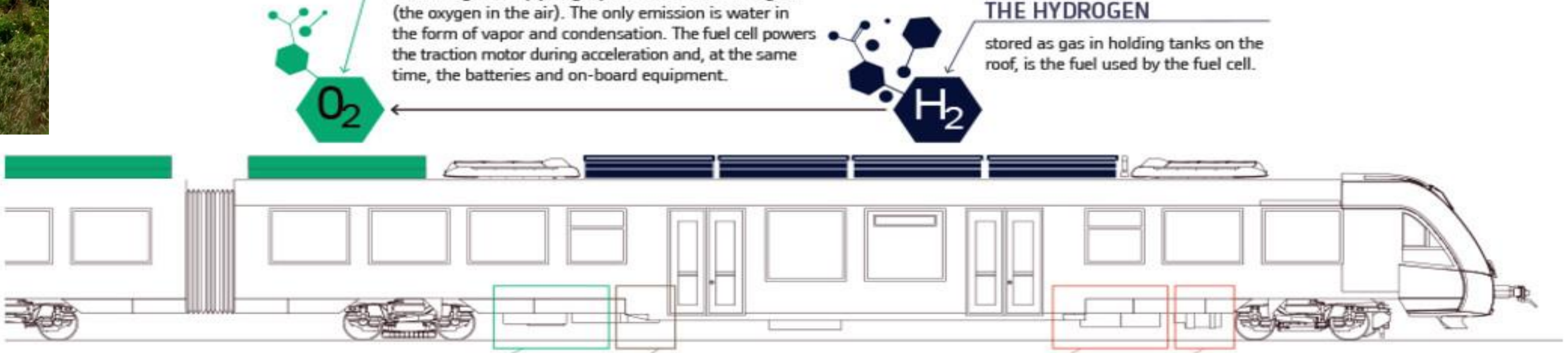
Electricity for the traction and on-board equipmentis generated by a fuel cell, stored in a battery and recovered during braking. All this is monitored energy management algorithms which optimise the system. The Coradia iLint is the world's first passenger train in commercial service powered by a hydrogen fuel cell.

A FUEL CELL

generates electrical energy via chemical reaction, combining a fuel (hydrogen) with a combustion agent (the oxygen in the air). The only emission is water in the form of vapor and condensation. The fuel cell powers the traction motor during acceleration and, at the same time, the batteries and on-board equipment.

THE HYDROGEN

stored as gas in holding tanks on the roof, is the fuel used by the fuel cell.



LITHIUM-ION BATTERIES

store part of the extra energy produced by the fuel cell as well as kinetic energy recovered during braking. The batteries supply the train under normal operation and can be used to boost the accelera-tion of the train when necessary.

THE AUXILIARY CONVERTER

converts electrical energy received from the traction inverter and the battery to adapt it to the various on-board equipment (air conditioning, doors, passenger information displays, lighting...)

THE TRACTION INVERTER/ CONVERTER

ensures that the appropriate energy is transmitted between the fuel cell, the battery, the traction motor and the auxiliary converter. It also collects energy generated by the movement of the train during braking, redistributing it to the auxiliary converter and the batteries.

THE TRACTION MOTOR

drives the wheels for acceleration and braking.

ALSTOM
· mobility by nature ·

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Alstom / Siemens

Coradia Ilint

Range : 900 to 1.100 km

Refueling from empty tank takes 15 minutes.

150 seated passengers and 150 standing passengers.

Maximal operating speed : 140 km/h.

Two traction motors: 314 kW each.

Mireo Plus H

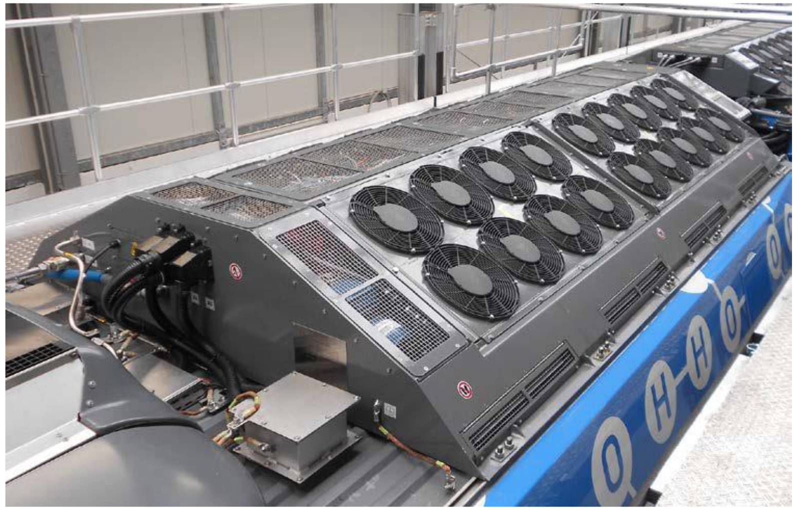
Range : 600 – 1000 km

Refueling from empty tank takes 15 minutes.

120 seated passengers (for 2 cars)

Maximal operating speed : 160 km/h.

Traction power : 1.7 MW.



Both use LTO Technology for battery.

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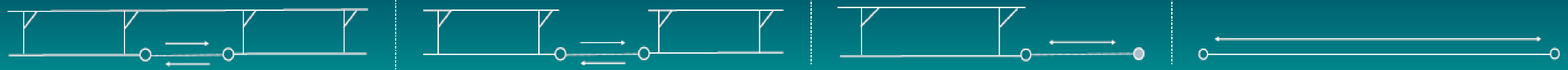
Siemens Solutions

Electrified lines	Connecting electrified lines	Last mile	No catenary



Mireo

For electrified lines

Mireo Plus

All Mireo advantages in one hybrid platform with all positive characteristics of the Mireo family: energy-saving, flexible interior, low maintenance and life cycle costs

Mireo Plus B: Battery solution for lines that are partially electrified; range: 80 – 120 km

Mireo Plus H: Hydrogen solution for long distances without catenary; range: 600 – 1,000 km

