Activities implemented under the Agreement and Key Outcomes

Letter of Agreement No. 2021-0039

FINAL REPORT

Technical Part

Trade and transport connectivity in the age of pandemics

Enhancing shift towards sustainable freight transport in Asia and the Pacific

Project start date:	24/01/2022
Project end date:	31/10/2022
Document date :	27/01/2023

INTERNATIONAL UNION OF RAILWAYS

TABLE OF CONTENT

Per the Letter of Agreement, the technical reporting was to be provided by 31st December 2022. Due to the holiday period of December and the end of the financial year at UIC, more time was necessary on UIC side for the submission of the present document to ensure the quality of the reporting. We therefore request that the formal deadline is extended due to these constraints.

1. BACKGROUND

UIC has developed training material on rail digitalization and organized regional training workshops with experts, and supported the implementation of following topics, as described in the Terms of Reference of the Letter of Agreement No. 2021-0039:

- Trade and transport connectivity in the age of pandemics
- Enhancing shift towards sustainable freight transport in Asia and the Pacific

The present report details activities implemented under the agreement and the key outcomes.

International railway transport has been quite resilient during the pandemic. The crisis unleashed by COVID-19 pandemic provides an opportunity for railways of the region to further increase their comparative advantages in resiliency and sustainability by deploying smart rail solutions and deepening digitalization in railways to enhance the operational efficiencies. This will further support modal shift to rail thereby enhancing shift towards more resilient and sustainable freight in the ESCAP region.

The primary objective of the partnership was to support ESCAP member countries along the Trans-Asian Railway network in using the opportunity provided by the pandemic context to deepen sustainability of freight transport by enhancing the understanding of the railway policy makers for digitalizing rail operations.

Railways are undergoing major transformation driven by emerging digital technologies like 5G, big data, cloud computing, internet of things, automation, artificial intelligence, and blockchain. During and post COVID-19 digitalization offers huge prospects for railways, owing to the numerous benefits it can provide that include improved capacity, traffic management, reliability, energy efficiency, services, and lower operating costs.

However, digitalizing railways presents a formidable challenge, given the divergence in railway development among countries of the region and therefore needs to be managed with systematic and staggered approach. There is considerable disparity in financial investments in digital infrastructure, research and innovation, and digital skills in the region that needs to be considered.

In addition, the change in the mindset could by far might prove more complicated a challenge for railway authorities and companies, which will have to share data and consolidate business resources since rail digitalization modifies the business model, which must evolve from a rather rigid model towards a more dynamic network joining suppliers, technological platforms, mobility providers and customers.

This needs capacity enhancement of the railway policy makers to manage the transition to digital rail smoothly. The rail digital transformation can, therefore, be accelerated through capacity building initiatives for rail mangers of the region, particularly, for the landlocked and least developed countries to enable them to leapfrog to digital rail.

Digitalizing railway processes will not only enhance operational efficiency, but also it will support contactless and seamless rail connectivity in the region thereby encouraging shift to rail initiatives and promoting shift towards sustainable freight in the region.

2. ROLE OF UIC

Concerning the role of UIC foreseen in the Letter of Agreement, the following actions have been completed:

- **“Assign staff, consultants and/or experts to design and develop suitable training materials on the rail digital transformation.”**
  Completion status and actions performed: UIC assigned the appropriate internal staff with the relevant knowledge to perform the tasks of the project. UIC also involved experts from working groups with specific expertise needed for the project (Freight, digital platform, sustainable development, talent expertise development, etc.).

- **“Plan and organize three capacity building workshops on the rail digital transformation in cooperation with ESCAP including provision of resource persons for training sessions during the workshops.”**
  Completion status and actions performed: the three required workshops were set up in cooperation with UNESCAP. They took place on the following dates:
  - 3 October 2022, online with Russian interpretation;
  - 17 October 2022, online;
  - 3 November 2022, hybrid mode (Bakou).

UIC ensured the promotion of the workshops through various communication channels such as the UIC website (https://uic.org/), mailing lists of members, etc. UIC also sent invitations to all concerned members of Asian Pacific regions.

- **"Provide regular updates on the development of training materials, and collaborate in the conceptualization of capacity building workshops."**
  Completion status and actions performed: UIC and UNESCAP exchanged on the content of the e-learning program for several months in order to agree on the e-learning modules. UIC drafted and proposed programmes of the workshops with speakers from various organisations, according to the expectations of UNESCAP.

- **"Provide project completion and financial report to ESCAP."**
  Completion status and actions performed: the elements are put in the section 6 "Financial Report" of the present document.

3. REPORT ON ACTVITY N°1: TRAINING MATERIALS

Concerning activity n°1 on Training Materials, the following actions have been completed:

- **"Develop training material on rail digital transformation as means to enhance resilience and sustainability of freight transport, considering the diversity ESCAP region (there are four subregions of ESCAP - North and Central Asia, South and Southwest Asia, ASEAN and East and North Asia)."**
  Completion status and actions performed: this is the core content which actions are detailed in the paragraphs below.

- **"UIC will set-up a steering committee, composed of representatives from each UIC technical departments and Asia Pacific region."**
  Completion status and actions performed: a UIC steering committee was formed with experts from different fields:
  - HR development & international training: Meryem Belhaj-Clot;
  - Digital platform: Francis Bedel;
  - Freight department: Sandra Géhénot & Philip Van Den Bosch;
  - Asia-Pacific region: Vincent Vu;
  - Sustainability unit: Lucie Anderton.

- **"The steering committee will ensure the constant operational link, throughout the project duration, with ESCAP."**

  Completion status and actions performed: meetings were held internally and with UNESCAP to co-construct the outline of the training program. At each step, the steering committee discussed the content and the storyline. A dedicated working group space was created in TEAMS in order to work at a different pace and collaborate with each other in a rapid manner.

- **"In the preparation phase, the steering committee will work on:**
  - **The provision of trainers;**
  - **The contents design and the necessary arrangements, depending on the nature of training, and its complexity;**
  - **The settlement of pedagogical objectives;**
  - **The targeted audience;**
  - **The profiles of trainees and participants."**

Completion status and actions performed: a Gantt chart and an action plan were shared in order to follow the different steps of the project and to respect the project schedule. A training engineering report was written and validated by the members of the steering committee, detailing the modules, educational objectives, etc. This report was sent to UNESCAP as agreed. The main content of the storyline is the following:

INTRODUCTION OF THE TRAINING (5 TO 10 MINUTES)

Rail is and will remain the backbone of mobility of people and goods.
Rail from its origin has survived various revolutions:
- *Industrial revolution at the very beginning*
- *Energetic revolution in the seventies*
- *Information technology revolution in the 80s - 90s*

This revolution is generating very strong impacts on all decision-making processes, all production and maintenance processes and obviously on the whole information chain itself.
Rail has obviously to take profit from this technical revolution to rapidly and efficiently improve productivity, security, reliability and services all this thanks to connectivity.
One key word is "reactivity" since we have currently to face very strong demands from the markets.
It can be either intra-urban markets, inter-urban, inter-regional or even inter-continental markets if we consider the emergence of large inter-continental corridors.

Key trends to be considered:
- *Artificial Intelligence*
- *5G*
- *Cloud computing*
- *IoT*
- *Cybersecurity*

Declined in:
- *Automation*
- *Predictive maintenance*
- *Rail infrastructure modelling*
- *New digital telecommunication, etc.*

All Rail sectors, all activities, all processes are or will be impacted.
The Digital revolution must be for Rail operators and manufacturers the unique opportunity to go faster and further in progress, enabling Railways in the world to once again be an actor and a vector of development of the 21st century.
One key success factor to be respected: the digitalization of Rail can only be achieved with the full support and commitment of the Decision Makers (Political and Rail Executives) at the highest level.

TRAINING MODULE #1: CHALLENGES AND OPPORTUNITIES FOR RAIL FREIGHT IN THE ERA OF SUSTAINABLE DEVELOPMENT

Sustainability challenge and the role of transportation to green the society
Main message: The UN Climate panel has called for action by everybody, especially policy makers to realize the Paris climate Goals. Transportation still needs to contribute significantly.
Objective: Provide insight on the sustainability challenge and the role of transportation in support of a green society.
Deliverable: Facts and figures.
Hand out:
Why?
- *Sense of urgency*
- *Globalization of trade*
- *Evolving production patterns and emerging trends (e-commerce)*
- *Impact on mobility and environment*

Who?
- *All continents concerned*
- *National and Supranational commitments towards the environment (provide examples from regions)*
- *Forecast 2050*
- *Collective commitments (UN & COP; financial institutions, etc.)*

TRAINING MODULE #2: DIGITALIZATION AS A LEVER TO ENHANCE RAIL COMPETITIVENESS AND SUSTAINABILITY

Main message: Transport has a major climate and environmental impact. To reduce this impact the share of rail needs to increase
- *The role of goods transportation and international exchanges on the eco footprint*
- *The challenges of rail in regard decarbonization*
- *The intrinsic advantages of rail as a transport mode for a sustainable society*
- *Ref to covid?*

Deliverable: facts and figures
Objective:
- *Provide fact and figures regarding rail freight in the various regions of the globe*
- *Provide general information on the challenges faced by rail freight vs other modes*
- *Provide insight into the challenges of rail to decarbonize & engage on option space*
- *Provide insight on rail freight's positive impact on the eco footprint*
- *Provide a zoom on the challenges and opportunities in Europe which will be our use case through out*

Handout:
- *Historical development and current situation*
- *The constraints impeding growth*
  - *Development of rail's future modal share key drivers*
    - *3 forces railways control*
      - *Competition*
      - *Big data*
      - *Scheduling*
    - *3 forces to watch*
      - *Trucking standards*
      - *Truck traffic regulation and pricing*
      - *Expanded and standardized infrastructure*
    - *3 forces that can impede growth*
      - *Energy efficiency of trucks*
      - *Increased infra charges*
      - *Environmental concerns*
  - *Zoom per region in terms of market share, etc.*
  - *Europe: a continent suffering from lack of interoperability choking capacity*

- *Opportunities and modal shift implementation strategies*
  - *Corridor organisation*

TRAINING MODULE #3: DIGITAL COMMUNICATION TECHNOLOGIES FOR RAIL (INCLUDE GSM-R/FRMCS/5G/LTE, RAIL CYBERSECURITY AND OTHER AS DEEM FIT)

Main Message: Digitization of freight will be the driver to make rail more competitive and gain more market share thereby contributing to less environmental impact of transport
Deliverable: Fact & figures with documented examples
Objective:
- *Provide the context for digitization within rail freight*
- *Provide the key technologies which are under development*
- *Provide examples for Europe*
- *Provide the policy context to foster digitization*

Handout:
Digitalization
- *For rail / For logistics*
- *Look at speed of innovation in other modes and impact on competitiveness*
- *Presenting the different new technologies*
- *GSMR*
- *ERTMS*
- *5G*
- *FRMCS*
- *ATO*
- *DCM*
- *Digital platforms*

Developing national strategy for accelerating rail digital transformation
- *Pre-requisite for rail digitalization (high level commitment demonstrated by adoption of rail digital transformation strategy)*
- *Key issues to consider in a strategy development*
- *State of digital infrastructure*
- *Calibrated approach spread over 10 years (identify areas where benefits are immense and immediate)*
- *Ramping up rail digital skills*
- *Culture shift to innovation*
- *Data management, protection, and security*
- *Regional cooperation can create synergies for rail Digitalization Experience of EU in bringing harmonized practices in rail digital operations*

Cybersecurity
Main message:
- *Digitalization has opened new critical breeches in security*
- *Challenges to enhance railway cyber security, by protecting networks and monitoring key systems*

Objective:
- *Focus on the main risks brought by Digital and the necessary actions to be taken*
- *Bring the conditions of the necessary awareness to cybersecurity*
- *Present the main solutions and conditions to ensure security*

Deliverable:
- *Session preparatory material*
- *Duration: tbc*
- *Format: tbc*

TRAINING MODULE #4: DIGITAL ASSET MANAGEMENT FOR RAIL

Main message:
- *Digitalization impacts on all assets management from optimization of timetable, development of digital twins up to predicative maintenance*
- *Focus on predicative maintenance:*
  - *How predictive maintenance is transforming how railways increase asset availability*
  - *Digitalization and securing assets require a comprehensive cybersecurity*
- *Moving from prevention to prediction optimizes asset management, reduces operating costs and improves reliability.*

Objectives:
- *Explain the path from preventive maintenance to predictive maintenance*
- *Analysis of the concept and overview of involved technical/digital components (IoT, big data, AI)*
- *Explain of the main outputs and potential benefits*

A use case: Kazakhstan Railways

MODULE #5: DIGITAL RAIL BORDER CROSSING

The content of this module was provided by UNESCAP, UIC put it in the right format as an e-learning module.
- *Electronic Information/Data Exchange among railways*
- *New technologies for efficient and secure border crossing (use of electronic seals)*
- *Railway consignments note as a customs document*
- *Railway – Customs electronic interface to support efficient rail border crossing*

- **"UIC will provide the team of technical experts to cover all capacity building topics for rail digital transformation among countries along the Trans-Asian Railway network."**
  Completion status and actions performed: UIC ensured that the topics that UNESCAP wanted to be addressed in the 3 workshops were covered. UIC experts were selected, and external experts were contacted.

- **"The core programme will be composed of the following areas:**
  - **Railway freight digital technologies (5G, automation, artificial intelligence, etc.);**
  - **Traffic management;**
  - **Energy efficiency."**

  Completion status and actions performed: all topics were covered and UIC responded to UNESCAP's requests by adding the themes wanted for the 3 workshops.

- **"UIC will use the following pedagogical methods on the delivery format of the training course:**
  - **Lectures when technical or academic lessons are to be taught;**
  - **Case Study enable participants to understand in a more practical manner;**
  - **Games and Activities create a fun learning environment (Quiz)."**

  Completion status and actions performed: e-learning modules with practical examples were developed. Each module is followed by a quiz. Specific case studies were delivered during the workshops. All workshops have been recorded.

- **"Training material and handouts: this will include detailed content and index of the programme, slides for presentation, educational material, reference documentation, examples, questionnaires, etc."**

  Completion status and actions performed: UIC delivered all e-learning material in SCORM format. Each module is accompanied by course document in PDF format (see Annex to this report).

4. REPORT ON ACTVITY N°2: E-LEARNING AND WORKSHOPS

Concerning activity n°2 on E-Learning and Workshops, the following actions have been completed:

4.1 E-learning

- **"In terms of substance of deliverables, an E-learning for asynchronous distance learning in digital format would be, finalized with:**
  - **Availability of the training on a digital platform;**
  - **Tests, quizzes."**

  Completion status and actions performed: all material has been sent to UNESCAP as agreed. The material can be available in UNESCAP learning management System (SCORM format, quizzes).

4.2 Workshops

- **"Organize one regional and two sub-regional capacity building workshops on rail digital transformation to deepen sustainability of freight transport (two subregions would be finalized mutually by ESCAP and UIC)."**
  Completion status and actions performed: the regional workshop was organized on 3rd October 2022, online. The two subregional workshops were organized on 17th October online too and 3rd November on hybrid mode in Baku, Azerbaijan.

- **Design of workshops:**
  - **Analysis and presentation of major digital trends using the technological watch function on UIC's Digital Platform;**
  - **Preparation of the contents by integrating the main items of the railway digitalization with a focus on Freight and sustainable development;**
  - **Study and adaptation of the best practices identified by the UIC at world level;**
  - **Involvement of industrialists and some representatives of the digital ecosystem: major trends, projects under development, innovations;**
  - **Involvement of UIC members who can testify to significant projects developed and implemented in their area;**
  - **Involvement of the UIC Asia-Pacific regional correspondents (Central Asia and ASEAN) to take into account regional specificities and to ensure that the content meets the needs;**
  - **Use of the ZOOM platform for multilingual simultaneous interpretation;**
  - **Recording and provision of workshop content for streaming;**

- **Provision of the main modules in e-learning in a commented slideshow format.**

Completion status and actions performed:

- Moderation of all 3 workshops;
- Invitation sent to UIC members and lecturers in Asia-Pacific, Middle East and Europe;
- Promotion during UIC Asia-Pacific events;
- Registration webpage and promotional banner on UIC website for regional workshops;
- Coordination by 1 UIC Director between UIC and ESCAP teams;
- 2 to 3 preparation meetings for each workshop;
- Management of registration and final list of participants;
- Surveys and feedback on priorities key issues and challenges for Digital Transformation, priorities for ESCAP during General workshop and ASEAN subregional workshop, communication and analysis of results;
- Keynote opening speeches by the Director representing the UIC Director General;
- Dissemination and archiving of presentations on UIC archiving system and extranet for railway participants (linked to ESCAP system);
- 3rd October regional workshop:

8:00 – 8:10	**Opening Session** • ESCAP • Mr. François Davenne, Director General, UIC
8:10 – 8:25	**Keynote address** • **Challenges in accelerating rail digitalization** (Birmingham Center for Railway Research and Education) (tbc)
8:25 – 8:45	• **Rail digitalization in ESCAP region challenges and way forward** *ESCAP*
8:45 – 9:10	• **E-learning material on rail digital transformation- an introduction** *UIC*
9:10 – 9:25	• **Major trends in rail digitalization** *Ms. Sandra Gehenot, Director Freight, UIC*
9:25 – 9:40	**Break**
9:40 – 10:40	• **State of rail digitalization including priorities and challenges Presentation by countries along the Trans-Asian Railway network** *ESCAP members*
10:40 – 11:00	• **Open source applied to rail** *Mr. Loïc Hamelin, SNCF, France*
11:00 – 11:20	• **The big data platform and its applications in freight railway** *Dr. Jun Liu, China Academy of Railway Sciences (CARS), China*
11:20 – 11:30	**Break**
11:30 – 11:50	• **Future Railway Mobile Communication System: roadmap andchallenges** *Mr. Dan Mandoc, Head of FRMCS, UIC*
11:50 – 12:10	• **Digital twins and their influence in decision making** *Dassault Systèmes*
12:10 – 12:30	• **Predictive/digital rail maintenance – key challenges and ways toaddress them** *Mr. Andy Kirwan, UIC Asset Management Chairman, Network Rail, UK (tbc)*

12:30 – 12:50	• **Open discussion on accelerating rail digitalization – challenges andway forward**
12:50 – 13:00	• **Conclusions and recommendations (UIC/ESCAP)**

- Survey on the priorities for digitalization of railways in the next 5 years, key issues and challenges for rail digitalization, Evaluation of workshop and ESCAP secretariat preparation (detailed results communicated by Excel file);
- 17th October subregional workshop:

PROGRAMME

Joint ESCAP-UIC Regional Capacity BuildingWorkshop on Accelerating Rail Digital Transformation in ASEAN region

Monday 17 October 2022 – 8:00 am Paris time Online

8:00 – 8:10	**Opening Session** • Ms. Azhar Jaimurzina Ducrest, Chief, Transport Connectivity and LogisticsSection, Transport Division, ESCAP • Mr. Vincent Vu, Director, Institutional Relations Department, UIC
8:10 – 8:25	**Keynote address** • Mr. Peter Mihm, Ex Head of international relations of the European RailwayAgency

8:25 – 8:45	• **Rail digitalization in ESCAP region challenges and way forward** *Mr. Sandeep Jain, Transport Division, ESCAP*
8:45 – 9:05	• **E-learning material on rail digital transformation- an introduction** *Ms. Meryem Belhaj-Clot, Deputy HR Director and Head of HR Development, UIC*
9:05 – 9:20	• **Freight Focus on ASEAN** *Mr. Philip Van Den Bosch, Senior Freight Strategy Advisor, UIC*
9:20 – 9:30	**Break**
9:30 – 9:50	• **State of rail digitalization including priorities and challenges** Presentation by ASEAN members
9:50 – 10:10	• **Artificial Intelligence applied to rail** *Mr. Christian Chavanel, Director Rail System, UIC*
10:10 – 10:30	• **The big data platform and its applications in freight railway** *Dr. Jun Liu, China Academy of Railway Sciences (CARS), China*
10:30 – 10:50	• **Developing Freight Operating Information System for railways** *Mr. Amit Kumar, Center for Railway Information System, Indian Railways*
10:50 – 11:10	• **Importance of rail cyber security – need for common guidelines** *Mr. Richard Thomas, Birmingham Center for Railway Research and Education,United Kingdom*
11:10 – 11:25	• **Concluding Session** *Mr. Carlo M. Borghini, Executive Director, Europe's Rail Joint Undertaking*
11:25 – 11:30	• **Conclusions and recommendations (UIC/ESCAP)**

- Survey on the priorities for digitalization of railways in the next 5 years, key issues and challenges for rail digitalization (detailed results communicated by Excel file):

Digitalization priorities of railways in ASEAN

3 questions | 23 a/ont participé

1. Participant profile (Choix unique) *

23/23 (100%) répondu

Ministry	(2/23) 9%
Technical department of Ministry	(3/23) 13%
Public Authority	(1/23) 4%
Government institute	(1/23) 4%
University	(5/23) 22%
Intergovernmental organization	(1/23) 4%
Non-governmental organization	(1/23) 4%
Railway company, UIC member	(6/23) 26%
Railway company, non-UIC member	(1/23) 4%
Other	(2/23) 9%

2. What are the priorities for digitalization of railways in the next 5 years (Choix multiple) *

23/23 (100%) répondu

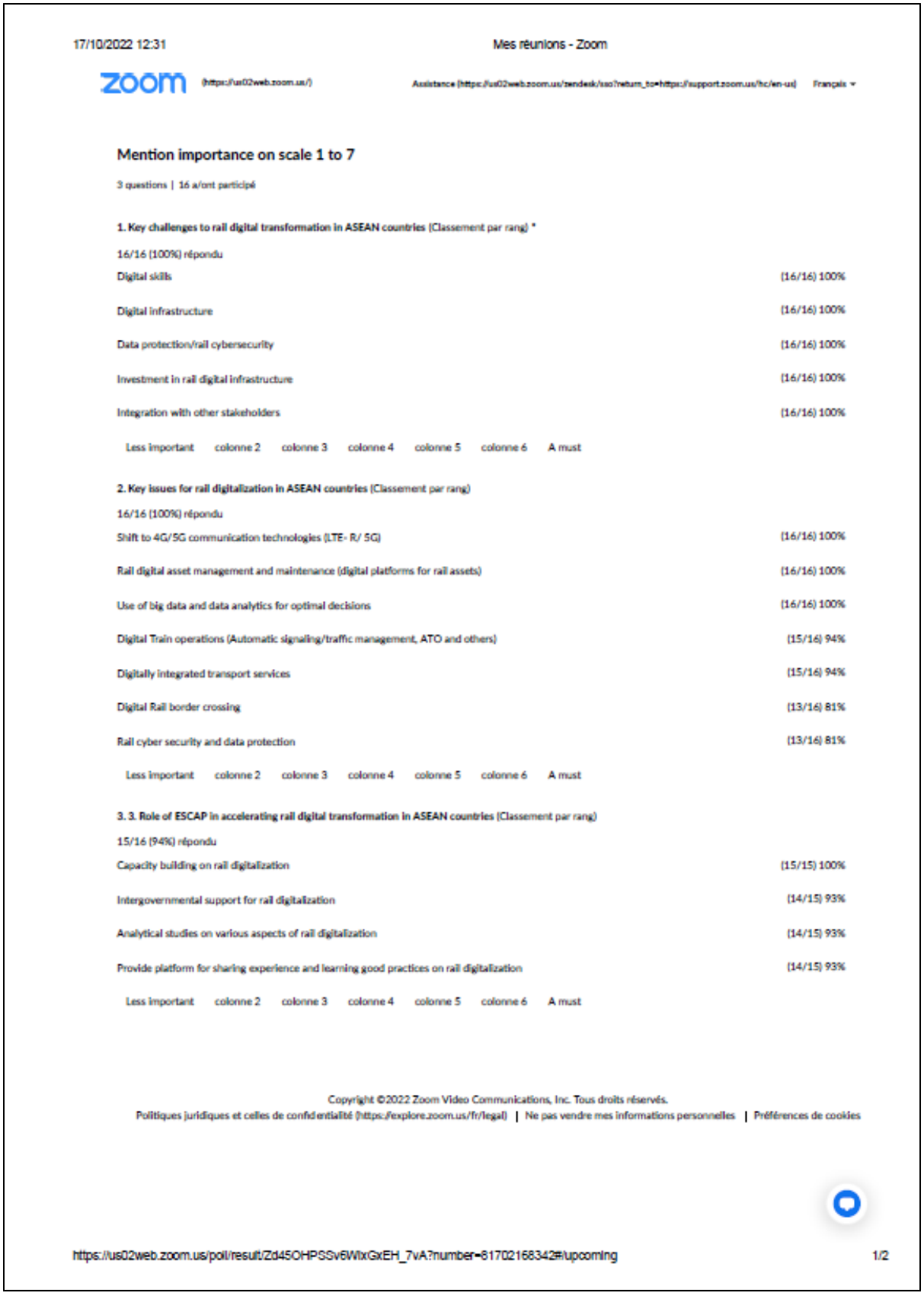
Digital passenger services (sales, live timetable, ticketing, ticket control, etc.)	(18/23) 78%
Open digital ecosystem for facilitation and interoperability of data exchange	(6/23) 26%
Digitalization of rail infrastructure operations for capacity increase and maintenance	(10/23) 43%
Rolling-stock	(4/23) 17%
Railway Telecom and 5G	(8/23) 35%
Data modelling and digital twins of the railway system	(7/23) 30%
Artificial Intelligence	(4/23) 17%
Cybersecurity	(7/23) 30%

3. Other priorities? (Réponse longue)

7/23 (30%) répondu

- digital passenger information
- NA
- Nil

Afficher plus de réponses



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Mention importance on scale 1 to 7

3 questions | 16 a/ont participé

1. Key challenges to rail digital transformation in ASEAN countries (Classement par rang) *

16/16 (100%) répondu

Digital skills	(16/16) 100%
Digital infrastructure	(16/16) 100%
Data protection/rail cybersecurity	(16/16) 100%
Investment in rail digital infrastructure	(16/16) 100%
Integration with other stakeholders	(16/16) 100%

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2. Key issues for rail digitalization in ASEAN countries (Classement par rang)

16/16 (100%) répondu

Shift to 4G/5G communication technologies (LTE- R/ 5G)	(16/16) 100%
Rail digital asset management and maintenance (digital platforms for rail assets)	(16/16) 100%
Use of big data and data analytics for optimal decisions	(16/16) 100%
Digital Train operations (Automatic signaling/traffic management, ATO and others)	(15/16) 94%
Digitally integrated transport services	(15/16) 94%
Digital Rail border crossing	(13/16) 81%
Rail cyber security and data protection	(13/16) 81%

Less important colonne 2 colonne 3 colonne 4 colonne 5 colonne 6 A must

3. 3. Role of ESCAP in accelerating rail digital transformation in ASEAN countries (Classement par rang)

15/16 (94%) répondu

Capacity building on rail digitalization	(15/15) 100%
Intergovernmental support for rail digitalization	(14/15) 93%
Analytical studies on various aspects of rail digitalization	(14/15) 93%
Provide platform for sharing experience and learning good practices on rail digitalization	(14/15) 93%

Less important colonne 2 colonne 3 colonne 4 colonne 5 colonne 6 A must

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- 3rd November subregional workshop:

PROGRAMME

Joint ESCAP-UIC Regional Capacity Building Workshop on Accelerating Rail Digital Transformation in North & Central Asia region

Thursday 3 November 2022 – 7:30 am Paris time (10:30 am Baku time)
Online & Baku (Azerbaijan)

7:30 – 7:50
(10:30 – 10:50)

Opening Session

- *Mr Nikolay Pomoshchnikov,* Head Subregional Office for North and Central Asia, ESCAP
- *Ms. Azhar Jaimurzina* Ducrest, Chief, Transport Connectivity and Logistics Section, Transport Division, ESCAP
- *Mr. Vincent Vu*, Director, Institutional Relations Department, UIC

7:50 – 8:10
(10:50 – 11:10)

- **Keynote address – Azerbaijan Railways**
  Mr. Kamil Valiyev, Head of Enterprise Resource Automation Department, Data Center, Azerbaijan Railways CJSC

8:10 – 8:30 *(11:10 – 11:30)*	• **Emerging opportunities for rail digitalization in ESCAP region challenges and way forward** *Mr. Sandeep Jain, Transport Division, ESCAP*
8:30 – 9:00 *(11:30 – 12:00)*	**1.** • **E-learning material on rail digital transformation- an introduction** *Ms. Meryem Belhaj-Clot, Deputy HR Director and Head of HR Development & Mr. Francis Bedel, UIC*
9:00 – 9:20 *(12:00 – 12:20)*	• **Freight digitalization focus on CIS** *Mr. Umidulla Ibragimov, Head of Logistic Digitalisation Development Department, Uzbek Railways*
9:20 – 10:30 *(12:20 – 13:30)*	**Lunch Break**
10:30 – 11:00 *(13:30 – 14:00)*	• **Digitalization of railways in countries of North and Central Asia - some issues** *Ms. Ekaterina Kozyreva, President IEC international*
11:00 – 11:30 *(14:00 – 14:30)*	• **State of rail digitalization including priorities and challenges** *Presentation/Intervention by countries in North and Central Asia Member States*
11:30 – 12:00 *(14:30 – 15:00)*	• **Artificial Intelligence applied to rail** *Mr. Christian Chavanel, Director Rail System, UIC*
12:00 – 12:20 *(15:00 – 15:20)*	**Coffee Break**
12:20 – 12:40 *(15:20 – 15:40)*	• **Digital interoperability along transport corridors using UN Standards** *Mr. Mario Apostolov, Regional Adviser Economic Cooperation and Trade Division,* *UN Economic Commission for Europe*
12:40 – 13:00 *(15:40 – 16:00)*	• **Digital twins for Future Railways** *Dr. Eng.Taha Ben Salah, Associate Professor at National Engineering School* *of Sousse (ENISo), Former Head of Computer Engineering Department* *CTO & Co-Founder at Core Techs Solutions IT company, Tunisia*
13:00 – 13:25 *(16:00 – 16:25)*	• **Rail Cyber Security Challenges and the Way Forward for the Railways of the Region** *Dr. Richard J. Thomas, Birmingham Centre for Railway Research and Education,* *United Kingdom*
13:25 -13:50 *(16:25 – 16:50)*	• **Digitalization of Indian Railway Freight Business** Mr. Amit Kumar, Center for Railway Information System, Indian Railways

13:50 – 14:00 *(16:50 – 17:00)*	• **Conclusions and recommendations (UIC/ESCAP)**

- **"Simultaneous Russian translation through Zoom have been included in the budget."**
  Completion status and actions performed: the simultaneous Russian translation has been provided for the regional workshop.

5. CONCLUSION

The partnership has enhanced capacities for rail digital transformation among countries along the Trans-Asian Railway network. The UIC/ESCAP cooperation was welcomed by all participants in the three regional workshops. There was a strong interest in discovering the e-learning training modules developed, as the topics were highly appreciated.

6. ANNEXES – DELIVERABLES: COURSE BOOKS

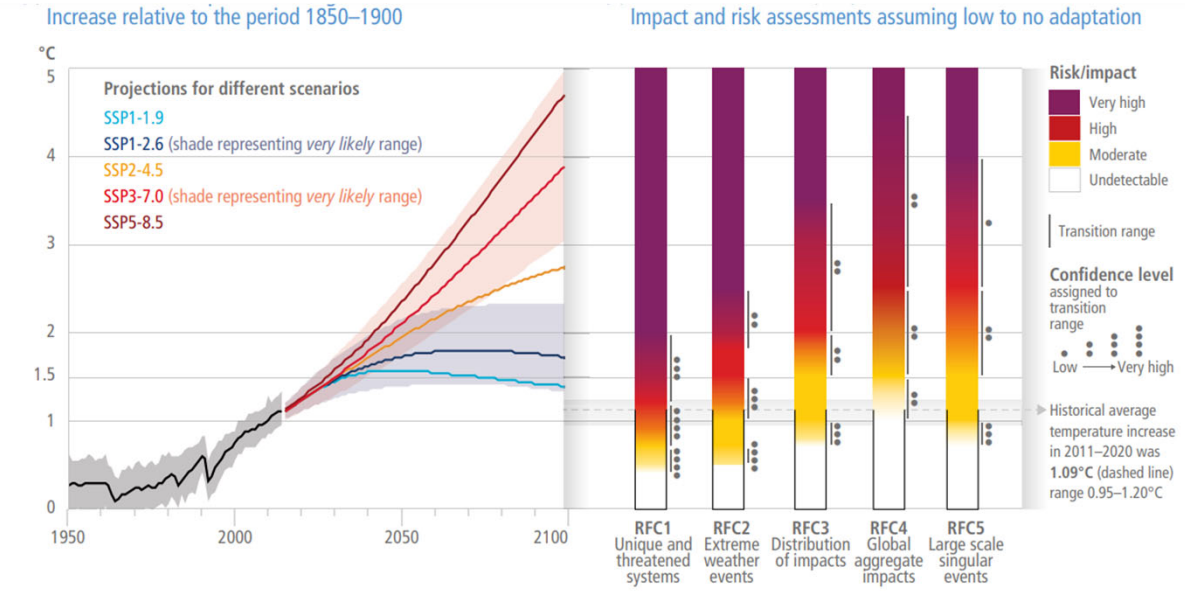
CHALLENGES AND OPPORTUNITIES FOR RAIL FREIGHT IN THE ERA OF SUSTAINABLE DEVELOPMENT

S Géhénot & P Van den bosch

The United Nations (UN) Climate Panel has urged everyone, particularly policymakers, to take action to achieve the Paris climate targets. Transportation must still make a substantial contribution.

This module introduces the sustainability challenge as well as the role of transportation in promoting a green society.

All IPCC reports over the last years have shown significant climate change and its impact on our planet



Through numerous agreement the global community has committed to reduce its impact on global warming.

If no urgent action is taken, climate change will fundamentally endanger the existence of mankind on earth-

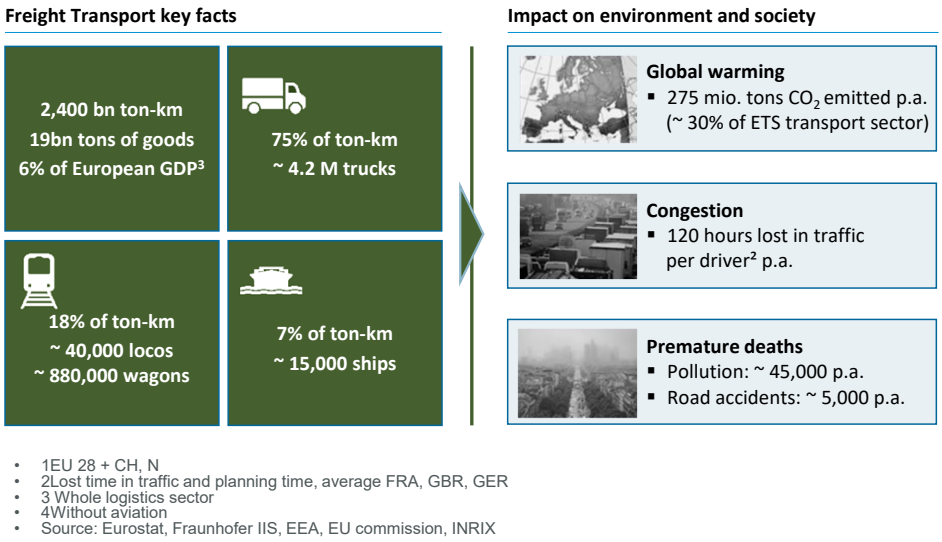
As the International Panel for Climate change stipulates, without decisive action, the world is facing a global temperature increase between x and y degrees.

The impact on society will be vast on all continents. For example, rising temperatures will increase the likelihood of devastating heat waves across Asia. Biodiversity will be negatively impacted on a global scale. By mid-21st Century, the international transboundary river basins of Amu Darya, Indus, Ganges could face severe water scarcity challenges due to climatic variability and changes acting as stress multipliers. Asian countries will face substantially higher temperatures, which will further increase the demand for energy and thereby create a vicious circle.

According to the IPCC, there is robust evidence, that increased climate variability and extreme events are already driving migration and that long-term climate change will further increase migration flows across Asia.

Land freight transport is an important economic sector with massive impact on environment and society – rail has a modal share of only 18%

European1 land freight transport facts and impact, 2015



- 1EU 28 + CH, N
- 2Lost time in traffic and planning time, average FRA, GBR, GER
- 3 Whole logistics sector
- 4Without aviation
- Source: Eurostat, Fraunhofer IIS, EEA, EU commission, INRIX

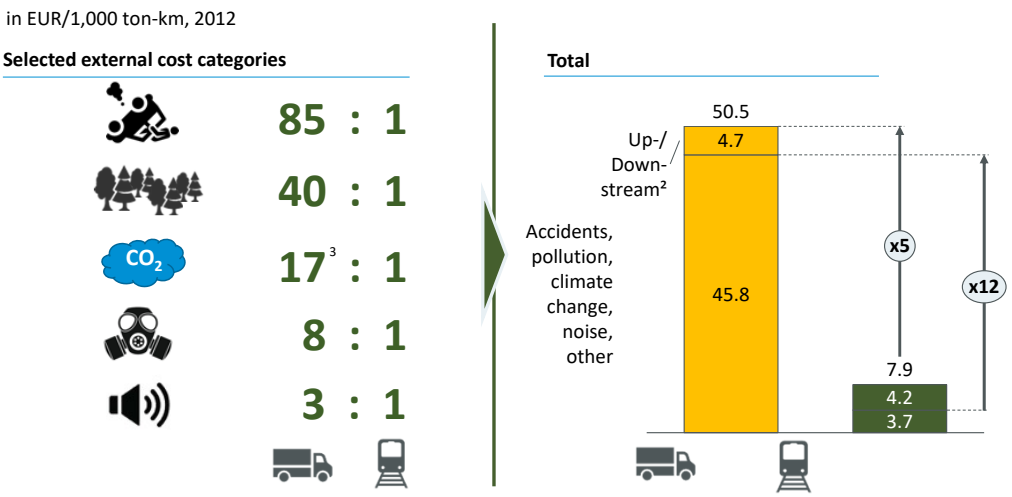
Trade and therefore the transportation of goods is the basis for economic development. It has been proven that regions, which are strongly embedded in logistics networks have a higher tendency of experiencing economic growth than others. Investors favour regions which are connected. Well connected regions show higher social mobility and are more attractive.

On the other hand, transport is a major contributor to global warming and pollution. Though major differences exist between different modes of transportation, transport generates around 25% of greenhouse emissions. Adding to this are other externalities such as land use, deterioration of general health conditions or economic losses due to congested roads. As an example, in Europe road transport accounts for around 50.000 deaths per year an generates around 120 hours of congestion or hours lost in traffic jams. However, not all modes of transportation contribute to these external effects to the same extent. Rail is the land freight mode with the smallest external impacts.

Compared to trucks, the impact of rail on society and environment is far lower

Comparison of external costs[1]

in EUR/1,000 ton-km, 2012



1 Noise, Climate Change, Pollution, accidents, other excluding congestion based on EU + CH, N
2 Impact of prior/later steps on value chain, e.g. supply of fuel
3 Figure based on source. Other more recent sources (e.g. German Umweltbundesamt 2018) use ratios of approx. 6:1
Source: eRRac, CE Delft 2012, Fraunhofer, INFRas

- Rail is not only the superior mode of transportation when it comes to effects on the environment and climate. Rail also has a far lower negative effect on the health of the population. This is even more true, when growing transport demand requires heavy investments in infrastructure.