2-Teiler: 47 m, max. 130 seats

3-Teiler: 63 m, max. 180 seats

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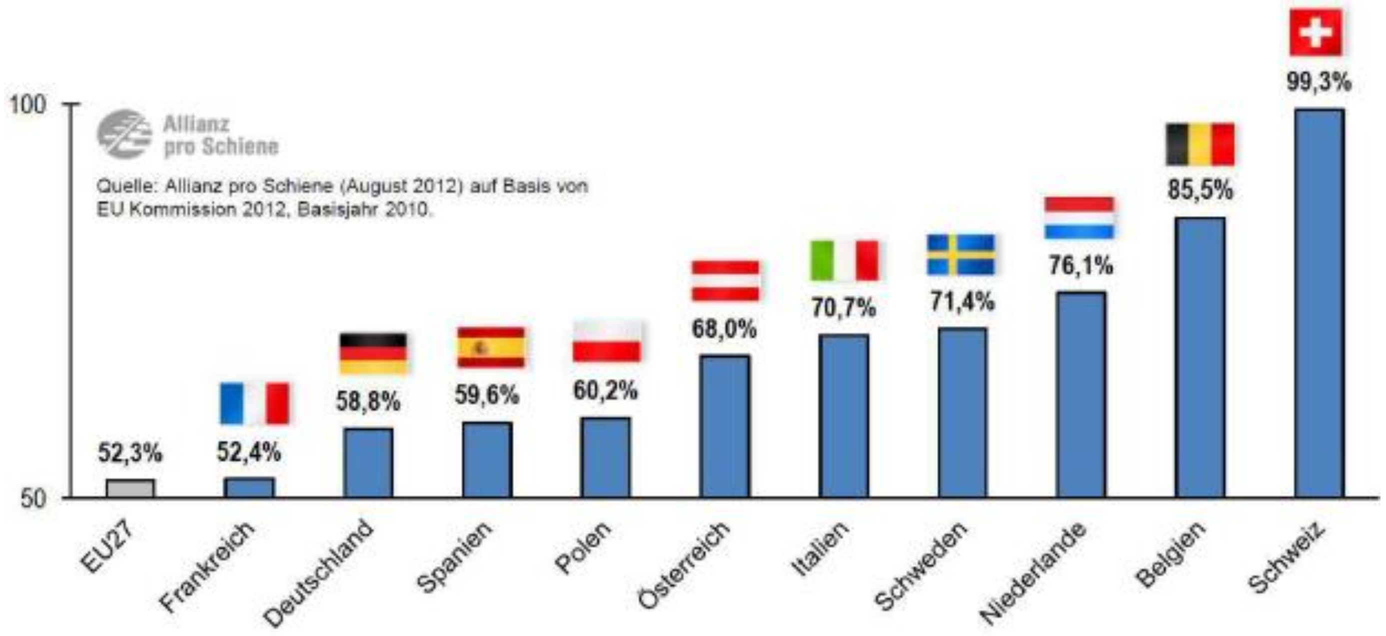
Electrification of Railway lines rate



Electrification of railway lines in the national railway network in selected European countries.

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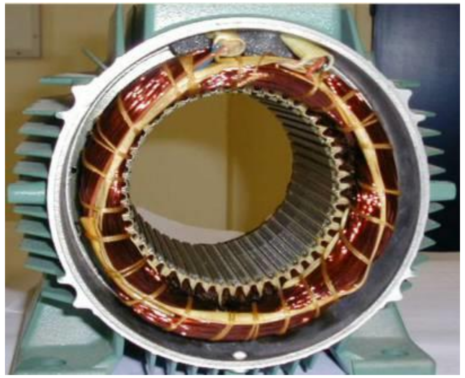
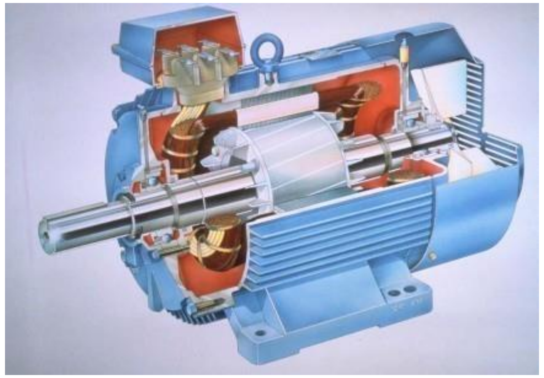
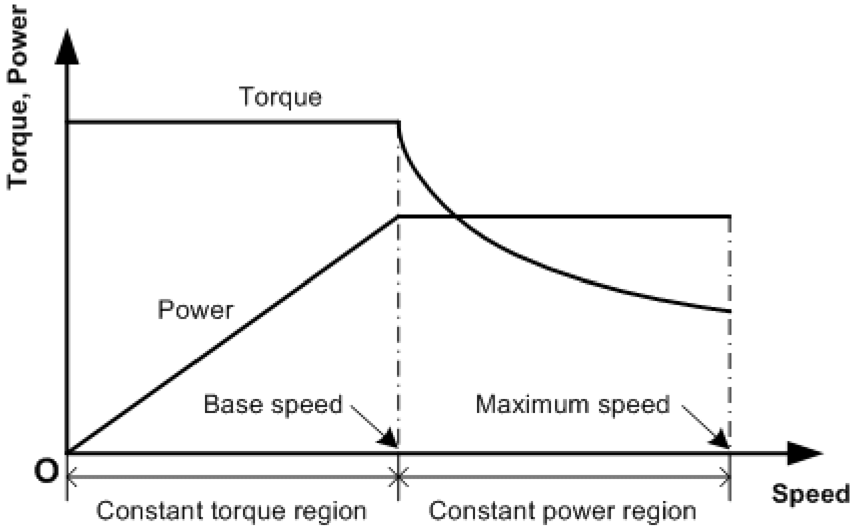
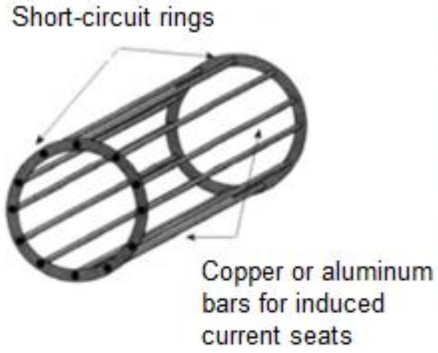
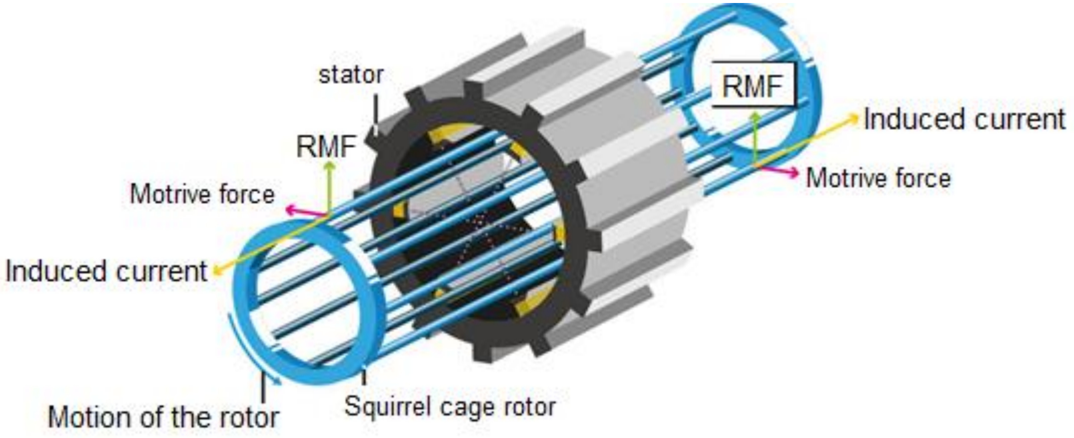
Traction Motors : Induction Machine











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Toshiba Traction System IM

Vehicle Manufacturer	Kawasaki Heavy Industries
Operator	Nishi-Nippon Railroad Co., Ltd.
Start of Supply	2006
Country	Japan
Electric System	1500 V DC
Track Gauge	1435 mm
Maximum Operating Speed	100 km/h
Vehicle Weight	Front car: 26-28 t, Middle cars: 35 t, (3 train configurations: Mc-Tc, Tc1-M-Tc2, Tc1-M1-T-M2-Tc2)

Triple Mode Type
Combined Power Conversion Unit

Output Power (kW)	175 x 4
Static Inverter Capacity (kVA)	80
Weight (kg)	1306
Dimensions (W x D x H mm)	4040 x 900 x 700
Cooling Method	Natural cooling

Traction Motor

IM/ASM

Output Power (kW)	175
Weight (kg)	650
Dimensions (Ø x W mm)	540 x 682
Cooling Method	Totally-enclosed (Outer fan cooling)

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Traction Motor : Permanent Magnet Synchronous Motor PMSM

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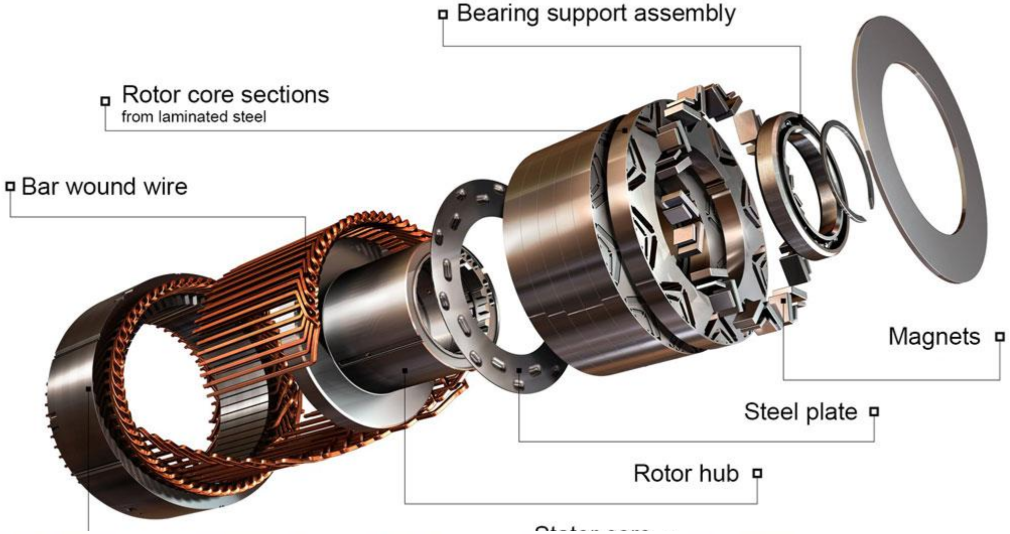

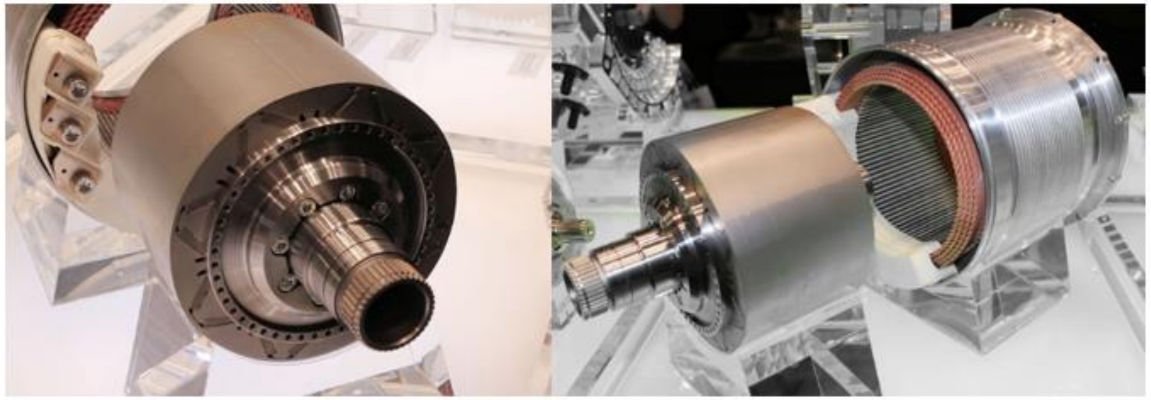

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Toshiba Traction System

Vehicle Manufacturer	Hitachi
Operator	Hankyu Railways
Start of Supply	2013
Country	Japan
Electric System	1500 V DC
Track Gauge	1435 mm
Maximum Operating Speed	115 km/h
Vehicle Weight	251.4 t (Train Configuration: 4M4T)

4-in-1 Traction Inverter

Output Power (kW)	190 x 4
Weight (kg)	1190
Dimensions (W x D x H mm)	3750 × 1070 × 700
Cooling Method	Natural cooling

High-capacity Traction Motor

PMSM

Output Power (kW)	190
Weight (kg)	635
Dimensions (Ø x W mm)	540 x 566.5
Cooling Method	Totally-enclosed (Outer fan cooling)

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Sustainable rail energy management

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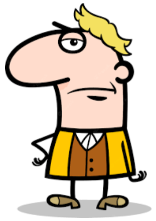
Contents

- Raise fundamental questions.
- Skeptical view
- Propose optimal solutions for a Green mobility.