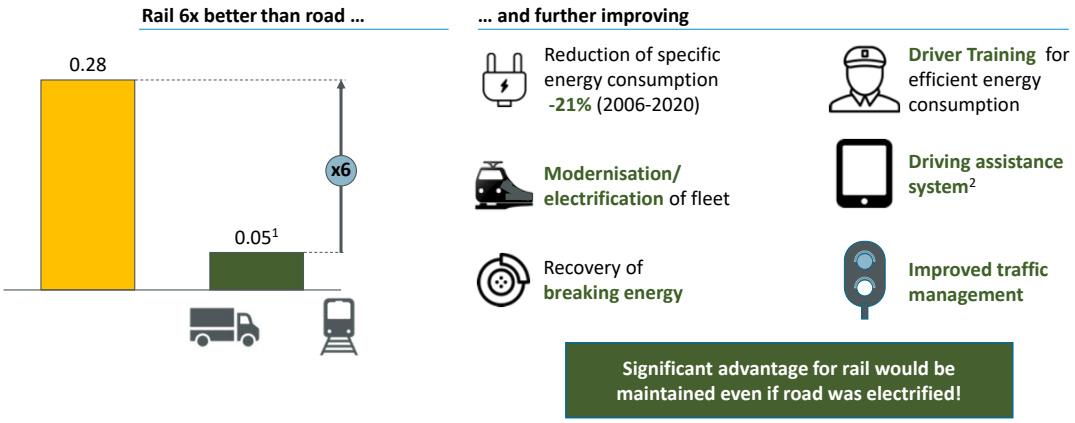
- European numbers show that the difference between environmental effects have a ratio between 5 and 12, depending on the source. Trucks are responsible for over 50 EUR per 1000 Tkm in external costs, whereas rail accounts for only around 8 euro per 1000 Tkm.

- In all categories of externalities, rail is superior – even regarding noise rail outperforms road by a factor of 1 to 3.

Rail has a 6x lower specific energy consumption than road due to physical advantages such as wheel-on-rail and air resistance

Comparison of energy efficiency

in kWh / ton-km specific energy input, 2017



1 Drivers: lower friction of steel-on-steel vs. rubber-on-road, lower air resistance of 1 train vs. ~ 40 trucks, high level of electrification
2 E.g., LEADER: Locomotive Engineer Assist Display and Event Recorder [co-financed by EU]
Source: Austrian Umweltbundesamt (2017), RUs

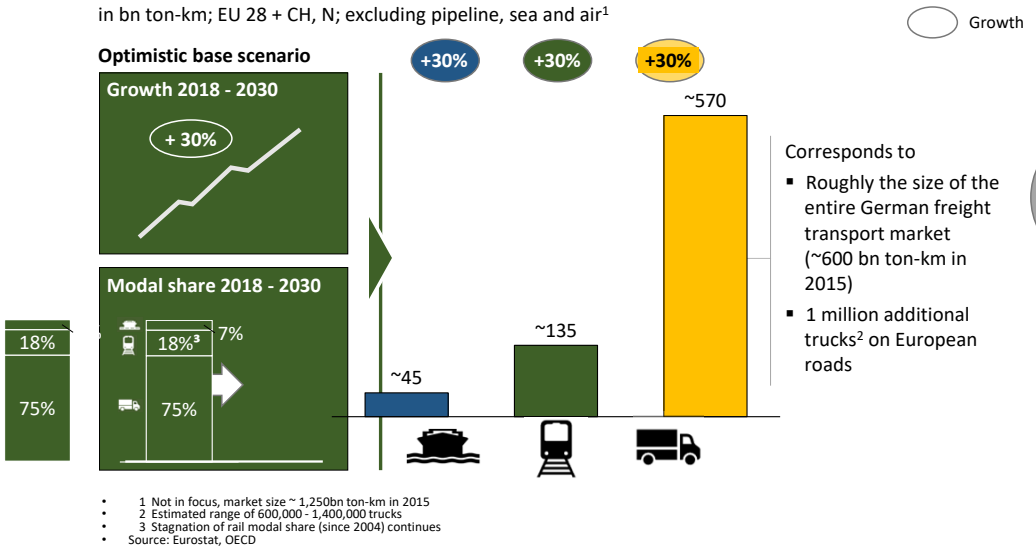
Trucks will eventually also become more sustainable and the gap to rail is likely to become smaller. Rail will however maintain its lead in energy efficiency. The friction of steel wheels on iron rails 6 times less than rubber on bitumen or concrete

Moreover, innovations will make rail even more energy-efficient. Energy consumption has already decreased by more than 20% during the last decade. Developments in breaking systems, better driver training and better operational procedures improving the traffic management have had and will have a positive impact on energy efficiency

The inherent properties of rail regarding energy efficiency are even more important given the current context of energy scarcity. For reaching climate goals, rail is the natural choice for climate-friendly transportation.

Additional 570bn ton-km would be transported on road in 2030 assuming constant modal shares

Additional freight transport 2030 vs. 2018



However, the inherent superiority of rail will not materialize in the current European setup:

- Nothing changed, the expected growth of transportation would require even more trucks resulting in an additional 570 lbn Tkm by trucks compared to 135 bln Tkm by rail and a mere 45 bln Tkm by inland waterways.
- This results in 1 million trucks if there are no policy interventions. 1 million trucks is the equivalent of the entire current German truck fleet
- This would render the aspirations of the Paris climate deal for the transportation sector unachievable.

Growth of road freight traffic will have a significant negative impact on reaching the Paris 2030 goals for Transport sector

Estimated impact on transport sector CO_2-emission target for Paris 2030

Excluding aviation, EU 28, 2030

WITHOUT TECHNOLOGICAL IMPROVEMENTS

~ 220 Mio. tons p.a.

Is the Paris 2030 absolute CO_2-target for the entire transport sector (incl. passengers transport)[1]

~ 80 Mio. tons p.a.

Of additional CO_2-savings are required due to the expected growth of road.[2]

Due to reinvestment cycles, efficiencies must be technically realized by latest 2025

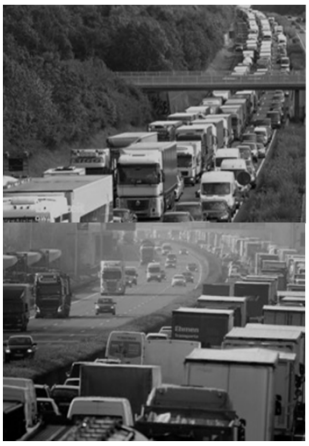
- 1 Based on total 2015 CO2-emissions of transport sector of ~ 880 Mio. tons, including ~ 275 Mio. tons from road freight. As non-ETS-sector (Emission Tracking Scheme), transport has to reduce emissions by 30% based on 2005 levels until 2030
- 2 Total of 300 Mio. Tons CO_2 corresponds to ~35% of 2015 emissions by transport sector

Source: UNFCCC, UIC Handbook, OECD

A few numbers say enough. Already the Paris climate deal requires the reduction of 220 mln Ton CO2 if Europe wants to honour the deal. Transport growth will c.p. add an additional 80 Ton of CO2 to this target.

Road congestion in 2030 will continue to lead to significant stress and hamper the European economic development

Estimated impact of road congestion in 2030



120 - 140 hours

are wasted in 2030 per year by every European driver due to congested roads[1]

95 bn EUR

is the total economy-wide cost[2] in 2030 for FRA, GBR and GER alone (40% of EU population). In comparison, this is 1% of total GDP of these countries!

1 Data based on sample countries FRA, GBR, GER and includes planning time index
2 Assumes average 2017 USD : EUR exchange rate (1.127 USD/EUR)
Source: INRIX, CEBR analysis, OANDA

Adding to the climate externalities, there are further costs attached to growing road transportation/

Another 20 to 40 hours in traffic jams per person and year, resulting in 95 bn EUR extra costs in France, Great Britain and Germany , which is roughly 1% of total GDP.

The increase in road transport will cause accidents and pollution with ~ 70,000 additional dead citizens until 2030

Estimated impact of road freight transport growth on mortality

WITHOUT TECHNOLOGICAL IMPROVEMENTS

~ 60,000 premature deaths

between 2018 and 2030 attributable to air pollution[1] due to additional road freight traffic

~ 8,000 fatalities

in road accidents with trucks between 2018 and 2030 due to additional road freight traffic[2]

1 Premature mortality and morbidity due to $PM_{2.5}$, NO_2 and O_3
2 Total fatalities in accidents involving heavy good vehicles, linear extrapolation 2014 - 2030
Source: EAA (European Environmental Agency), EU commission

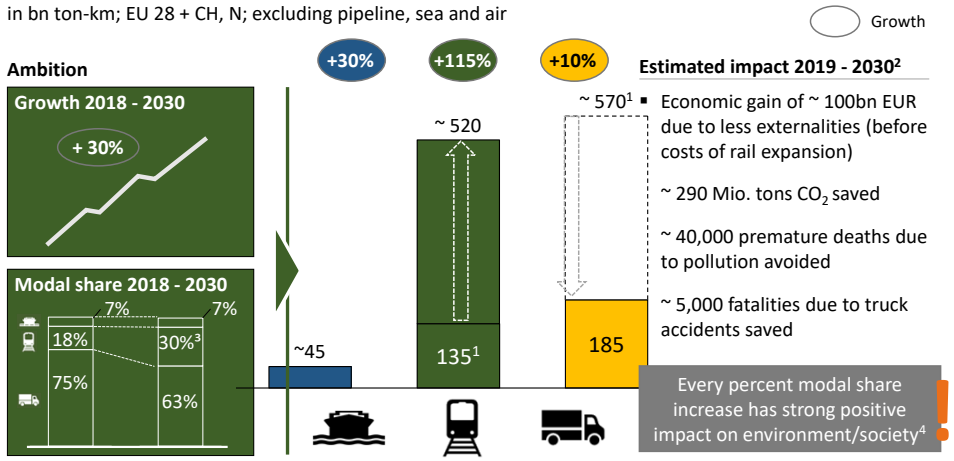
Europe would suffer 60.000 more premature deaths due to pollution and 8000 road fatalities.

The conclusion is clear. Society can not bear this increase in transport if no significant modal shift is realised.

This story is explicitly true within a European context but also other continents will face the same issue.

A higher modal share of 30% rail freight by 2030 is the macro-economical better solution for European transport growth

Impact of modal shift on additional freight transport 2030 vs. 2018



1 Freight transport growth without modal shift
2 Assuming linear growth of rail modal share from 18% in 2018 to 30% in 2030
3 Average for Europe, not each country; shares in AT (32%) and CH (37%) in 2015 even higher; conditional ambition (see next chapter)
4 Reduction of ~ 8 bn EUR in external cost, ~ 25 mio. tons CO_2, ~ 3,500 premature deaths/fatalities (assuming constant growth)

Source: CER, EuroStat, EU Commission, EAA

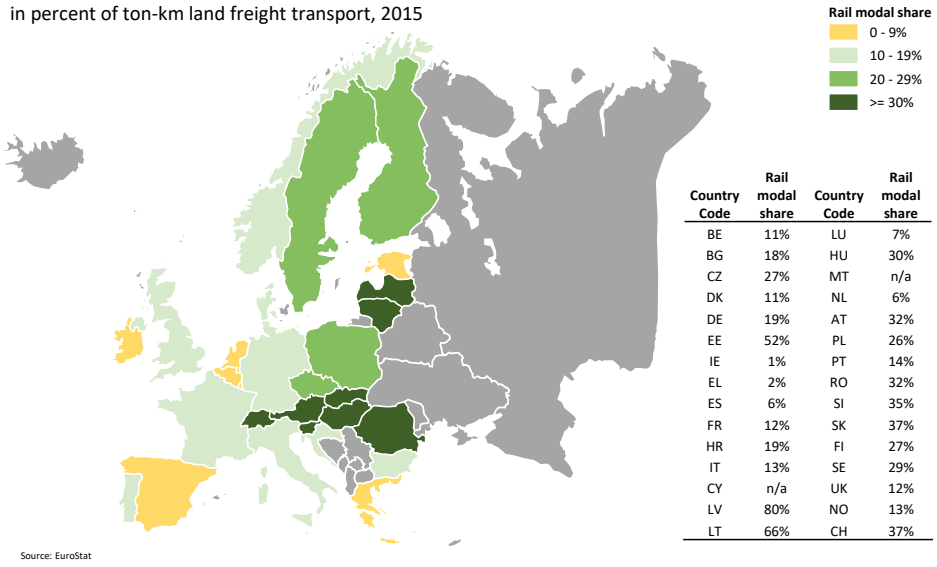
A shift to rail to accommodate the growth of transportation would benefit society substantially. Road transportation in absolute terms would remain constant, while the overall growth would be covered by rail. The share of road transportation would go down from 75% to 63% by 2030 in Europe.

The economic and societal gains of this modal would be substantial. By 2030 such a modal shift in Europe means 100 bln euro reduction in externalities. Over 290 mio tons of CO2 would be saved, 40.000 premature deaths and 5000 casualties due to truck accidents would be avoided.

A modal share of 30% is possible – as demonstrated by countries in Northern and Eastern Europe

Modal share of rail in European countries

in percent of ton-km land freight transport, 2015



Country Code	Rail modal share	Country Code	Rail modal share
BE	11%	LU	7%
BG	18%	HU	30%
CZ	27%	MT	n/a
DK	11%	NL	6%
DE	19%	AT	32%
EE	52%	PL	26%
IE	1%	PT	14%
EL	2%	RO	32%
ES	6%	SI	35%
FR	12%	SK	37%
HR	19%	FI	27%
IT	13%	SE	29%
CY	n/a	UK	12%
LV	80%	NO	13%
LT	66%	CH	37%

Source: EuroStat

A modal share of 30% is feasible, as it is already proven in Northern and Eastern Europe. In fact, the most populous, central and western European countries have the lowest share of rail transportation, with particularly France, Italy, Spain and Germany lagging behind. Due to the relatively high share in the European economy, it is imperative that Central Europe catches up.

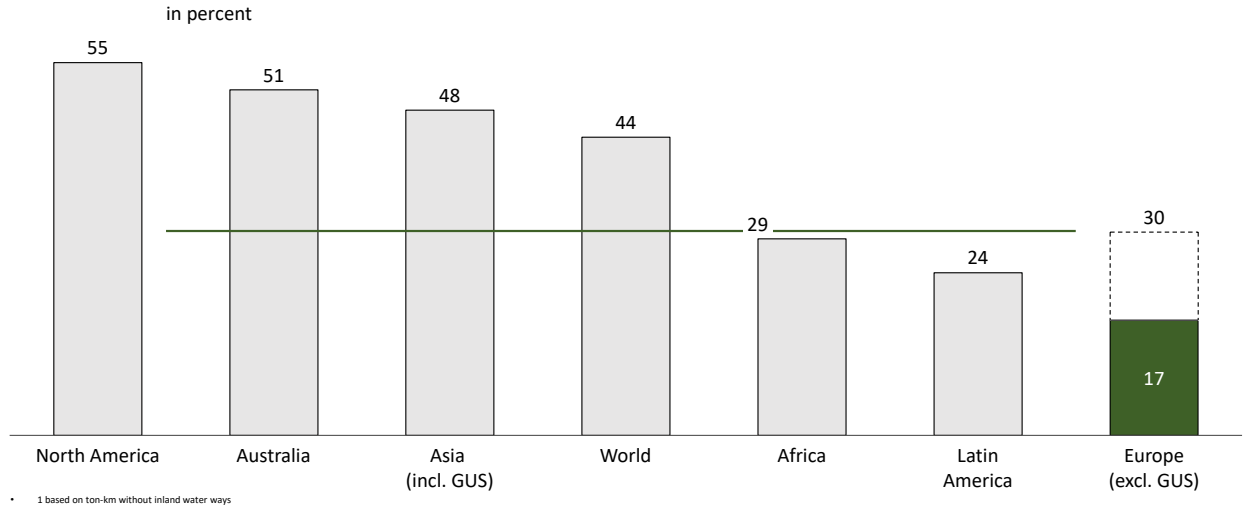
Research show a high correlation between an integrated set of policy measures and the market share for rail. Data is proving, that countries with an all encompassing transportation and rail policy tend to have a more balanced modal split than countries which do not have this. Of course exceptions exist but these are mainly due to the national/local industrial set-up. Countries with high shares of basic industries that have a high affinity to rail will obviously show higher levels of rail share

What does this integrated policy encompass? It is a combination of a number of elements.

- First an appropriate legal framework is needed. This legal framework should be comprehensive, including all modes of transportation or even comprise the entire logistics system.
- Second, it requires incentives for modes of transport which are more environmentally friendly. This can be by taxation of externalities or subsidies.
- Third, governments should design an investment strategy which favours modes of transport or initiatives within each mode of transport that cause the least externalities. The most obvious way to do this is investment in physical infrastructure, however digitization is becoming increasingly important. It is proven that government investments in digital initiatives are more efficient and have shorter lead times. Knowing that investment cycles in physical rail infrastructure tend to be at least 10 years, upgrading the infrastructure through digitization is imperative, as it is more efficient, has shorter lead-times and basically no externalities.

On a global scale, a modal share of 30% would match Africa and would still be lower than the world average of currently 44%

Modal share of rail 2011/2012[1]



1 based on ton-km without inland water ways

30 by 2030 – Rail Freight strategy to boost modal shift

In Europe, rail accounts for only 18% of land freight transport. The low modal share of rail freight in Europe is even more remarkable, as Europe is already the continent with the lowest share of rail transportation in the world. This is of course due to lack of investment in rail infrastructure on the one hand, but even more due to technical barriers, making Europe a patchwork of different, not compatible rail networks ultimately resulting in limited competitiveness in regards to road.

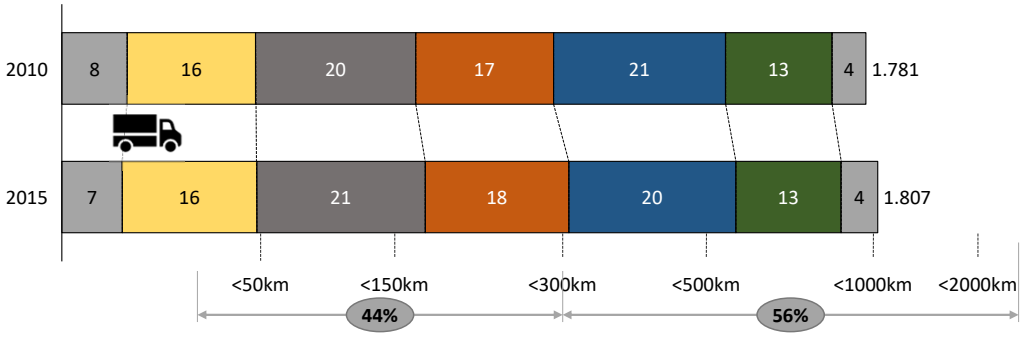
Other regions perform much better. Northern America is a showcase – their rail accounts for around half of all land transport.

Due to significant infrastructure issues the share of market in Africa is very limited and almost most non-existing.

Substantial share (56%) of road freight market attractive for rail in terms of distance

European road freight transport by distance

in percent bn ton-km, EU 28 + CH, N



- Distance structure of road freight transport rather constant over time with small gains for low distances
- Road freight transport below 300km (44%) rather difficult to shift to rail since rail cannot weigh in its cost advantage on long distances
- 56% (1,012 bn ton-km in2015) with distances longer than 300km should in principle be addressable by rail freight. This corresponds to twice the size of total rail freight volume in 2015 (429 bn ton-km)

Source: EuroStat

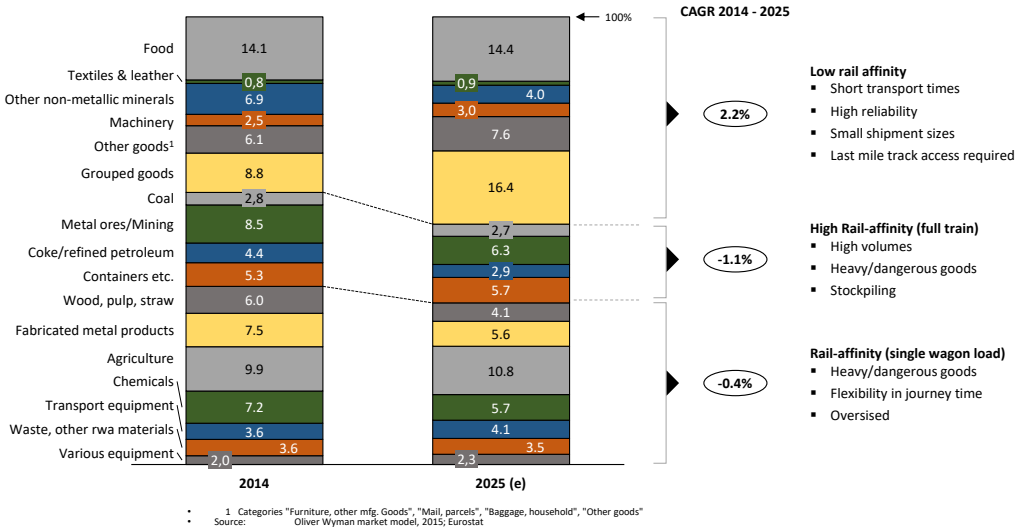
Challenges for increasing the modal share of rail are significant, but the potential is available. The point is proven by looking at the shares or distribution of the total trucking market in relation to the distance. For example, of the total truck kilometres driven, only 8% of those were for trips shorter than 50km, which is the “sweet spot“ for trucks. The average distance of truck trips has even slightly increased over the years. Knowing that rail is more efficient on longer distances, the potential for rail should slightly increase in the time to come.

In principle, 56% of the road freight is prone to be replaced by rail. Rail - ignoring technical barriers to interoperability between countries - is particularly attractive for distances greater than 300km.

The share of transported goods with low affinity to rail is projected to grow significantly

Transport market structure by goods, 2014 - 2025

in percent ton-km, EU 28 + CH, N



1 Categories "Furniture, other mfg. Goods", "Mail, parcels", "Baggage, household", "Other goods"

Source: Oliver Wyman market model, 2015; Eurostat

Although the potential is high, there are still some hurdles to overcome since growth in transportation has and will come predominantly in areas, that for various reasons have a lower affinity to rail transportation

- Short transport times
- High need for reliability
- Small shipment sizes
- Last mile access required

The solutions to this challenge are two-fold

- Rail needs to grow over proportionally in sectors, that are stagnant and even shrink in size, making the goal of 30% even more aspirational in the short-run
- Rail needs to find solutions to become more reliable, efficient and able to deal with product categories for which it is not designed by nature. Innovation and digitisation are some of the answers. Innovation in different transhipment technologies which make transferring loads from or to rail more easy and more efficient. Digitisation will be required to make rail load more transparent and easier to follow by its customers.

Maintaining current modal share already is a challenge for RUs

Risk of decline of rail modal share[1]

… reduces the share of goods that traditionally have been on rail

- Strong growth of (consumer) goods with low affinity to rail[2]
- Negative growth of goods with (high) rail affinity (e.g., coal, metal, ores, wood)

… lead to higher transport requirements for all goods (easier fulfilled by road)

- Smaller shipment sizes
- Increased pressure on price
- Shorter lead and transport times
- Higher reliability of transport

… is expected to reduce the price of road transport tremendously

- Gigaliners
- Platooning
- Autonomous driving
- E-Trucks with overhead wires

1 Also see backup pages in appendix
2 Due to small shipment sizes, short transport time requirements, JIT-delivery …

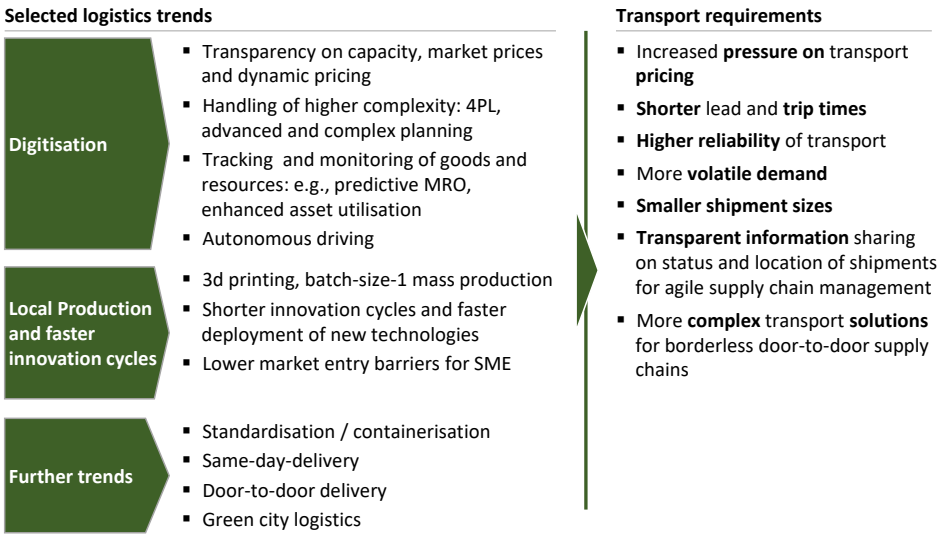
Also, rail will have to cope with general trends in the market which could lead to an advantage for road transportation – particularly if current cost levels are maintained and external costs are not charged. In some continents the changing industrial context does not favour rail as we move away from a traditional heavy industry in more smaller and faster load industrial set-up. The growing share of E-commerce evolutions is certainly a trend that should be observed.

Innovation in other modes of transport will also not stop. Inland waterway transportation is heavily innovating in autonomous ships. Showcases exist, where one shipper is simultaneously controlling 3 to 5 inland water vessels. Innovation programs exists to switch from heavy emitting diesel engines into less sulphur emitting and more clean engines.

Also trucking is heavily innovating. Platooning where several on itself autonomous trucks are coupled to create freight platoons are tested. Electrification for heavy duty transport is on the edge of industrialisation. Truck manufacturers are experimenting with autonomous driving. Already some passenger bus lines on specific stretches are being operated by driverless busses.

Logistics trends such as digitisation evolve in higher transport requirements for all goods

Logistics trends and evolving transport requirements



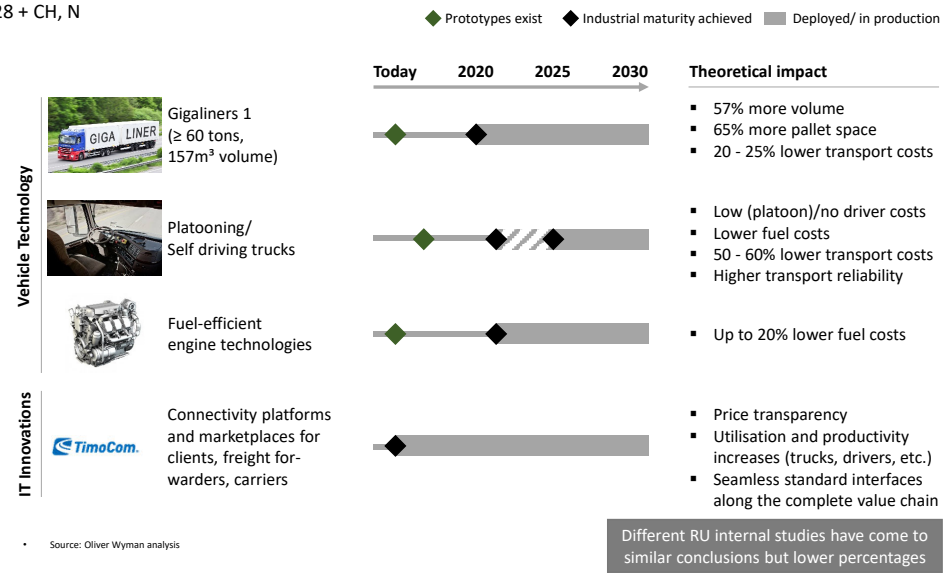
General industry trends require an agile reaction of transportation in general and of rail freight more in general. Some of those trends are Digitisation, first trends towards more localised productions – at least for some highly innovative industries and some other trends like green city logistics, same-day delivery and further containerisation.

The effects on rail freight will be a continued pressure on pricing, shorter lead times required and even more complexity in multi-modal supply chains.

Cost of road transport is expected to decline tremendously until 2030

Core upcoming road technology innovations

in bn ton-km, EU 28 + CH, N



In the road sector, costs are expected to go down dramatically, rendering road transport c.p. even more attractive. Already today the introduction of longer and heavier trucks is creating a cost-reduction of about 5-10%. Platooning is an answer to driver shortages which is occurring in certain regions. Rising living standards and ageing of society will reduce the availability of drivers. Platooning (meaning you only need 1 driver for 5 trucks) and autonomous driving are adequate answers to this problem.

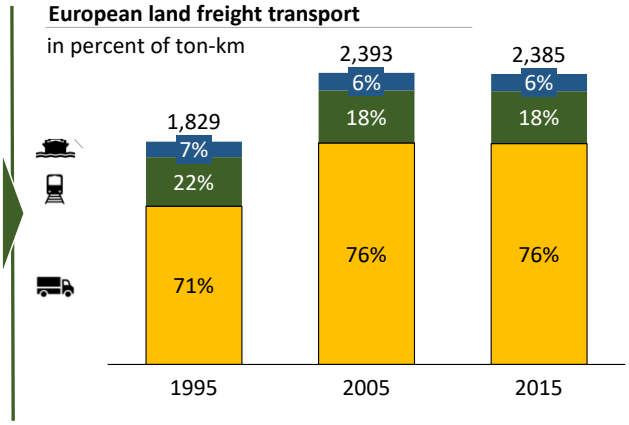
Costs will further go done due to more efficient fuel technologies. Last also digitisation will further develop in the road sector making it more efficient (more load and better routing).

In a nutshell – rail needs to increase the pace and to close the efficiency and effectiveness gap.

Despite promotion of rail freight being a key part of EU policy for the last 25 years, there have been no satisfactory results. There needs to be a fundamental change to the system

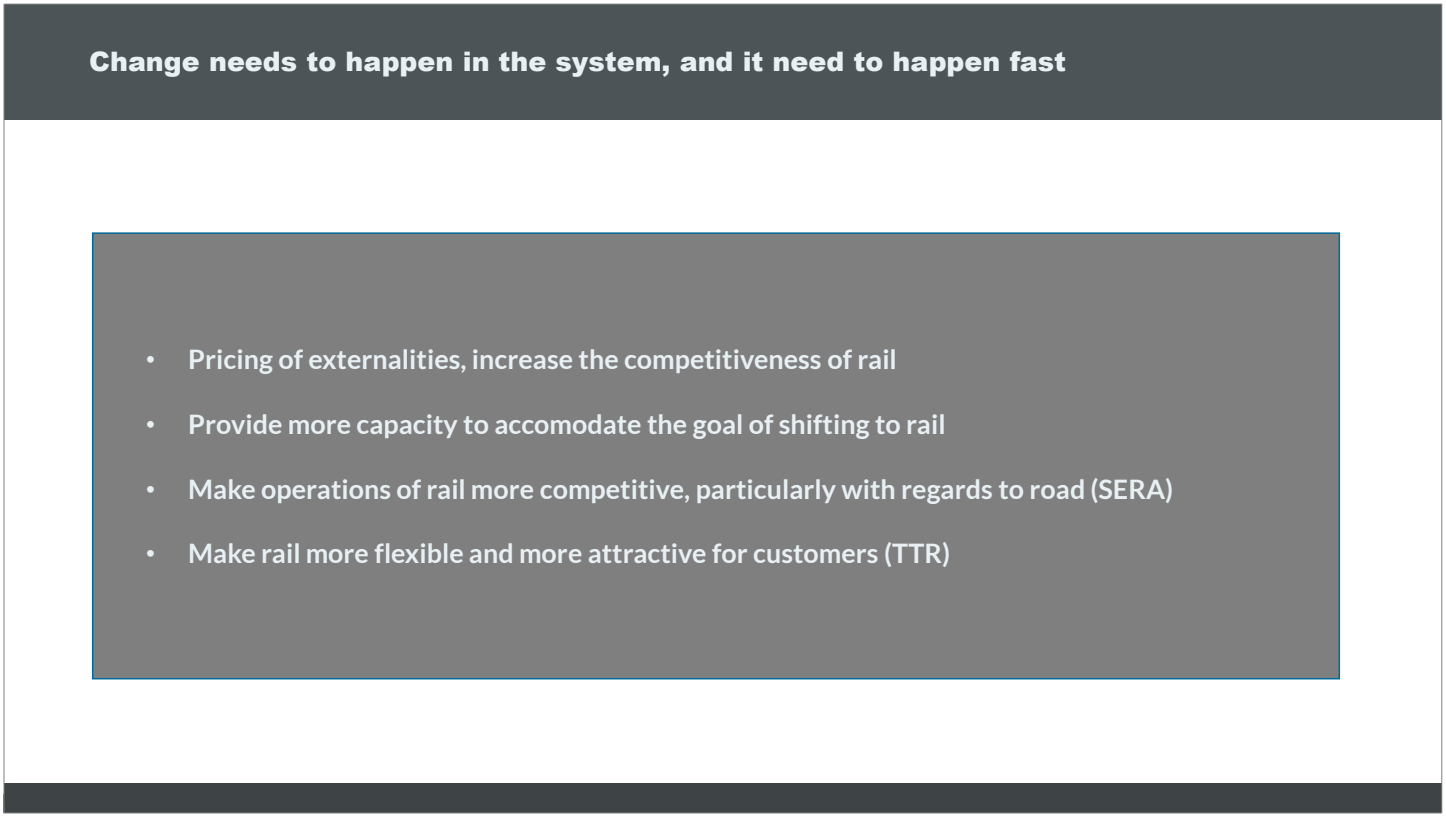
Actions taken by EU Commission

- Release of White Papers (last 2011) for the future of transport with objective to shift goods to rail (30% modal share of rail freight for distance >300 km by 2030 and 50% by 2050)
- Release of 4 railway packages (2001, 2004, 2007, 2016) with directives to be implemented to increase modal share of rail freight
- Contribution of 28 bn EUR to funding rail projects from 2007 until 2013



Source: EU Commission, European Court of Auditors

So far Europe has been unsuccessful in promoting rail to a higher modal share. Several railway packages with the aim to increase the modal share of rail freight have not delivered on the desired results. In fact the modal share of rail has dropped from 22% in 1995 to 18% in 2005 and has stagnated ever since. This is reflecting the of c.p. worsening competitive position of rail freight when compared to road.



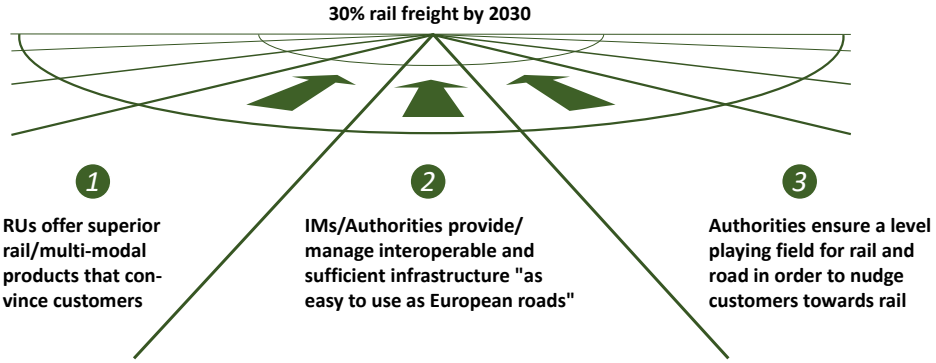
There needs to be a fundamental change to the system that addresses four areas

- More capacity, particularly on the main transport routes through investments in physical infrastructure and digitization of the existing network
- Dedicated capacity to rail freight
- Establishment of SERA (Single European Rail Area)
- Making rail more flexible and attractive for customers (TTR)
- Drastically improving the relative cost position of rail by making sure to price externalities of road transportation

Decisive joint actions are required by RUs, IMs and Authorities in order to achieve the target modal share of 30%

Fields of action

in percent rail freight model share

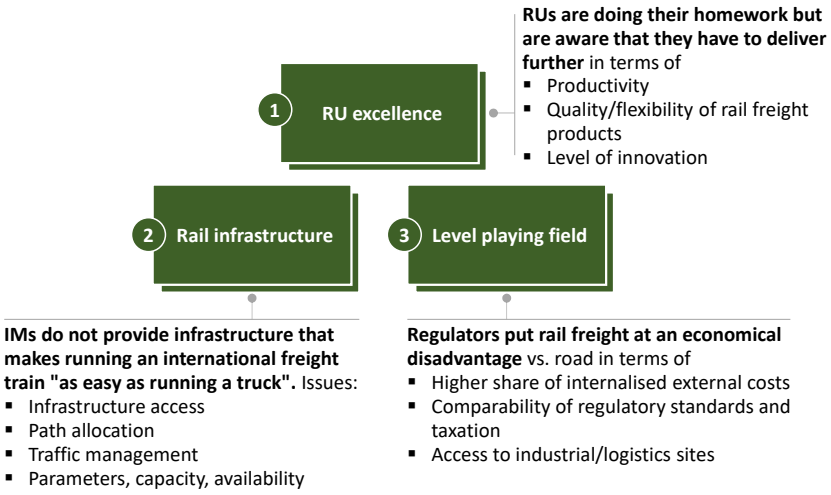


In fact, all parties of the system need to work together along a shared vision to make the modal shift happen.

An all encompassing and holistic approach can fundamentally increase the modal share of rail: The Railway undertakings, The Infrastructure managers and the authorities or policy makers need to work together. RUs need to provide innovative, integrated and digitised solutions. The IMs need to evolve from a maintenance culture into customer oriented flow managers. The authorities need to provide a stable legal framework which supports a level playing field between the different modes of transportation.

Modal shift is currently prevented by issues in 3 fields

Challenges for modal shift



However, so far the common and shared knowledge of the deficiencies of the current system has not yet led to a fundamental revamp of the system. The rail system is struggling with a number of issues. RUs have not reached a level of customer excellence that attracts new customers. The IMs are not dynamic enough to adhere to the demands of their customers, the RUs, who rely on the system to fulfil the customer demands

It can be questioned whether authorities fully understand the impact their policy initiatives can have on the modal shift, on the positive or negative side. Long lead times in investments in rail with little improvements in the meantime – as disruptions become greater with the level of investments – make investments in rail hard to communicate to the broader audience.

Creating a level playing field for all modes of transportation would have a major impact on the modal share of rail. The choice of the logistics supplier remains predominantly driven by price. As long as externalities of road are not reflected in the internal contractual price between parties, little will change. It remains the task of the authorities to assure that total costs are reflected in the prices of the different modes of transportation.

More physical infrastructure and a fundamental shift in legislation to more favorable conditions for rail is cumbersome. Digitization of the existing system is an obvious way to proceed. It reflects the needs of the customers. Digitization has relatively short lead times and does not disrupt the functioning of the system in the short to medium term. And digitization requires less capital, therefore delivering higher rates of return (important for IMs and the authorities who deal with limited budgets).

DIGITALIZATION AS A LEVER TO ENHANCE RAIL COMPETITIVENESS AND SUSTAINABILITY

S Géhénot & P Van den bosch

From the previous chapter we have learned that modal shift is the only way forward to cope with the expected growth in transport without making it unsustainable from a societal point of view.