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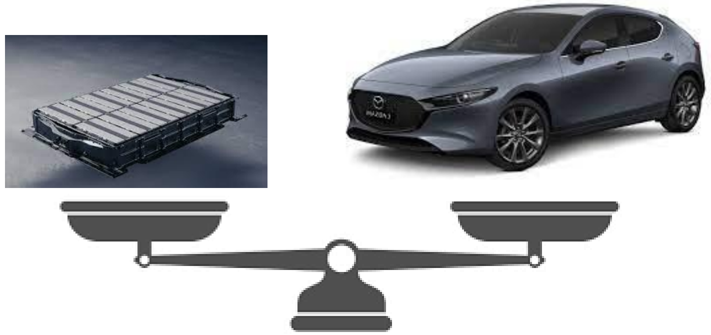
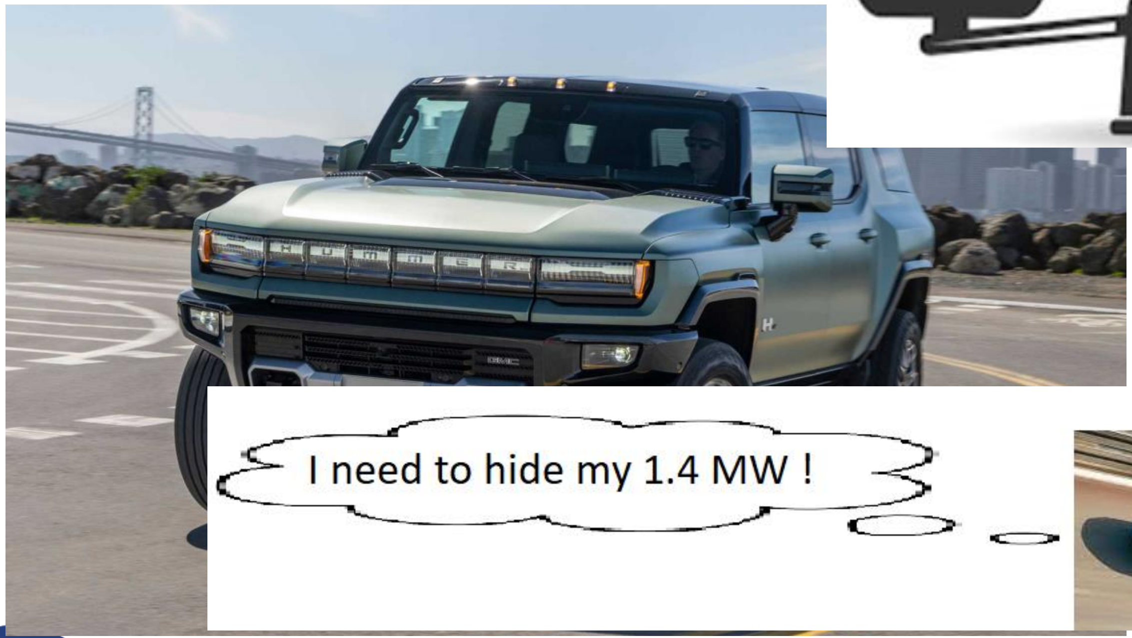
Is Electromobility Green ?

GMC Hummer EV Edition1
560 km range
205 kWh battery
750 kW Motors power
4000 kg Weight
1325 kg Battery Weight





Hey ! I've got a 700 kW motor. And I am cool !

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Rail Transport Emission in France

	Emissions (gCO_2/pass.km)
TGV	2,36
Long Distance Train	5,92
Regional Express Train (TER) – majority are diesel loco	29,6
Paris metro	2,74
Regional Express Network (RER) and transilien	7,28
Paris Tramway	2,68
Metro, tramway, trolleybus - 2018 – Urban area > to 250 000 residents	3,29
Métro, tramway, trolleybus - 2018 - Urban area between 100 000 and 250 000 habitants	5,03

In case of freight rail transport: 1.99 g of CO2 per tonne-km in France (17.4 g of CO2 / tonne-km in Europe !!!)

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Let us investigate the Battery.

A NMC Li-Ion battery contains

Lithium

Cobalt

Nickel

Manganese

Natural Graphite

Silicon

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Let us investigate the Cathode Materials

Raw Material (*critical)	Use in LiB	Main EU Supply	EU import	EU deposits	Recycling	Note
Lithium* (Li)	Lithium oxide is the active cathode material. Li ions passes from cathode through elec-trolyte to the anode and back.	Chile, Bolivia and Argentina (from brine). Canada, Australia, China and USA (from hard rock mining).	100%	Portugal, Spain, Czechia, Finland.	Possible, but presently not so economically viable	Li is abundant, but production capacity and supply is limited
Cobalt* (Co)	Provides thermal and chemical stability to the cathode	DRC, Australia and as byproduct to copper and nickel mining globally.	86%	Co is bypro Cu- and Ni and availa recycled		Price and mining conditions in the DRC are drivers for Co-free batteries
Nickel (Ni)	Improves energy density and replaces Co.	Australia, New Caledonia, Canada, Russia.	59%	Finlar Explorati Greece, Spain, Sweden.	all to original state and quality.	Ni is abundant, but supply is limited.
Manganese (Mn)	Improve the cathode and is a cheap alt. to Co and Ni.	South Africa, Ukraine, Brazil, Australia, India	89%	In Czechia from tailings. Found in low concentration in soils globally	Mn can be recycled (37% 2005)	Mn is abundant, but supply is limited