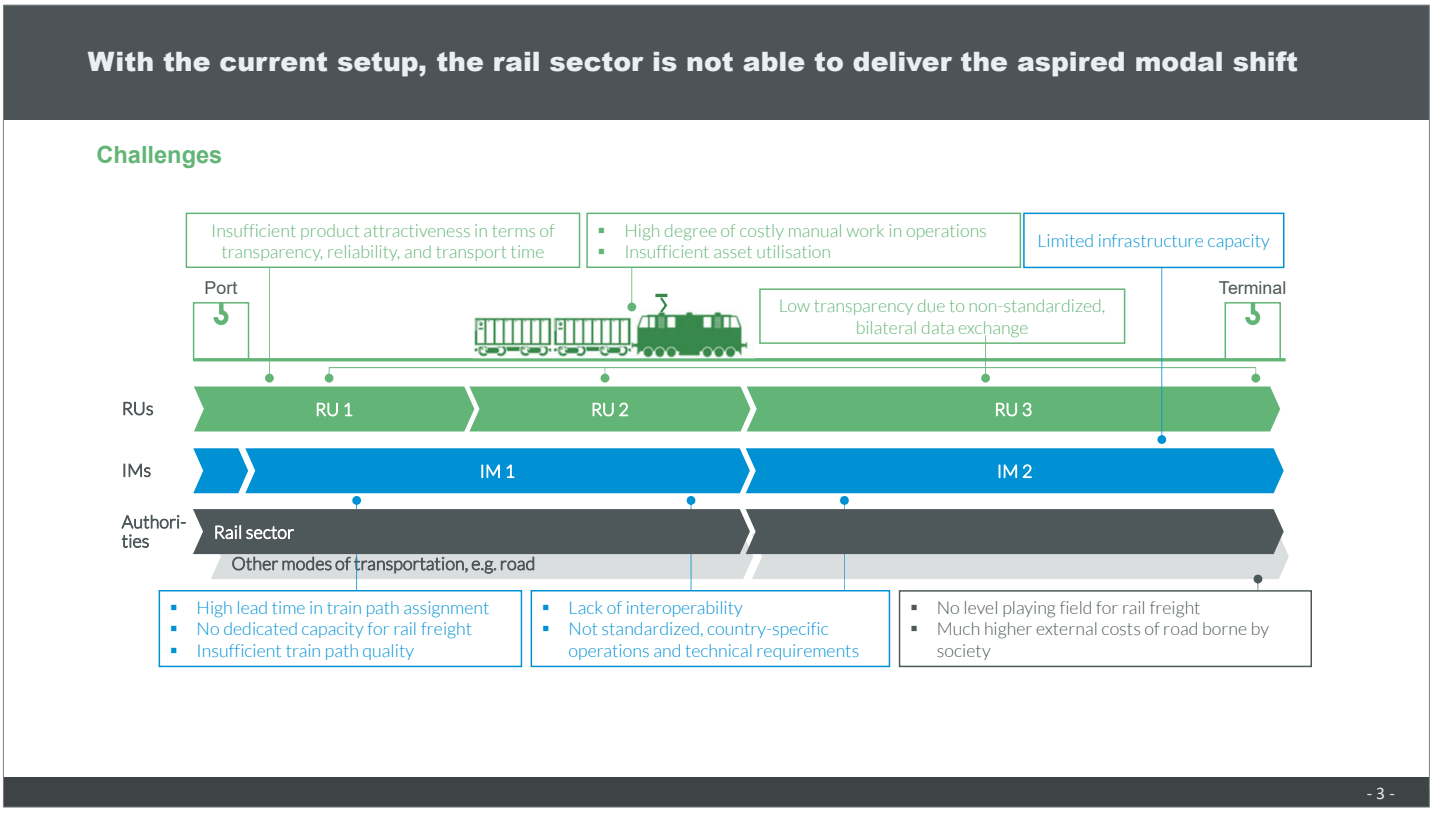
We have learned that all stakeholders in the sector are needed: RUs, governments and Infrastructure managers. A sound strategy going forward needs to change the system in several ways. A sound legal framework and sufficient capacity will be needed. RUs need to innovate in solutions and products that adhere to contemporary supply chain needs from its customers.

The most important leaver to improve the position of rail freight in the short- to medium term is digitization. Not only the customers expect it, but it also addresses the need for more capacity to realize the modal shift.

The European rail freight sector has committed itself to reach 30% modal share by 2030

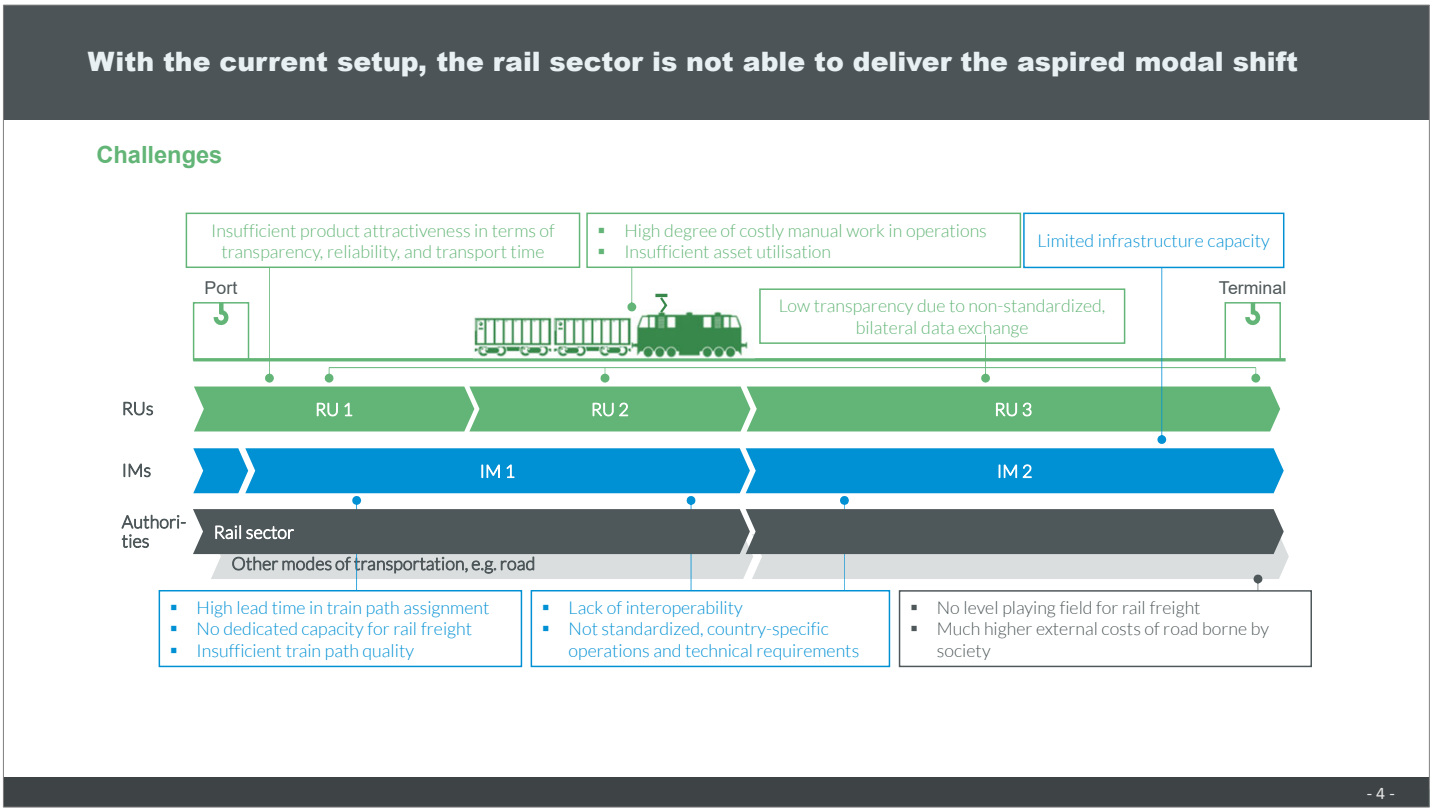
While this is not enough, it is a major step towards a sustainable future in transportation of goods on land

Ambitious targets of significantly increasing volumes via rail will need to be developed for all regions.



However, the current setup will not enable the ambitious growth targets for the rail sector. The problem is three-fold:

- Limited capacity: The current capacity in Europe is already constraint. Capacity has to be added (through physical investments and/or better management of capacity by means of digitization) to the network to support the aspired modal shift
- Bad management of capacity, leading to low product quality:
    - No flexible assignment of train paths, particularly short term, therefore no real match for road transportation
    - Bad path quality for freight
    - Lack of interoperability (with interoperability being of utmost importance, with 50% of all freight traffic being international in Europe), due to
        - Technical reasons (no common European train control system)
        - Different standards and regulations in each country
- Inherently low competitiveness of rail transportation in current setup
    - High cost position (insufficient asset utilization, manual work)
    - Relatively low product quality:
        - Transparency, reliability and transport time
        - Non standardized data exchange…

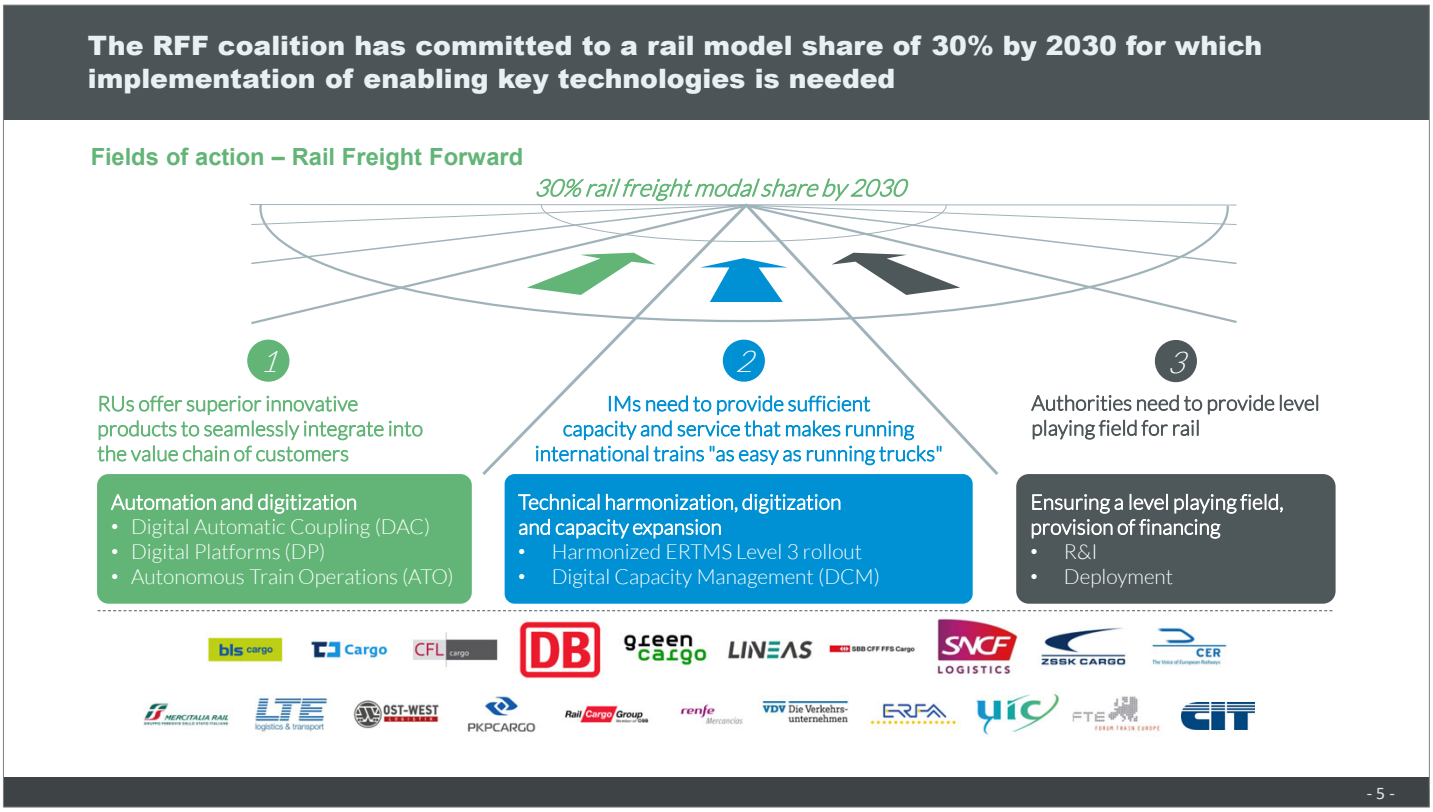


(continued)

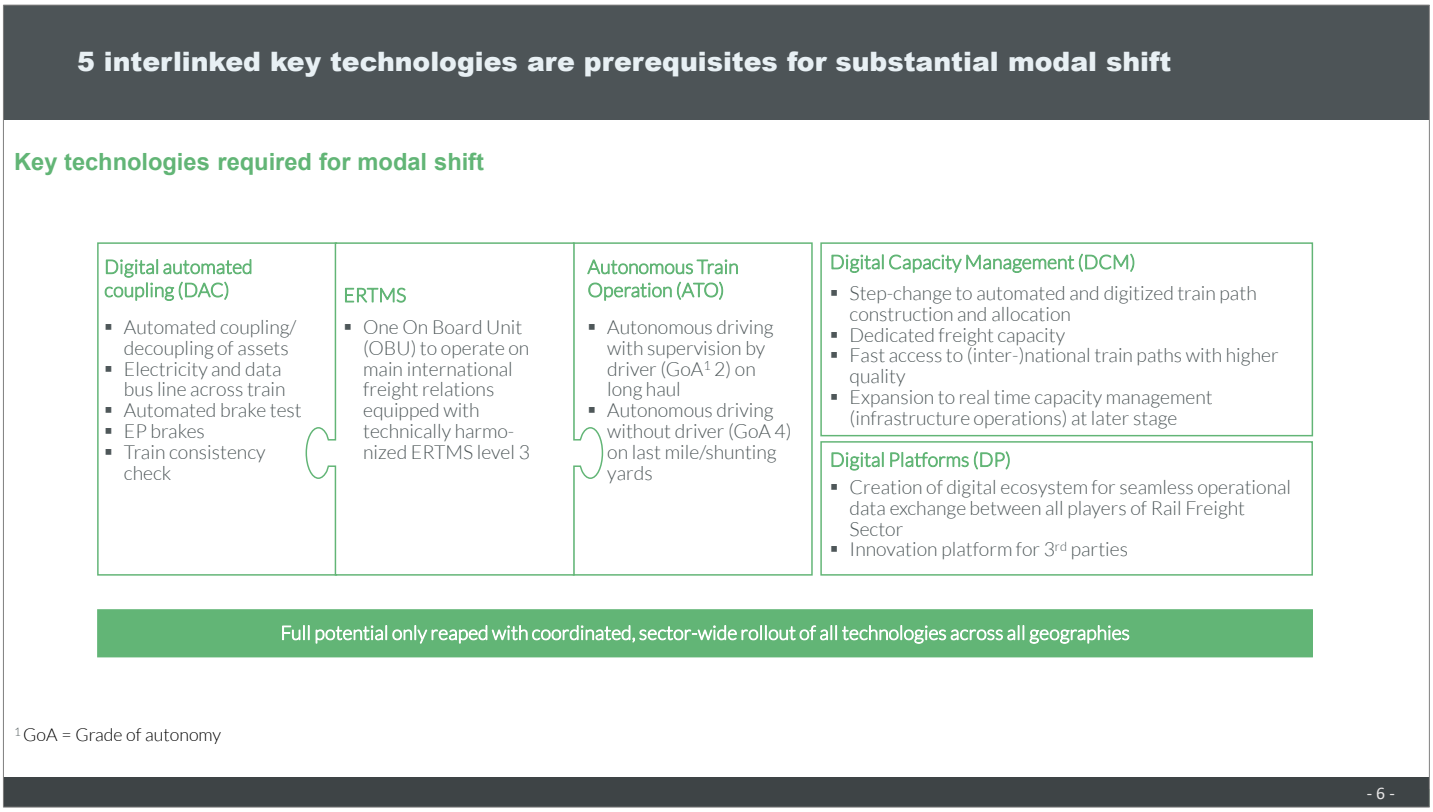
On top of this the sector is confronted with long life cycle of investments. It takes several years before project can be kicked-off. This has a number of reasons. Budgets tend to be big and tend to compete with other priorities. Even if budgets are available, societal support for these projects is not always available. The “not in my backyard” syndrome also applies of rail infrastructure investments.

Timings between principle agreement on a certain project and effective kick-off of the project are long. Also the life cycle of investments is long. Wagons and locos tend to have a life cycle between 30 and 50 year meaning, resulting in long lead times to fundamentally change the system.

However, initiatives focusing on process innovation and projects focusing on digitisation are a very attractive alternatives. They can be relatively easily implement with efficient use of funds and with shorter lead-times.



To make the modal shift happen, there needs to be a coordinated sector approach of the three major players. Digitization is the key to enhance/expand capacity, capacity utilization and product quality. Governments are pivotal to making the necessary changes happen, as they provide the legal framework as well as the financing.



A harmonized set of technologies will both increase capacity on the existing network as well as making rail freight interoperable.

The technologies go hand in hand and are strongly interlinked. The full potential of the technologies can only be reached if aligned and implemented more or less at the same moment. DAC, Digital automatic Coupling is the physical enabler of communication along a train and from that train to the track and to the control centres. The physical aspect is important but the physical coupling paired with data transmission is the real benefit for the rail system.

The European safety system ERTMS with its onboard aspects and track side aspects assure that the entire international system becomes interoperable. It also enables efficiency in the other digitisation projects as it will, if properly implemented, set a number of standards on which the other projects can be developed.

Digital Capacity management, Digital platforms for efficient train operation and eventually Autonomous Train operation will create the necessary efficiency to enable growth particularly in the short- to medium term given the long lead times of physical investments in rail infrastructure.

These key technologies provide strong benefits in terms of product quality, cost reduction, and available capacity

Benefits of key technologies to rail

	Enabler	DAC	DP	ATO	ERTMS	DCM
A Higher RU product quality	RU	▪ Faster delivery, higher reliability and lower cost	▪ Seamless operational data exchange across countries/companies	▪ Higher reliability (~15%[2] higher punctuality)	▪ Higher punctuality due to less failures of trackside signalling	▪ ~-6%[1] travel time, better reliability (train path quality), instant capacity check, dedicated freight capacity
B Cost reduction	RU/IM	▪ Improved utilization of personnel and assets	▪ Reduction of manual data gathering efforts, better utilization of wagon/train capacity	▪ ~10%[3 4] lower cost for energy (GoA 2), reduced need for drivers in shunting and first/last mile	▪ Decrease of infrastructure maintenance costs	▪ Improved utilization of rolling assets and drivers (up to ~15%[3]) and rail path engineers
C Better utilization of available infrastructure capacity	IM	▪ Higher speed, enabler for ERTMS level 3, more capa-city in marshalling yards/terminals	▪ Optimized utilization of wagon capacity	▪ ~10%[2 3] on top of moving blocks (optimized distance between trains)	▪ Level 3 moving blocks: +~40%[2 3]	▪ ~+4%[1] through optimized rail path planning/assignment
D Better working conditions	RU/IM	▪ Higher safety and more ergonomic working conditions		▪ Reduction of on-train operations and better utilization of bottleneck resource driver	▪ Higher safety	

[1] DB Netz / [2] S2R / [3] Expert interviews / [4] ÖBB
GoA = Grade of autonomy; GoA 2 supervision by driver, GoA 4 without driver

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All technologies depicted will help to increase the competitiveness of rail. They form a system approach and need to be implemented in a coordinated manner at a European scale.

Rail will need to deliver higher quality products, will need to further reduce costs to keep up competition with other modes of transport, will need more capacity but will also need to use existing capacity more efficiently. Finally the sector will need to maintain good working conditions. In a playing field with scarce human resources, it will all come down to offering superior and more attractive jobs, already knowing that operational and executional jobs in the rail sector are often very demanding.

The digitisation initiatives will benefit all players in the sector. Society will hugely benefit from the technological upgrades of the system, as efficiency of public spending is increased, and investments in digitization will contribute to reaching the climate goals reiterated in the Paris climate agreements.

All 5 technological priorities have direct impact on product quality, cost position and the available infrastructure capacity. Also better working conditions are addressed: DAC through automated coupling will create higher safety for workers. Although ATO will c.p. to reduce the workforce needed, it is merely addressing the issue of shortage of personnel.

These key technologies provide strong benefits in terms of product quality, cost reduction, and available capacity

Benefits of key technologies to rail

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(continued)

Deployment of key technologies will strongly enhance RU product quality Transparency

- Improved booking of train paths ("one-stop shopping")
- Availability of dedicated, systemized rail freight capacity
- Seamless integration of transport chains via Digital platforms
- Seamless Track & Trace of goods

Transport time

- Significantly reduced transport times due to
  - Dedicated freight capacity bands with less disruptions
  - Better train paths

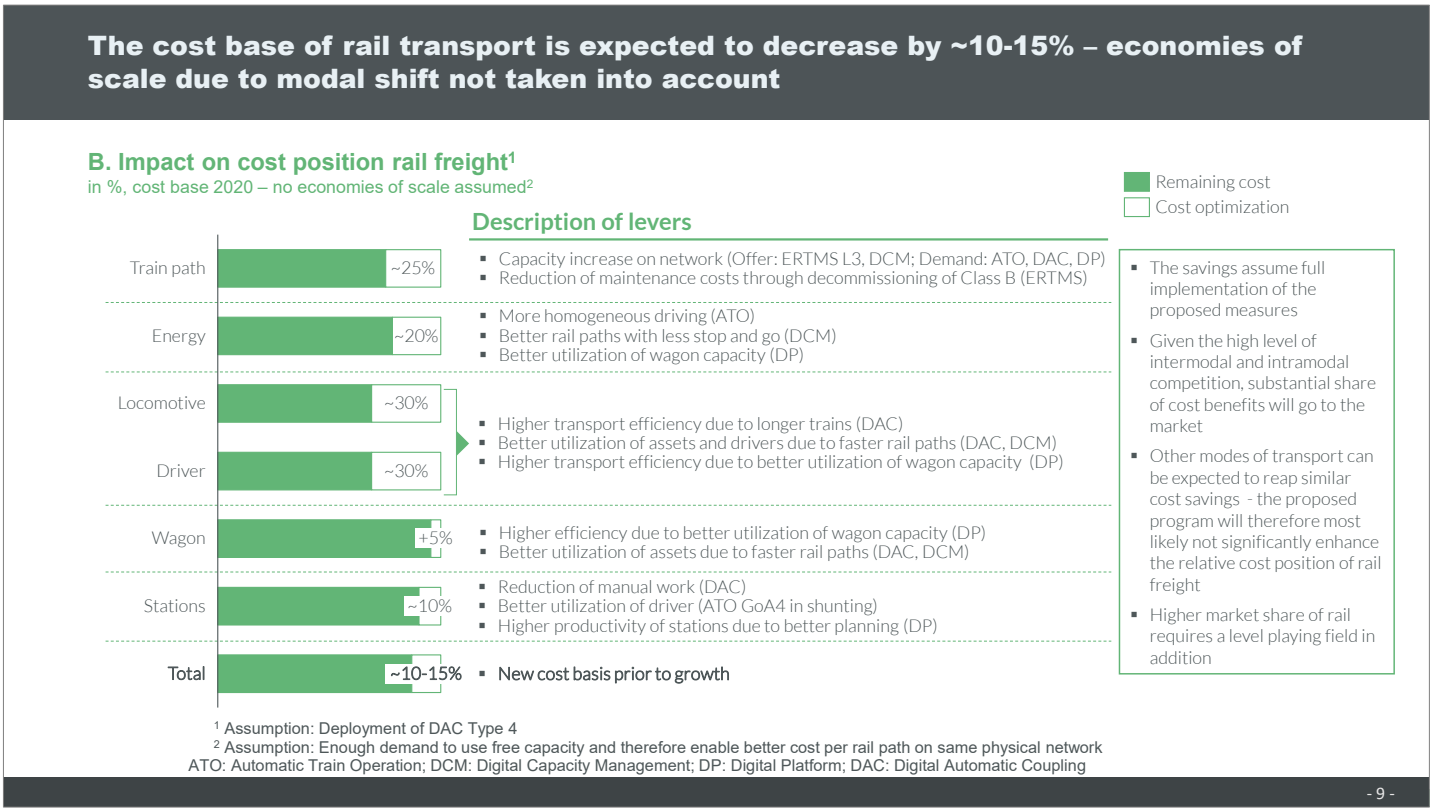
Reliability

- Higher punctuality
  - Less trackside signalling failures (ERTMS 3)
  - Less congestion due to significantly increased capacity (“moving blocks”)

Better synchronisation across Europe through data transparency

Less dependency on critical bottleneck resources (DAC, ATO)

As a result, supply will match the ambition for more demand



A number of high level industry expert calculations have been made on the expected impact of digitisation projects.

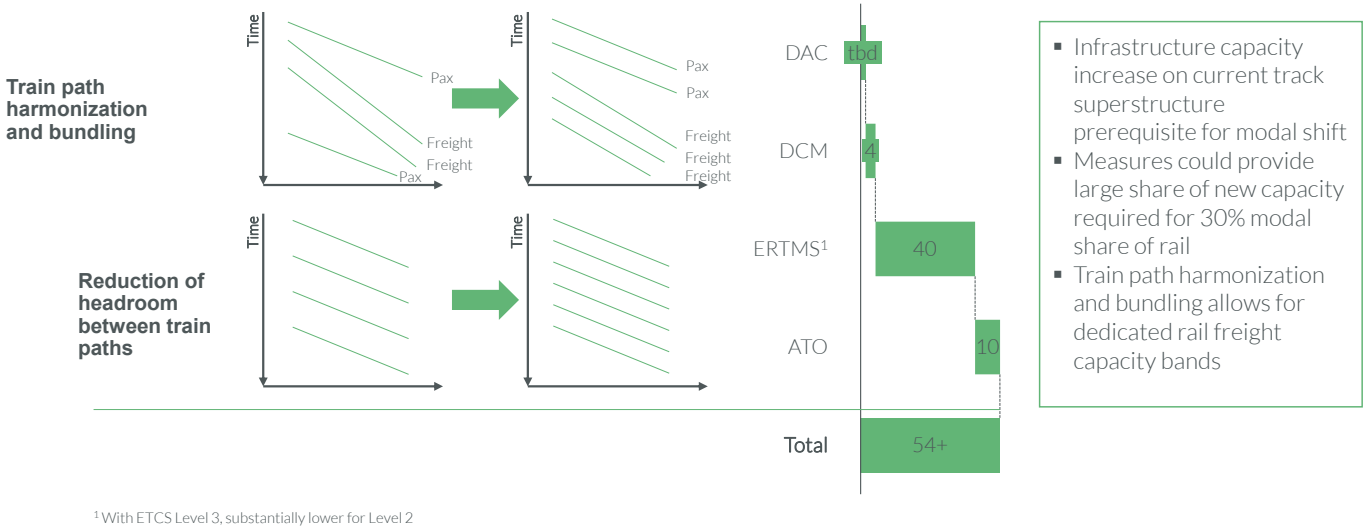
The sector estimates that these projects will have impact on all different aspects of freight train operations. Faster and better train path allocation, higher driver efficiency by better train paths, ,higher energy efficiency, better utilisation of wagons, locomotives and other equipment.

In total the benefits are estimated at 10 to 15% when compared to current costs.

Deployment of key technologies allows for strong capacity increase on current track superstructure without construction of entire new lines

C. Impact on infrastructure capacity

in % of current no. of train paths

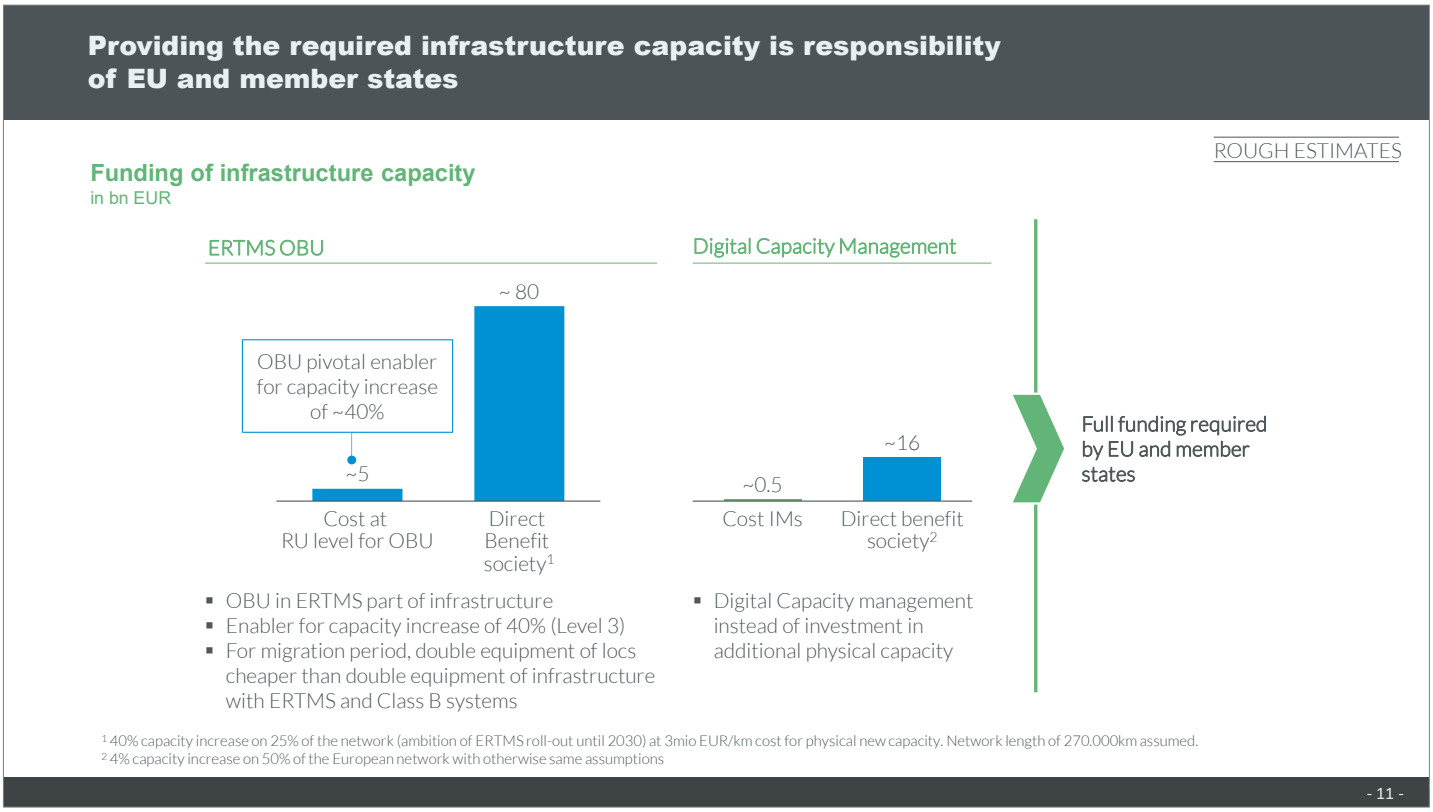


- Infrastructure capacity increase on current track superstructure prerequisite for modal shift
- Measures could provide large share of new capacity required for 30% modal share of rail
- Train path harmonization and bundling allows for dedicated rail freight capacity bands

[1] With ETCS Level 3, substantially lower for Level 2

- 10 -

Apart from the financial gains, the deployment of these key technologies will allow for strong capacity increase on current track superstructure without construction of entire new tracks. Train path harmonization and bundling allows for dedicated rail freight capacity bands



Investment in digitization is highly beneficial compared to investments in physical infrastructure. The provision of infrastructure capacity is a public good and therefore primarily the responsibility of national governments and the EU.

As the digital technologies have positive influence on the supply side of capacity, the rollout should largely be paid for by the governments in a coordinated approach.

But also given the current limited profitability leading to significant cash constraints, public funding will be needed. Without public financing the sector will not be able to fully adapt "mandatory" sector technologies DAC and Digital Platform. Additionally, clear and uniform regulation for deployment is needed to ensure full rollout. E.g. DAC will only be a gamechanger if roll-out as a network feature on sector scale, not as stand-alone for individual player.

Higher attractiveness of rail freight offering through mandatory, standardized technology platforms outweighs to large numbers versus the gains in societal costs. Calculations have shown that for example the investment in digital capacity management would cost around 500 mio Euro. To gain the same capacity increase via physical infrastructure investments would require 16 bln euro.

UN ESCAP FREIGHT DIGITAL TRAINING

JOINT ESCAP-UIC eLEARNING MATERIAL FOR ACCELERATING RAIL DIGITAL TRANSFORMATION IN ASIA-PACIFIC REGION

Introduction by Francis BEDEL (UIC)

The United Nations (UN) Climate Panel has urged everyone, particularly policymakers, to take action to achieve the Paris climate targets. Transportation must still make a substantial contribution.

This module introduces the sustainability challenge as well as the role of transportation in promoting a green society.

We are at the very beginning of a new era

19th century : 1st Industrial revolution

20th Century: - Oil revolution
- IT revolution
- And now, Digital revolution

- **Big Data**
- **IoT**
- **Cybersecurity Blockchain**
- **Cloud Computing Facial recognition**

Changes are exponential and we are only at the beginning.

Rail is and will remain the backbone of mobility of people and goods.

Rail from its origin has survived various revolutions:

- Industrial revolution at the very beginning
- Energetic revolution in the seventies
- Information technology revolution in the 80s - 90s

Today, we are now facing the so called 4th industrial revolution: Digital revolution.

This revolution is generating very strong impacts on all decision-making processes, all production and maintenance processes and obviously on the whole information chain itself.

Rail has obviously to take profit from this technical revolution to rapidly and efficiently improve productivity, security and services all this thanks to connectivity.

One key word is “rapidity” since we have currently to face very strong demands from the markets.

It can be either intra-urban markets, inter-urban, inter-regional or even inter-continental markets if we consider the emergence of large inter-continental corridors.

Digital technology is disrupting pretty much every component of railway operations:

- **Rolling stock**. Advances in automation, self-diagnosing, or real-time geolocation tracking mean that trains are becoming considerably smarter and safer.
- **Control and signaling system**
- **Railway infrastructure**. Internet of things sensors and devices are opening new possibilities for obstacle and damage detection, preventive maintenance, linkages with other systems,
- **Faster self-learning algorithms in Enterprise Asset Management** (EAM) systems make for more efficient dispatching, routing, and maintenance scheduling.
- **Smart monitoring and surveillance systems** are changing the way operators manage hazards, intrusions, railway crossings, and driver behavior.

International railway transport has been quite resilient during the pandemic. The crisis unleashed by COVID-19 pandemic provides an opportunity for railways of the region to further increase their comparative advantages in resiliency and sustainability by deploying smart rail solutions and deepening digitalization in railways to enhance the operational efficiencies. This would further support modal shift to rail thereby enhancing shift towards more resilient and sustainable freight in the ESCAP region.

The primary objective of this partnership is to support ESCAP member countries along the Trans-Asian Railway network in using the opportunity provided by the pandemic context to deepen sustainability of freight transport by enhancing the understanding of the railway policy makers for digitalizing rail operations.

Railways are undergoing major transformation driven by emerging digital technologies like 5G, big data, cloud computing, internet of things, automation, artificial intelligence, and blockchain. During and post COVID-19 digitalization offers huge prospects for railways, owing to the numerous benefits it can provide that include improved capacity, traffic management, reliability, energy efficiency, services, and lower operating costs.

However, digitalizing railways presents a formidable challenge, given the divergence in railway development among countries of the region and therefore needs to be managed with systematic and staggered approach. There is considerable disparity in financial investments in digital infrastructure, research and innovation, and digital skills in the region that needs to be considered.

In addition, the change in the mindset could by far might prove more complicated a challenge for railway authorities and companies, which will have to share data and consolidate business resources since rail digitalization modifies the business model, which must evolve from a rather rigid model towards a more dynamic network joining suppliers, technological platforms, mobility providers and customers.

This would need capacity enhancement of the railway policy makers to manage the transition to digital rail smoothly. The rail digital transformation can, therefore, be accelerated through capacity building initiatives for rail mangers of the region, particularly, for the landlocked and least developed countries to enable them to leapfrog to digital rail.

The potential benefits of digitization include:

- Performance
- Competitiveness
- Increased efficiency
- Improvements in safety and security
- Smaller environmental footprint

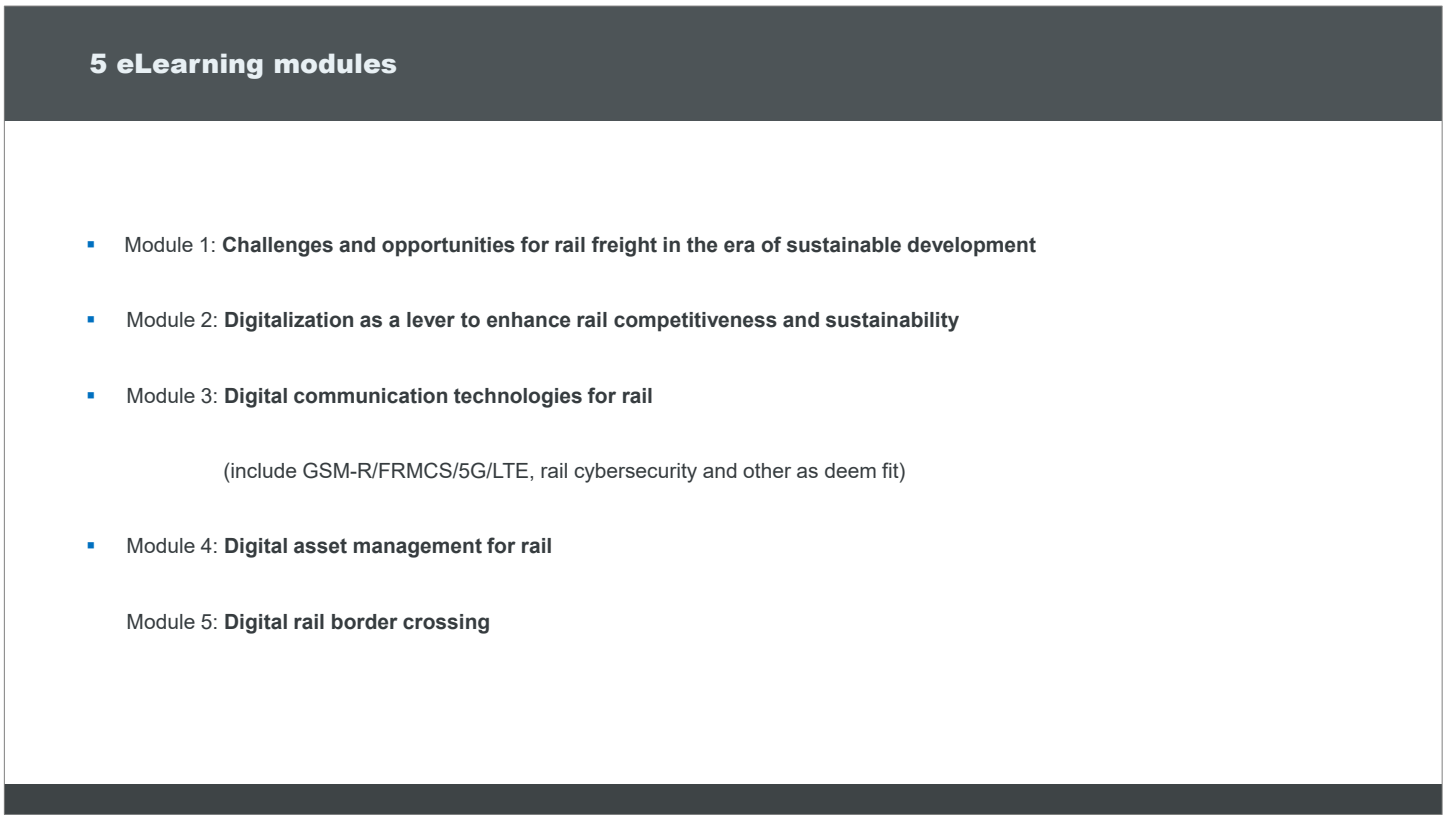
Digitalizing railway processes would not only enhance operational efficiency, but also it would support contactless and seamless rail connectivity in the region thereby encouraging shift to rail initiatives and promoting shift towards sustainable freight in the region.

It is hard to overstate the impact of digitization on the railway sector. In fact, digital technology is disrupting pretty much every component of railway operations:

- Rolling stock. Advances in automation, self-diagnosing, or real-time geolocation tracking mean that trains are becoming considerably smarter and safer.
- Control and signaling systems:
- Railway infrastructure. Internet of things sensors and devices are opening new possibilities for obstacle and damage detection, preventive maintenance, linkages with other systems,
- Faster self-learning algorithms in Enterprise Asset Management (EAM) systems make for more efficient dispatching, routing, and maintenance scheduling.
- Smart monitoring and surveillance systems are changing the way operators manage hazards, intrusions, railway crossings, and driver behavior.

With these breakthroughs, digital development provides a unique opportunity for railways not just to stay relevant, but also to increase their share in the overall logistics market, and to become an integral part of the transition toward greener, more sustainable freight transport. The potential benefits of digitization include:

- Performance.
- Competitiveness.
- Increased efficiency
- Improvements in safety and security
- Smaller environmental footprint.