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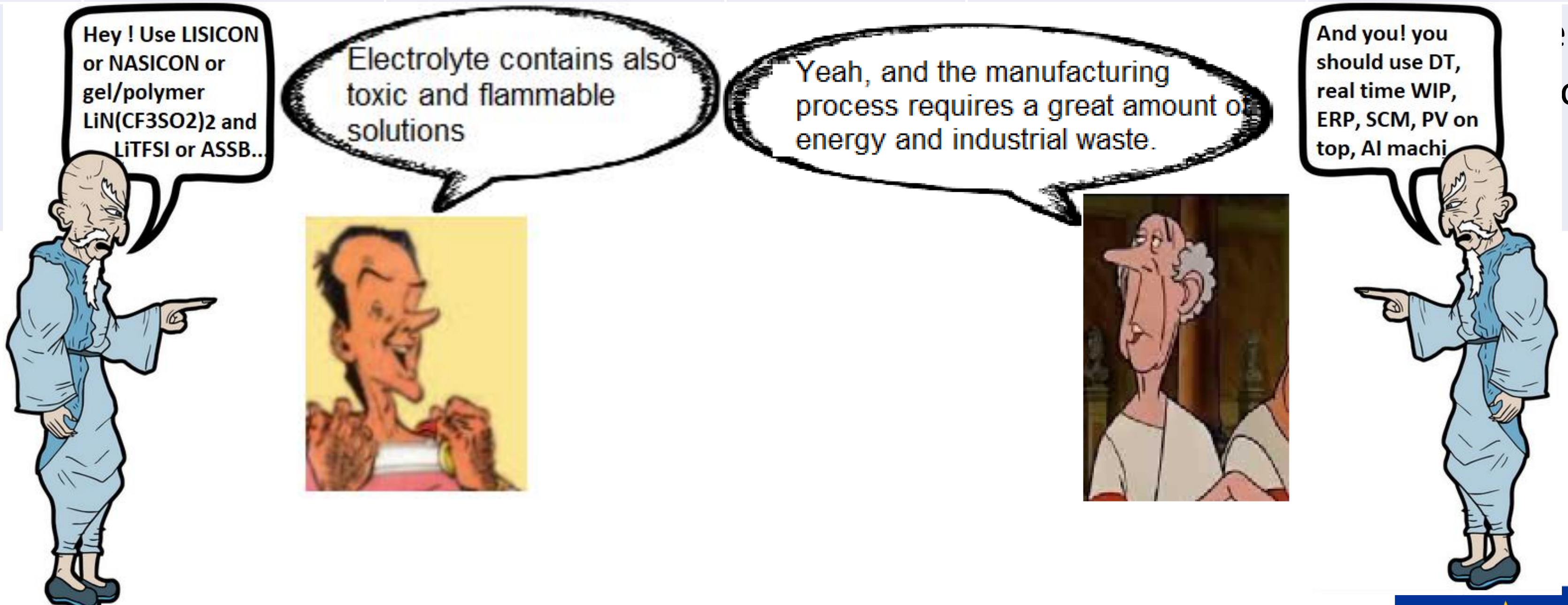
Let us investigate the Anode Materials

Raw Material (*critical)	Use in LiB	Main EU Supply	EU import	EU deposits	Recycling	Note
Natural Graphite* (C)	Active anode material	China, India, Brazil, Turkey.	98%	Norway, Czechia and Austria have reserves.	Not often recycled, but methods are underway.	Synthetic graphite is an option.
Silicon* (Si)					in ot	Abundant, but supply is limited.



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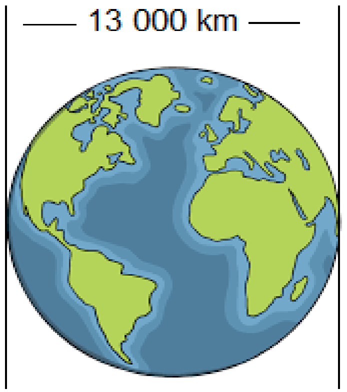
Mendeleyev Table

Pipes coming from a rare-earth smelting plant spew into a tailings dam on the outskirts of Baotou in China's Inner Mongolia autonomous region.

The mining of critical raw materials leaves rubble dumps in its wake

Periodic table of the elements

- Alkali metals
- Alkaline-earth metals
- Transition metals
- Other metals
- Other nonmetals
- Halogens
- Noble gases
- Rare-earth elements (21, 39, 57–71) and lanthanoid elements (57–71 only)
- Actinoid elements



period \ group	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

lanthanoid series 6	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
actinoid series 7	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

*Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC).

Yellow-brown acid mine drainage flows into a wastewater pond in efforts to reduce heavy metal and chemical contaminants

Rare earth discharge gushes into a black lake that has accumulated from wastewater near Baotou in northern China

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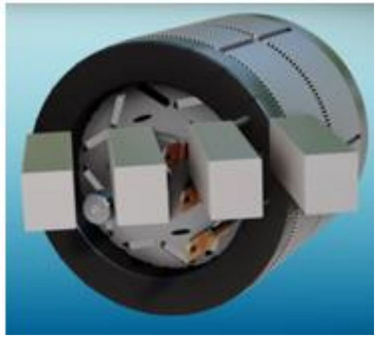
Back to Railway Electrotechnical Systems



A permanent magnet for the rotor is an alloy such as:
Samarium cobalt (SmCo)
Neodymium-iron-boron
To allow an increase in power:
Part of the neodymium is replaced with dysprosium and terbium which are also heavy rare earths elements, very expensive, and extracted almost exclusively from China.

In electromobility, the cooling of electrotechnical systems (such as traction motors, batteries,…) is crucial to maintain their efficiency and prevent overheating. There are several types of coolants that can be used for this purpose, including:
Air cooling
Water cooling
Water-Glycol Mixtures : Ethynol glycol is toxic and could have aquatic impact and ground water contamination if disposed improperly.
Dielectric Coolants : Could lead to environmental contamination if there is a leak or improper disposal.
Refrigerant-based Systems : Refrigerants, like R-134a and R-410a, have high global warming potentials.
Oil-based Coolants : Contain substances that are considered greenhouse gases.

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Innovation in Traction System

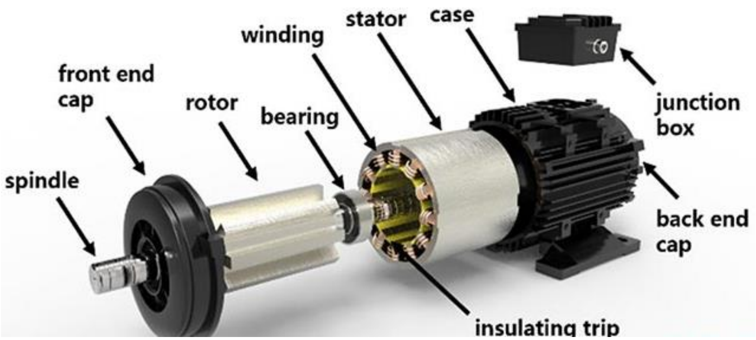
PMSM based on **ferromagnetic ferrites rare earth free** ($SrFe_{12}O_{19}$ – strontium ferrite) are iron oxide ceramics.

Disadv : They are weak**.**

Reluctance Motor

Robust construction, tolerance for degraded operation, high power density, easy control, interesting torque-speed characteristics

Disadv: Generation of acoustic noise, High current and torque ripples, Complex topology of the converter.



Reluctance Motor

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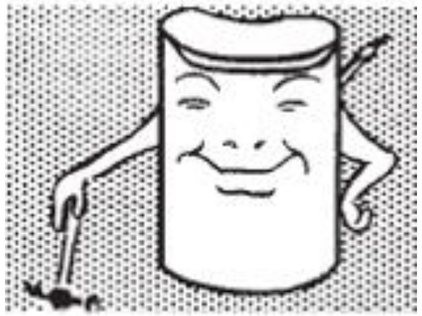
Innovation in Traction System



Back to traditional synchronous motor with wound rotor
Easily controllable motor flux

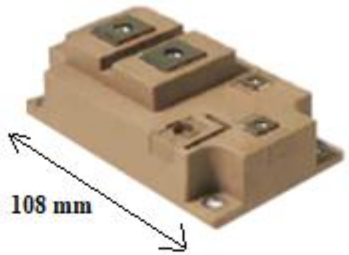
Significant range of constant maximum power at various speeds.

Operation at unity power factor

Acceptable efficiency (>95%)

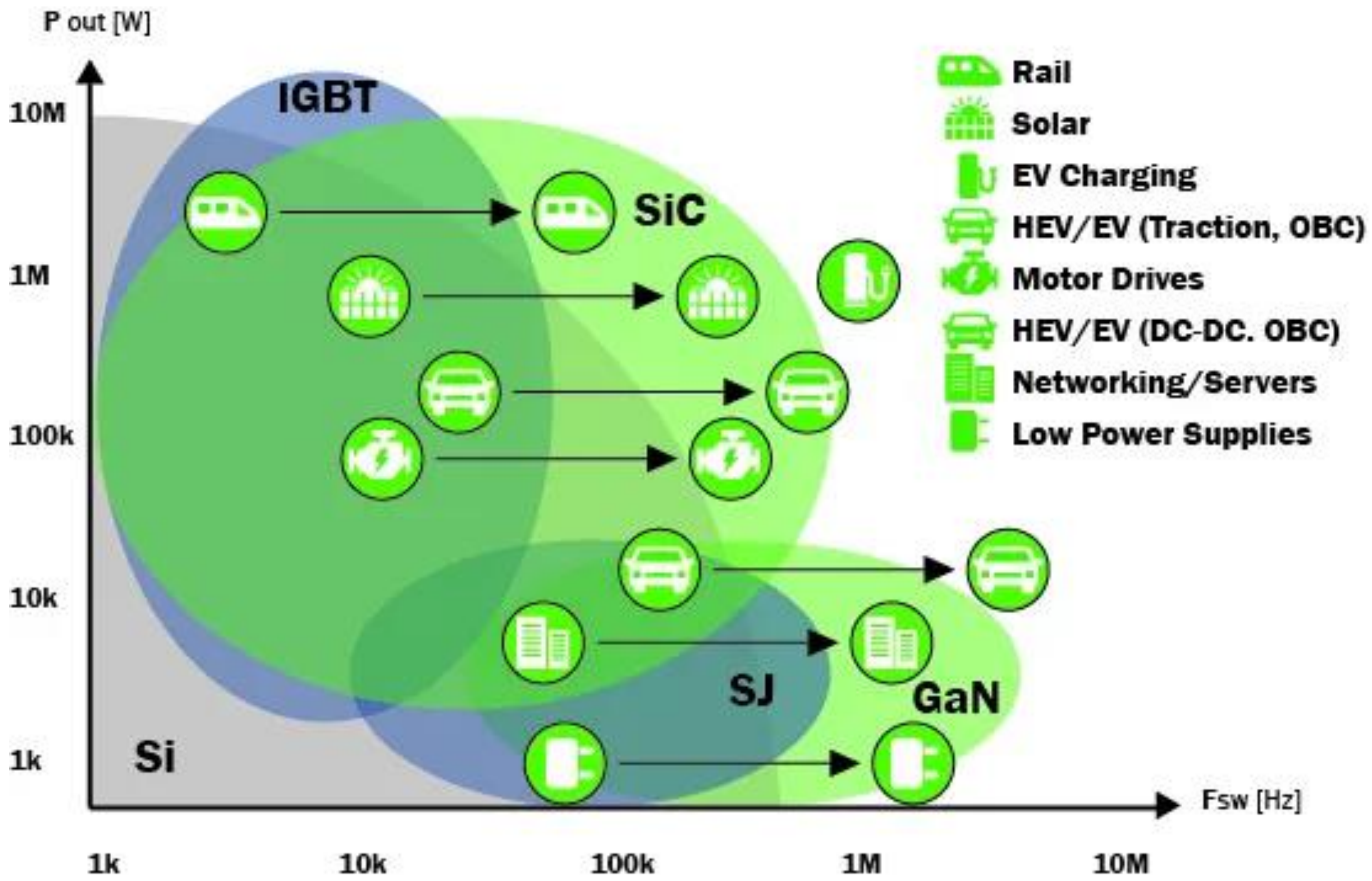
- Disadv: lower mass and volume power density, need to cool the rotor, lower maximum speed compared to IM, more challenging manufacturing

Innovation in Power Conversion



Fuji Electric / IGBT Module
1200 V / 900 A

1.2 kV SiC modules for a half-bridge 120 A



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Innovation in Power Conversion

- The mutation of SiC high power and high frequency power switch technology could :
  - Increase power converters efficiency by minimizing losses and consuming less power.
  - Reducing size and weight
  - Lower cooling requirements
  - Improve the voltage and current signal waveforms by working on high frequency thus :
    - Reducing harmonics (and filters).
    - Improve the output torque of the traction motor.
    - Improve the recharging of the battery pack
    - Use of more advanced control requiring higher switching frequencies.