With the e-learning package which is now made available for you, all the above mentioned trends will be detailed and explained in distinct modules:

Module 1: Changes and opportunities for Rail Freight in the era of sustainable development

Module 2 : Digitalization as a lever to enhance rail competitiveness and sustainability

Module 3 : Digital communication technologies for Rail

Module 4 : Digital asset management for Rail

Module 5: Cybersecurity

With this training, we aim at supporting you :

- To develop the capacity of the railway policy makers to manage the transition to digital rail.
- To deepen freight digitalisation in railways in ESCAP region.
- To understand better the challenges and opportunities of rail digital transformation
- To support and undertake with confidence projects and activities to digitalize their railways.
- To promote sustainable railway digital freight transport

At the end of the training, you will be able to:

- Contribute to a policy document on rail freight digitalisation
- Analyse and review a policy digitalisation document
- Identify key elements of a freight digitalisation strategy

Conclusion

The Digital revolution must be for Rail operators and manufacturers the unique opportunity to go faster and further in progress, enabling Railways in the world to once again be an actor and a vector of development of the 21st century.

The key success factor to be considered is the total involvement and commitment of the decision makers!

DIGITAL COMMUNICATION TECHNOLOGIES FOR RAIL

Sandra Géhénot & Philippe Van den bosch

Digitisation of freight will be the driver to make rail more competitive and gain more market share thereby contributing to less environmental impact of transport.

It has been proven in a number of studies that digital projects are faster to implement and that they deliver more value for the invested money. Typically in rail physical investment require a time span ranging from 5 to 10 years at least. In this digital era the same time span can deliver many digital improvements with similar impact on capacity, reliability or even safety.

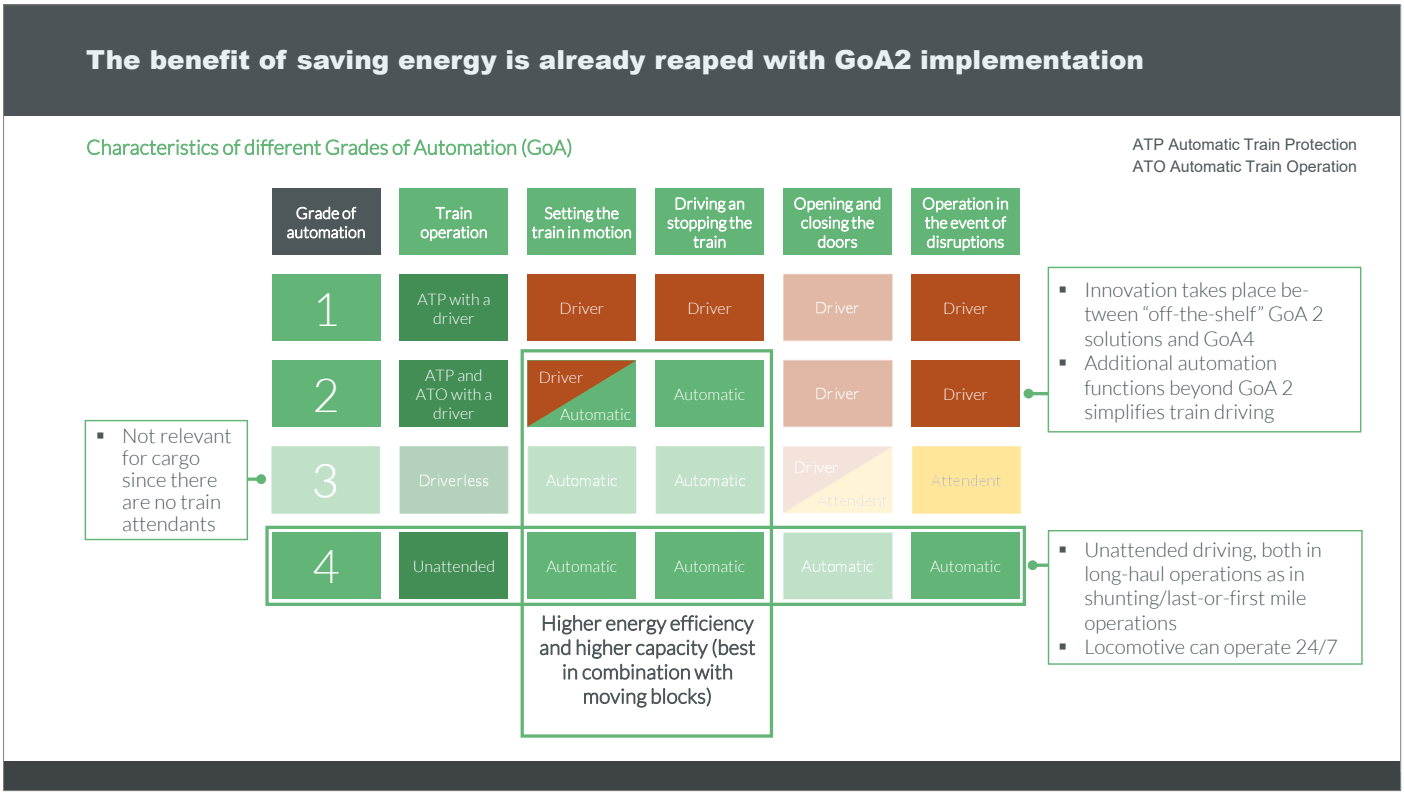
European Policy understood the importance of innovation in digitisation. Already the previous European Commission set-up a specific agency aimed at encompassing all innovation initiatives related to rail. To assure alignment with the sector the structure of a Joint undertaking was chosen A join undertaking is financed 50% by public funds and 50% by private sector funds. Decisions within that JU or Joint undertaking are taken on an equal share basis.

The following session will discuss more in detail a number of the key technologies which have been defined by the sector as levers to gain competitiveness. Public policy is supporting them with investments, support from innovation agencies like Europe's Rail and the necessary legislative framework.

GAME CHANGER 1

AUTONOMOUS TRAIN OPERATION (ATO)

Philippe Van den bosch



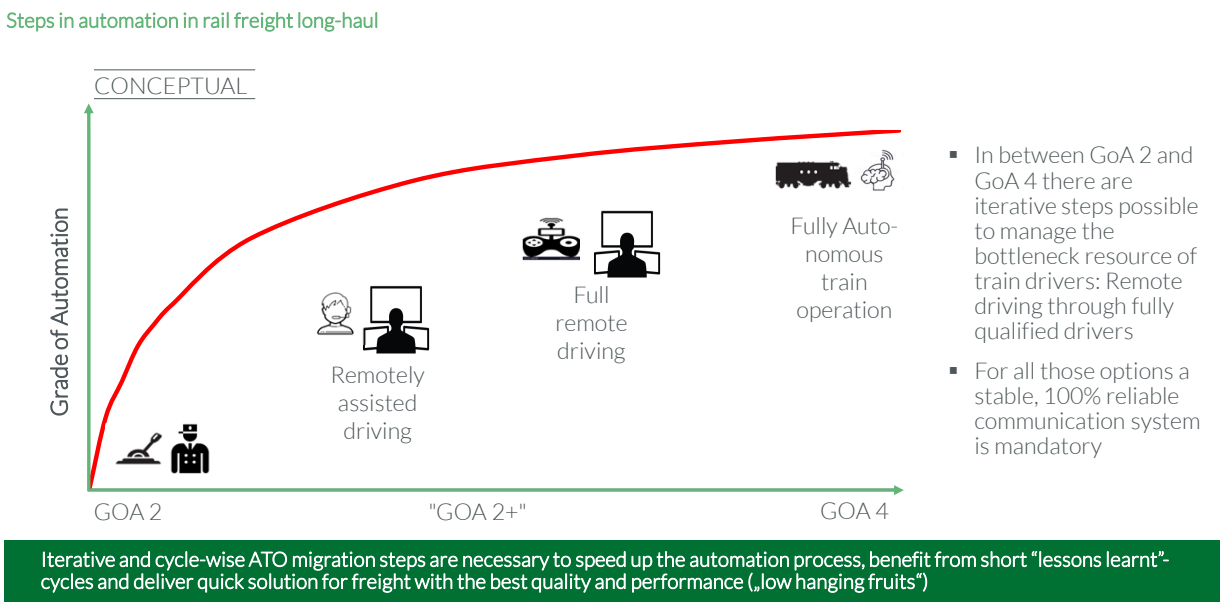
To know what we mean with automation a conceptual framework of the different levels of automation can be very helpful. Grades of automation are ranked from 1 to 4. The higher the number, the higher the degree of autonomy. As of GoA, Grade of Autonomy, level 2, the role of the train driver is becoming less important. At level 2 the driver is still in control in case of events and during operation. At this level of automation, the driver is assisted by smart systems to primarily assure a safe and more energy efficient operations.

As of level 2 driving the trains is (partially) done by the system. The driver is still in charge for safety.

ATO in general is more efficient. Energy is saved during accelerating and braking. The level of anticipation and management outperforms human capabilities. The highest system effects from automation are to be expected on capacity and energy consumption:

- The continuous calculation of optimum speed profile at any time avoids energy-consuming accelerating/braking. Some additional effects are:
  - Less wear & tear of brakes and wheels
  - Less noise
  - Less potential of train ruptures
  - Higher punctuality due to better flow
- Capacity effects will be obtained by combining ATO with moving blocks (e.g., ERTMS level 3) or optimized rail path operations (DCM)

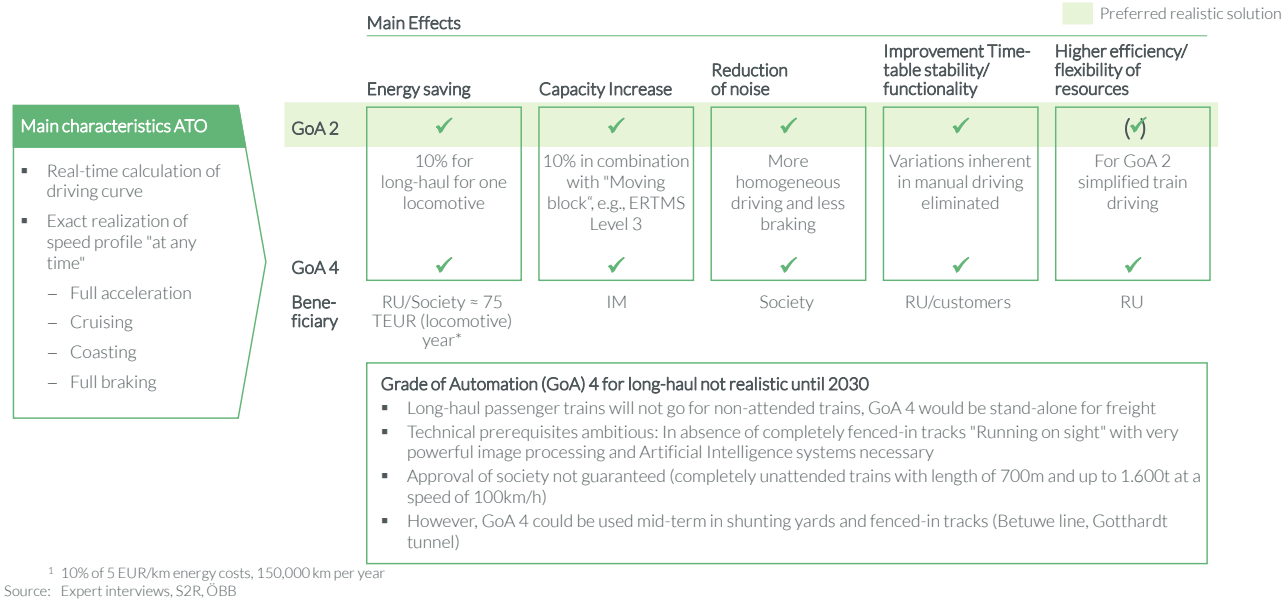
For rail freight, iterative automation steps from GoA 2 to fully automated train operation (GoA 4) are possible



Though level 4 is the optimum level of automation from a cost perspective, the sector believes, that GoA 3 will be the feasible state in the medium term.

Also the biggest gains are to be expected from GoA 1 to 3. Additional investments required to reach level 4 will probably not outweigh the benefits. From a societal point of view it is not likely that people will accept fully autonomous freight trains running through their backyard, even if objectively it can be proven that it is still the most safe means of transport compared to all others or even if it can be proven that autonomous operated trains tend to be safer than trains driven by a human being.

The realistic scenario for full-scale implementation of ATO until 2030 is based on GoA2



[1] 10% of 5 EUR/km energy costs, 150,000 km per year
Source: Expert interviews, S2R, ÖBB

The optimal automation level will be reached at GoA level 3. Realistically the sector assumes a full Grade of Autonomy level of 2 around 2030.

While the main benefits are for the sector there are also general benefits for the society. Smoother operations will reduce the need for braking and upgearing, therefore creating less noise.

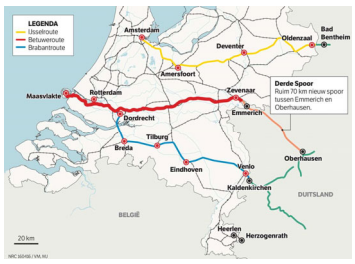
- For the RUs higher capacity of assets will be achieved due to the de-coupling of transport offer from availability of bottleneck resource “train driver”, thereby driving market growth
  - Energy savings of up to 10% for long-haul depending on type of operations
  - Shorter transit times and higher level of punctuality (up to 10%)
- For the IMs a higher capacity up to to 10% depending on concrete rail path characteristics and installed ATO could be feasible

ATO is supported by the entire sector ranging from infrastructure managers to operators. Also the industry is on board with companies such as Thales or Siemens.

Betuwe would be a possible pilot line for ATO migration in rail freight

Betuweroute is an ideal project pilot line for ATO operation

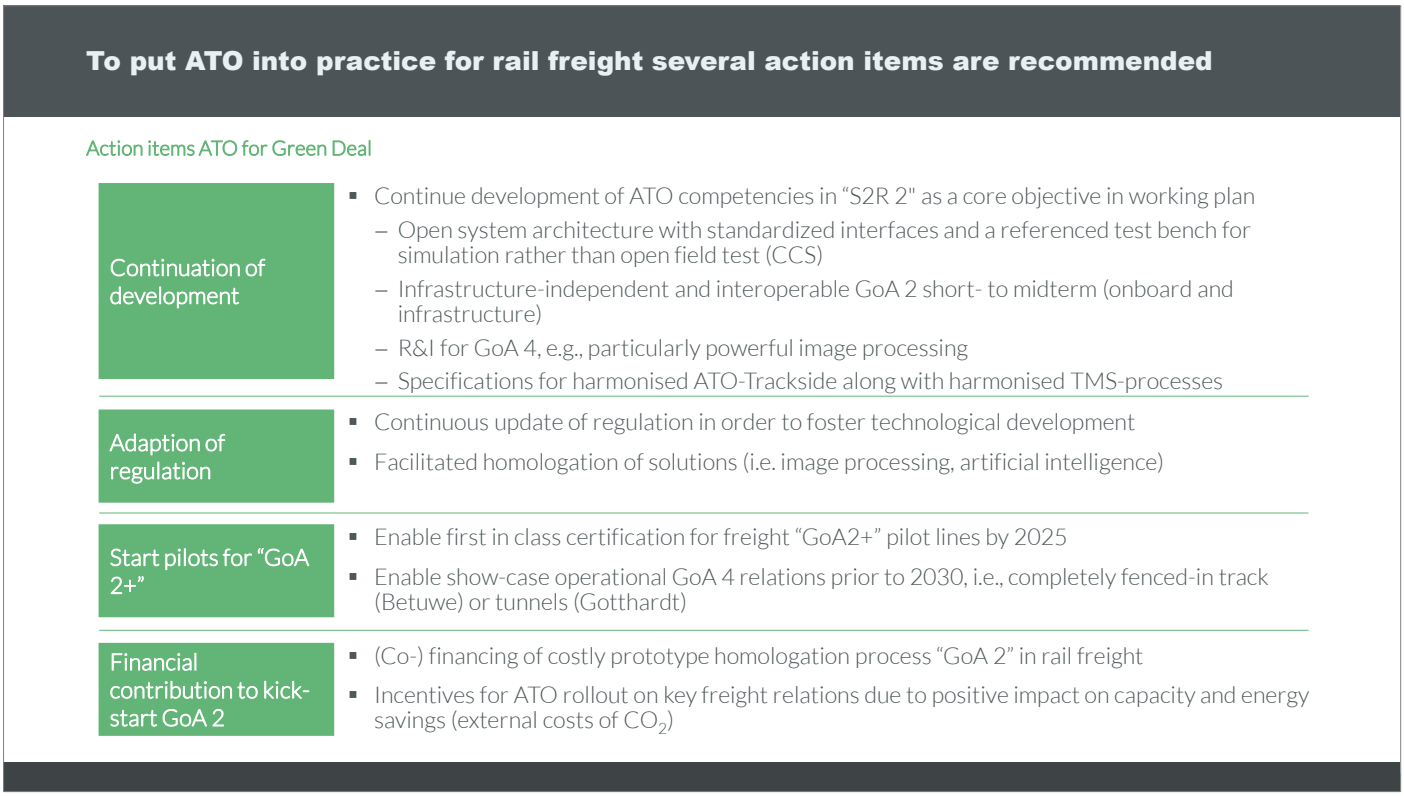
- Betuwe line is a dedicated freight line on a European growth corridor
- Fenced in track with ETCS L2 is ideal base infrastructure for testing of ATO
- ProRail has vast experience with and expressed interest in ATO pilot line operation
- Rhine-Alpine corridor will continue to be a backbone for mainline transport
- Continuation Emmerich-Oberhausen ideal for continuation under ETCS L2 from 2025
- Political climate DL/NL is ideal under JDOI and Masterplan offering 50% funding



ATO is more than a theory. Some specific stretches, particularly for freight are very suitable for tests of different levels of ATO.

The Betuwe line running from the port of Rotterdam into Germany is very suitable as it is fully fenced.

In 2021, Prorail in close collaboration with all sector stakeholders developed a vision on ATO. By 2025 a detailed action plan and implementation plan will be available. As of that moment open field tests can be realised. They will focuson mainline as well as shunting operations. The Betuwe line will probably be the showcase for mainline tests.



To get to higher levels of automation 4 types of action will be required:

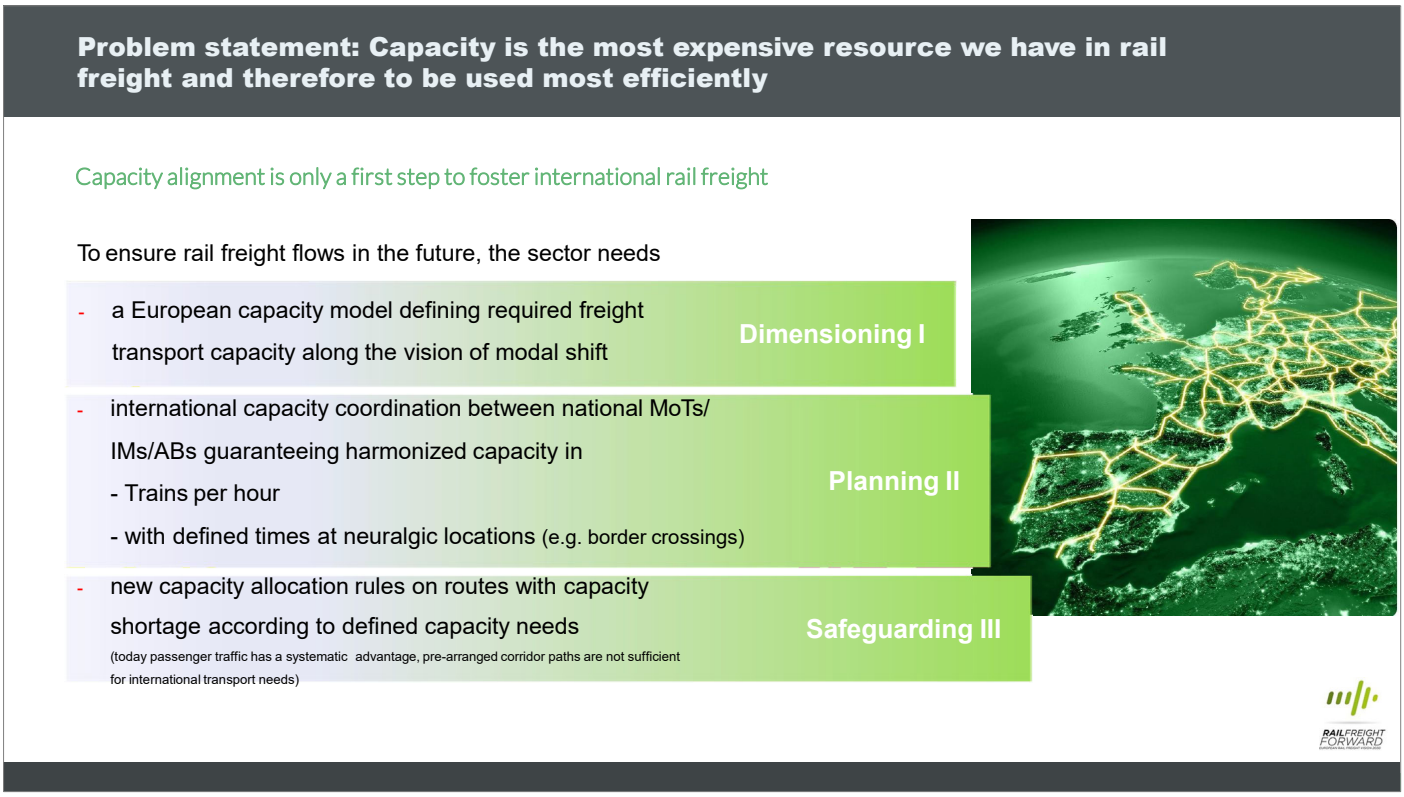
- Technical development will need to continue. Still some R&I will be needed. Specific technical solutions will need to be developed.
- Legislation needs to be adapted to accomodate ATO operations
- Tests on all types of operations need to be executed
- ATO will require significant investments. As with all other digitisation efforts, the benefits for society are a multitude of these investments, particularely by adding capacity and reducing external effects (less noise and less energy consumption).