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Efficiencies comparison

Diesel	(Renewable) Energy 100 kWh		
Internal Combustion Engine 20-35 %	**Hydrogen Efficiency H2 (23%)**	**Electric Battery Efficiency (69%)**	**Electrical Train Efficiency (77%)**
	AC Power (95%) 95 kWh	AC Transmission (90%) 90 kWh	AC Transmission (90%) 90 kWh
	Electrolysis (75%) 71 kWh	DC + Battery Charging (85%) 77 kWh	DC Conversion (95%) 86 kWh
	Hydrogen Compression (90%) 64 kWh	Traction (90%) - 69 kWh	Traction (90%) 77 kWh
	Hydrogen Transport (80%) 51 kWh		
	Fuel Cell Conversion (50%) 26 kWh		
	Traction (90%) 23 kWh		

Overall energy efficiency of hydrogen not much better than diesel
Environmental benefits hydrogen comparable for non-CO2 emissions
+ Low efficiency & vulnerability fuel cells (replace every 2-3 years)

Rail Transport : Solutions to get Greener

Increasing the share of green energy in its mix

Enhancing energy efficiency of the rail system

Managing energy consumption

Material recyclability

Use of recycled material

Energy regeneration to the overhead wires during braking

A more aerodynamic nose shape

Thermal insulation of carriages

Optimizing air conditioning based on passenger count

Eco-driving system.

Eco-parking of trains

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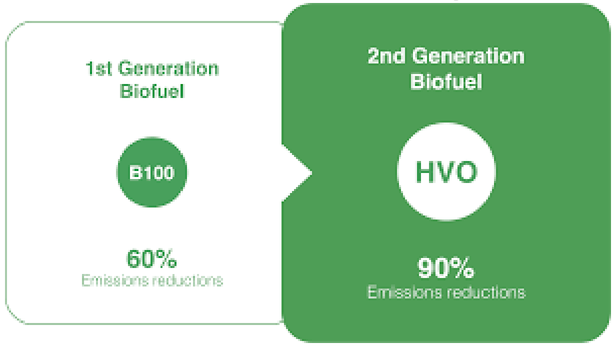
Rail Transport : Solutions to get Greener

- Replace diesel with **biofuels** in thermal trains to reduce greenhouse gas emissions like :

- B100, a 100% pure biofuel that doesn't compete with food needs.

- HVO (Hydrotreated Vegetable Oil), a biofuel made from hydro-treated vegetable oil, or from waste processing (used oils, animal fats).

- This solution brings more than 60% reduction in greenhouse gas emissions and requires no modification to the trains' engines.



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Rail Transport : Solutions to get Greener

- For air conditioning in various rolling stock, replacing Hydrofluorocarbon (HFC) refrigerants with a new refrigerant that better withstands high temperatures and contributes less to the greenhouse effect.
- Replacing current refrigerants (R134A and R407C) with **R513A**, which enhances the resistance and reliability of high-temperature air conditioning units and has a significantly lower "Global Warming Potential."

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THANK YOU !!!

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Summer School on "The European railway system"

Difficult choices – which alternative for which application?

Michael Lehmann

University of Applied Sciences ERFURT

Rome, 17 July 2024

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FACHHOCHSCHULE ERFURT UNIVERSITY OF APPLIED SCIENCES

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(3) TASK 1 – Understanding national starting points

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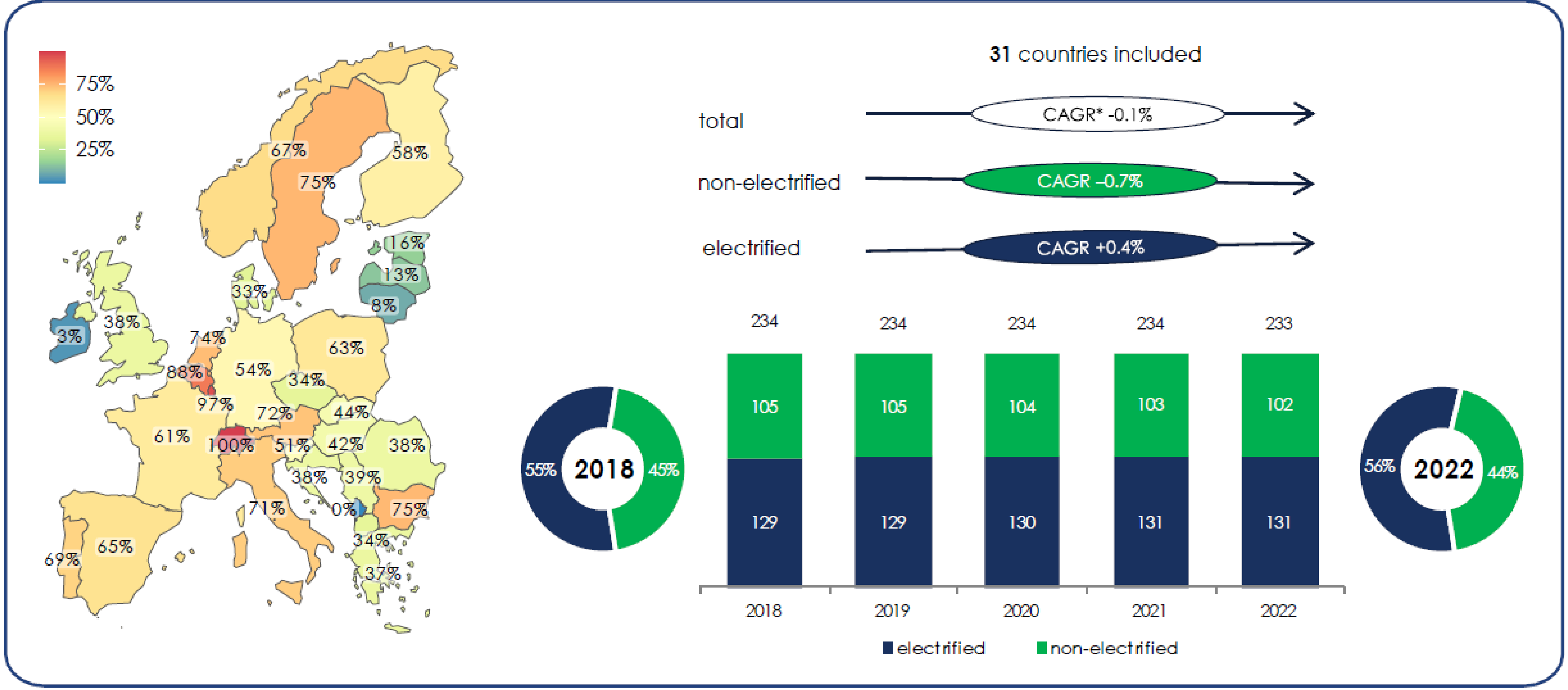
Figure 4 – Total route length (thousands km) and electrified share of participating countries from 2018 to 2022[6] (right) and electrified share per country in 2022 (left)

Of the 31 countries that reported data, 56% of the total route length was electrified in 2022. This corresponds to an extension of 2,000 electrified route km and an increase of 1 percentage point of electrified route share from 2018.

The level of electrification of the railway network varies significantly across Europe, ranging from 0% (Kosovo) to 100% (Switzerland). Among the monitored countries, eight have a share of electrified network higher than 70% and six have a share of electrified network below 33.3%.



*CAGR: compound annual growth rate

Pic. 5 Shares of electrief network lengths [IRG 2024]

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TASK 1 - IRG Report 2024

- *Pick a country*
- *Determine network length*
- *Determine length/share of non electrified network*
- *Determine traffic volume (train km)*
- *Determine share of non electrified traffic*
- *Give example of a typical not electrified line*

Results table – TASK #1

Criteria	Country 1	Country 2	Country 3	Country 4	Country 5	Country 6
Network length [km]						
Length of elec. network [km]						
Share of elec. network [%]						
Total traffic volume [train km]						
Share of elec. traffic [%]						

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Discussion

- Discuss urgency / necessity of converting diesel traffic to carbon-neutral traffic for specific rail application:
  - Freight (long distance / international)
  - Freight (shunting)
  - IC Passenger (High speed / long distance)
  - IC Passenger (low capacity, medium distance)
  - Regional Passenger (low capacity, medium distance)
  - Regional Passenger / Public transit (high capacity, short distance)

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Discussion - table

Application	Country 1	Country 2				
Freight (long distance / international)						
Freight (shunting)						
IC Passenger (High speed / long distance)						
IC Passenger (low capacity, medium distance)						
Regional Passenger (low capacity, medium distance)						
Regional Passenger / Public transit (high capacity, short distance)						

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(3) TASK 2 – Power consumption and suitable topologies

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Group tasks – Powers consumptions and applications

Group	Application	Rolling stock	Distance Single trip	Distance Round trip
#1	Pass. Regional light	2 coaches multiple unit	75 km	150 km
#2	Pass. Regional heavy	5 coaches bi-level	250 km	500 km
#3	IC light passenger	5 coaches bi-level	400 km	800 km
#4	High-speed passenger	ICE / TGV / FR	750 km	1500 km
#5	Freight light regional	Single waggons	50 km	100 km
#6	Heavy freight	2000 t train	500 km	1000 km

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Power consumptions in different rail applications

Application	Rolling stock and operation	Specific power consumption [Wh/tkm]*
Freight - long distance	6 MW loco, 1500 t train	25-35
Freight – regional service/ shunting	2 MW loco, 700 t train	15
Passenger high speed	12 MW, constant power, >180 km/h	70
Passenger (Intercity)	6 MW, 100 km/h, various grades, stops every 20-40 km	35
Regional trains, loco pulled	6 MW, 100 km/h, various grades, stops every 20-40 km	45
Regional train, light multiple unit	cruising acceleration	45 165

* According [Biesenack 2006]

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Common assumptions

- Specific energy density of batteries: 100 … 150 Wh/kg
- Specific costs of batteries: 100 … 150 EUR/kWh
- Charging power: use of *Mega Charger*, i.e. P = 1 MW

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Task 2 – Energy storages in diff. applications

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1. Determine spec. power consumption for the chosen application.
2. Decide on a vehicle weight and calculaten the transport effort (tkm).
3. Determine absolute power consumption for a typical roundtrip in your chosen application.
4. Determine the necessary size of the energy storage assuming that only 2/3 of capacity may be used for a round trip (1/3 threshold).
5. Determine necessary charging time after a roundtrip to completely recharge the storage.
6. Estimate the costs and the weight for the energy storage system.

- *alternatives for steps 4.-6.: Recharging after a single trip.*

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Group tasks – Powers consumptions and applications – *Results* *TASK #2*

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Group	Application	Round trip	Spec. power	Energy consumpt.	En. storage size	Charging time	Costs energy storage	Weight en. Storage
		km	Wh/tkm	kWh	kWh	*Hours*	Euro	*t*
#1	Pass. Regional light	150 km						
#2	Pass. Regional heavy	500 km						
#3	IC light passenger	800 km						
#4	High-speed passenger	1500 km						
#5	Freight light regional	100 km						
#6	Heavy freight	1000 km						

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Literature and sources

Source	Meta data
[AEERL 2022]	AERRL – Association of European Rail Rolling Stock Lessors: Study on alternatives to fossil diesel use in railways Presenting a roadmap for near term decarboni s ation together. Brussels, 2022.
[Biesenack 2006]	Biesenack, H.; George, G.; Hofmann, G. et. al.: Energieversorgung elektrischer Bahnen. Vieweg + Teubner Verlag, Wiesbaden, 2006.
[IRG 2024]	IRG – Independent network regulators group: 12th Annual Market Monitoring Report. 2024
[NEE 2017]	NEE – Netzwerk Eeuropäischer Bahnen [Hrsg.]: ZUGKRAFT FÜR DEN VERKEHRSSEKTOR, WETTBEWERBER-REPORT EISENBAHN 2017/18, LANGFASSUNG. NEE, mofair, VPI. Berlin, 2017.
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[VDE 2019]	VDE – Verband der Elektrotechnik e. V. [Hrsg.]: Alternativen zu Dieseltriebzügen im SPNV Einschätzung der systemischen Potenziale. Frankfurt/Main, 2019.

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