GAME CHANGER 2

DIGITAL CAPACITY MANAGEMENT

Philippe Van den bosch

The entire European community is convinced of need for more sustainable transport system. One of the prerequsites is to realise the modal shift.



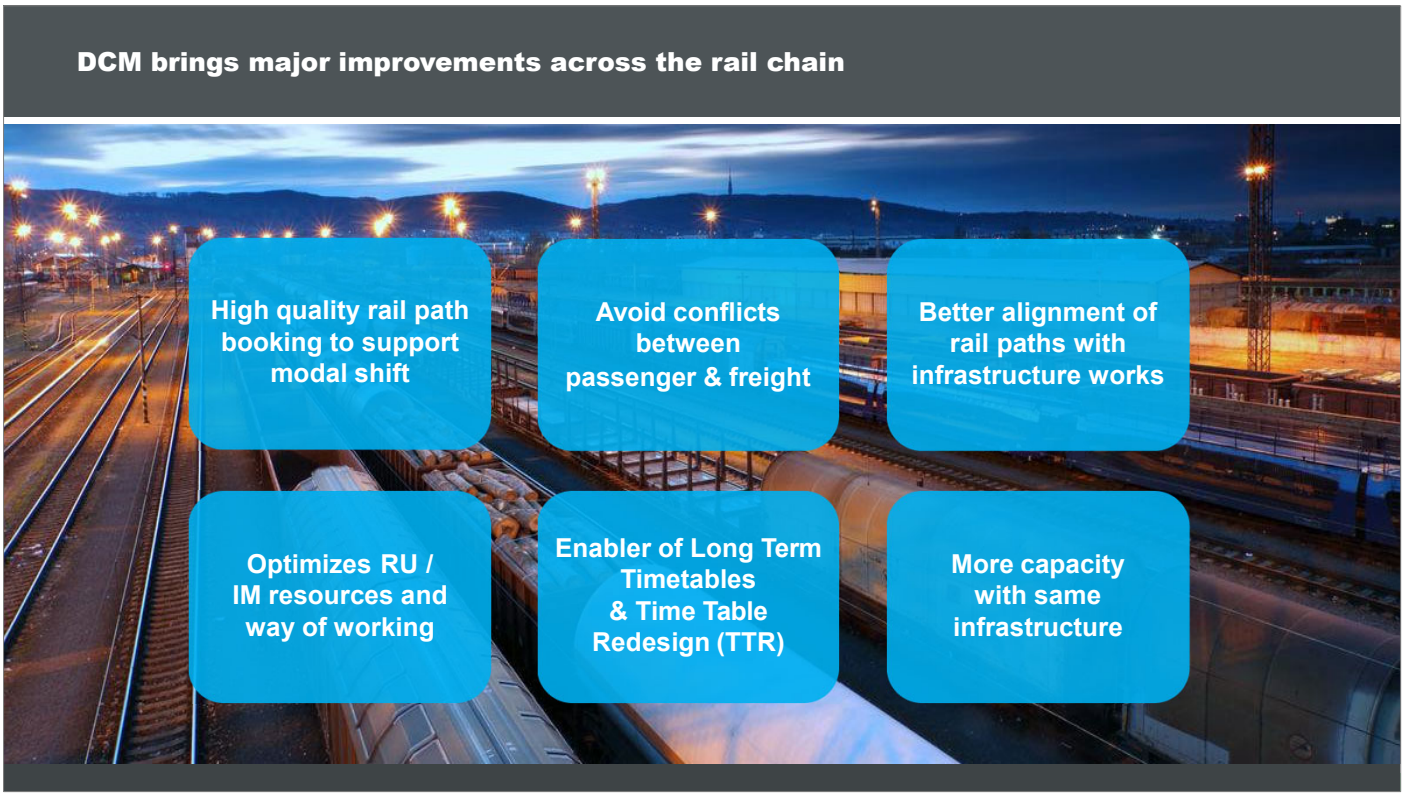
For the modal shift, more capacity will be needed, as more demand can actually not be fully met with more supply on important corridors. More physical capacity will be needed. In the short to medium term, expanding existing capacity via digitisation and better planning is the path to take.

First, there needs to be an alignment how much capacity is needed on which corridors by when. The usage of the capacity requires a balanced equilibrium between all stakeholders, between freight and passenger transport and even between modes.

Once this capacity model has been established, it needs to be operationalized. There needs to be a proper planning to assure that implementation prioritizes those projects, that deliver the most value to society. In that equation, reduced external costs and environmental impact will certainly be the main drivers.

Last, a capacity strategy should assure proper equitable allocation rules.

That renewed capacity strategy can only be maintained if supported by a strong digitisation strategy encompassing all components. The allocation of capacity and the design of timetables with enhanced overall capacity will be the task of DCM or Digital capacity management. It can be deployed by each IM on individual basis and for the coordination of international traffic by associations such as RailNetEurope or RNE.



Digital capacity management allows real-time timetabling and planning. By means of a digital app rail paths can be booked automatically and the feasibility can be checked within the timespan of minutes.

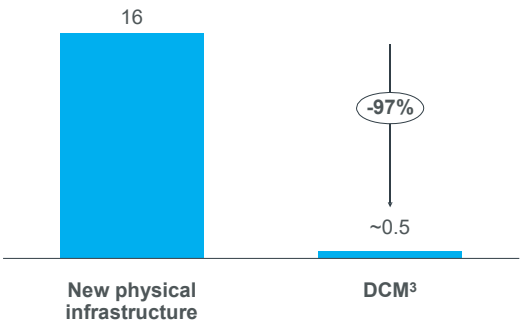
Germany is the first country in Europe to test its applicability. It is specifically adapted for spot traffics. Despite its partial roll-out it has already proven it benefits with the customers using it. The complete roll-out with first mover countries like Belgium, France or Germany can be foreseen within a time span of 5 years. It will be executed by the country's infrastructure manager associated in their representative body RNE.

DCM or Digital Capacity management should also address a number of the inconveniences currently existing within the rail business and the rail freight business more specifically. If properly implemented with balanced and agreed allocation rues a number of conflicts between passenger and rail freight could be avoided. There will be a better alignment between necessary infrastructure works and rail paths. In short it will allow more capacity with the same physical infrastructure.

In the end the goal is to develop the "Google maps" for rail freight with instantaneous booking capability.

DCM as highly efficient infrastructure investment

Estimated investment needed for 4% capacity increase on 50% of the network[1]
in bn EUR



Funding

- Investment of approx. 0,5 bn EUR required[2]
- Faster payback due to faster roll out vs new infrastructure
- DCM as capacity expansion is eligible for funding by EC/national governments (case example Germany)[4]
- Green Deal financing targeted by rail sector
- Funds to be released based on deployment commitment

1 Current European Railway net: 270,000 km, cost for additional capacity: 3 Mio. EUR/km
2 The study "TTR migration concept and IT landscape" refers to 675 Mio. EUR, including costs for countries, which are not part of the first wave
3 Higher maintenance costs for physical infrastructure not accounted for
4 IMs with little incentive to invest own money

As with all other digitisation initiatives DCM is adding capacity to the network at a very low cost when compared to physical investments. In the European case, an investment of 0,5 bn EUR in DCM could generate 4% more capacity. To achieve the same target of that 4% capacity increase via physical investment, around 16 bn EUR would be needed.

GAME CHANGER 3

DIGITAL PLATFORMS

Sandra Géhénot

The European rail freight undertakings (RU's) do not have a harmonised approach to production as well as digital solutions for the service to the customers.

Around 400 IT systems are currently being used by rail freight in Europe, with little or no interface to ease communication between them.

There is however a strong consensus in the Sector that RUs need to better leverage digital technologies for both improving internal operational excellence and satisfying services to the shippers.

Therefore :

- The Digital Platform (DP) came about as a Sector initiative that aims at delivering a smart integration of current IT systems with the rail freight ecosystem to enable new use cases mainly through telematics to ultimately allow data driven decision making as well as modern interfaces on the entire logistic chain.
- DP The European rail freight undertakings do not have a harmonised approach to production as well as digital solutions for the service to the customers.
- Around 400 IT systems are currently being used by rail freight in Europe, with little or no interface to ease communication between them.
- There is however a strong consensus among Rail Freight Forward members that RUs need to better leverage digital technologies for both improving internal operational excellence and satisfying services to the shippers.

GAME CHANGER 3

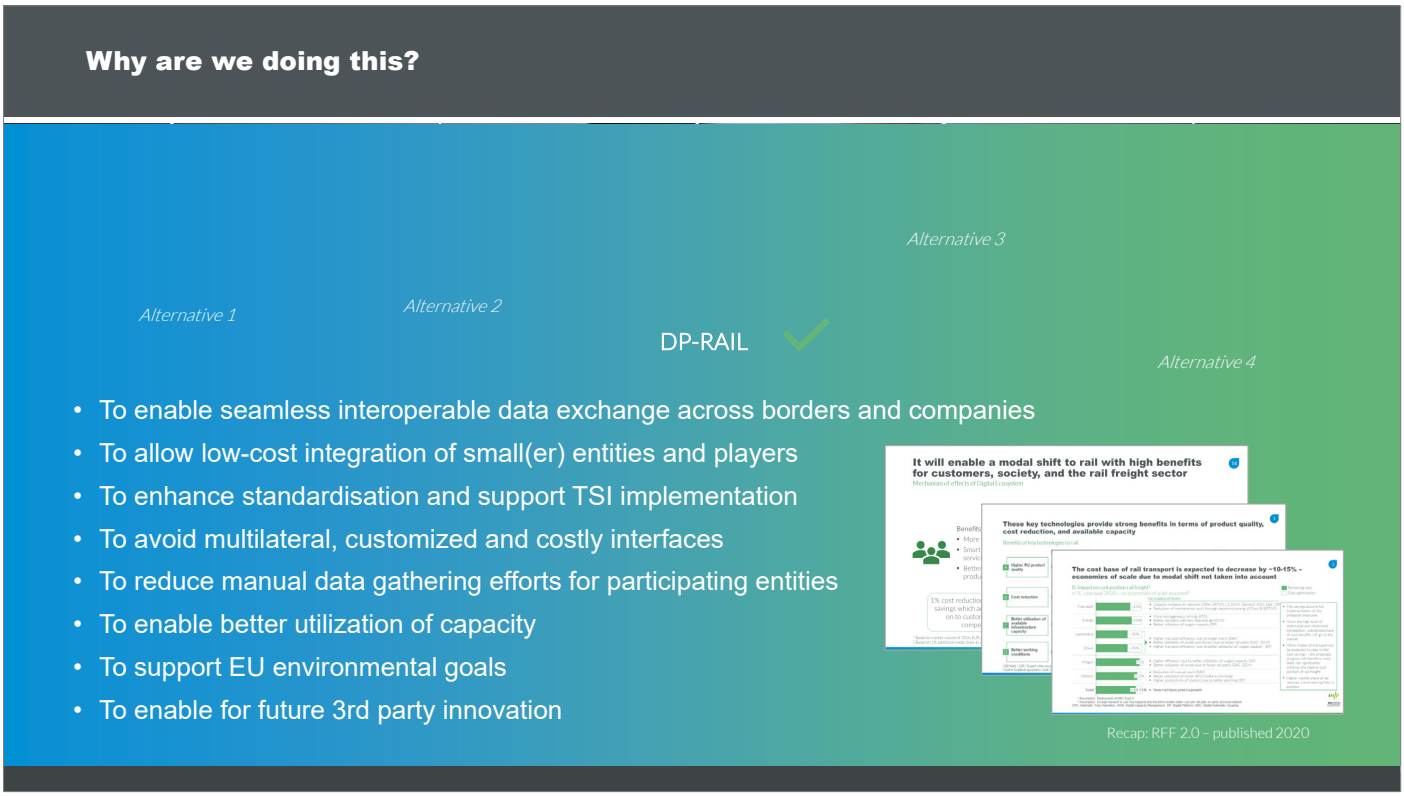
DIGITAL PLATFORMS

Sandra Géhénot

(continued)

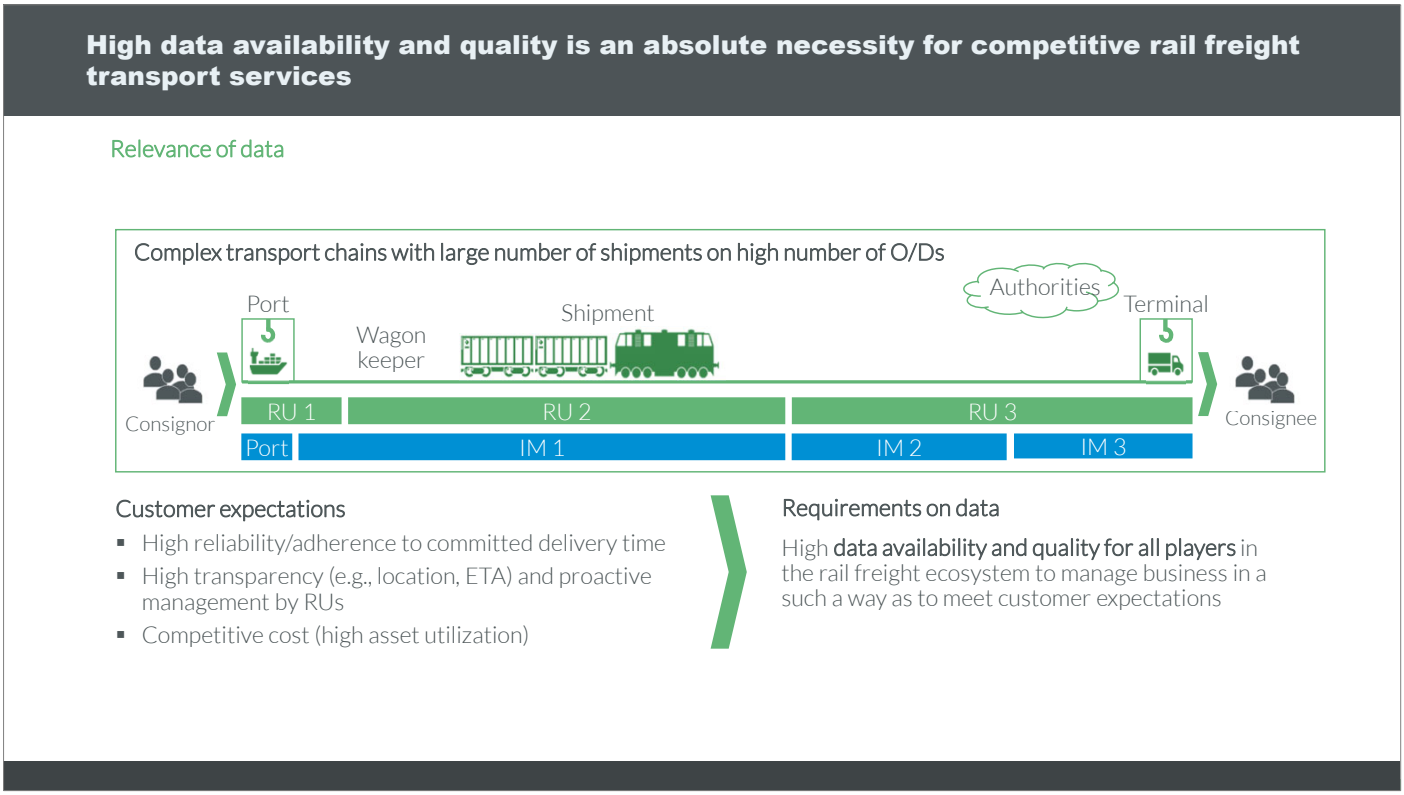
Therefore :

- The Digital Platform (DP) is a rail freight sector's project that aims at delivering a smart integration of current IT systems with the rail freight ecosystem to ultimately allow data driven decision making as well as modern interfaces on the entire logistic chain.
- DP will accompany the competitiveness of the rail freight sector by being the paramount digital asset allowing the future milestones of our technological leap; Digital Automatic Coupling, Autonomous Train Operations but also IM initiatives like TTR / DCM will create new streams of data that will feed DP and deliver new ranges of services to Rus and their customers.
- DP will help the sector, with a special focus on the smallest actors of the freight sector, to meet the European objectives established by the already existing regulation such as TAF-TSI.
- will accompany the competitiveness of the rail freight sector by being the paramount digital asset allowing the future milestones of our technological leap; Digital Automatic Coupling, Autonomous Train Operations but also IM initiatives like TTR / DCM will create new streams of data that will feed DP and deliver new ranges of services to Rus and their customers.
- DP will help the sector, with a special focus on the smallest actors of the freight sector / those that have little or no IT capability, to meet the European objectives established by the already existing regulation such as TAF-TSI.



There are several reasons why an integrated digital platform makes sense. Digital Platforms will render the demand side of rail more attractive, making sure, that more capacity is met with additional demand.

Apart from sector-specific reasons like efficiency or better customer satisfaction it also hooks onto European policy. Standardisation and implementation of the Technical Standards for Interoperability have been the corner stones of European rail policy. The digital platform should provide a sound sector backed solution for that.



Is was already stated in our previous contributions: digitisation is more efficient and faster way to transform the rail sector towards the goal of a significant modal shift. secto. It will help reducing the efficiency/attractiveness gap with other modes.

Digitisation in general and digital platforms more specifically will help to increase the reliability and transparency of the services offered. Location and ETA will become central in the data transactions between RUs and customers.

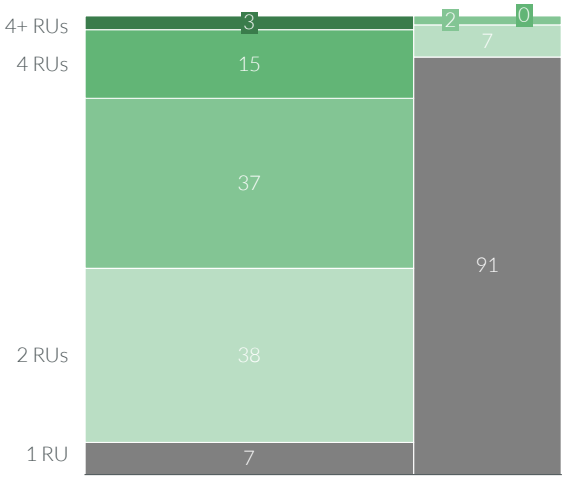
It will also help to better integrate rail services with other modes of transport for a better End to End supply chain package for the customer.

So in a nutshell, the aim is to strengthen by connecting it, the rail sector actors to make rail the strong/robust backbone of a seamless end-to-end multimodal chain.

Most rail freight transports are processed on international level involving at least 2 RUs

Number of involved RUs in transport chains, in percent by number of transport orders

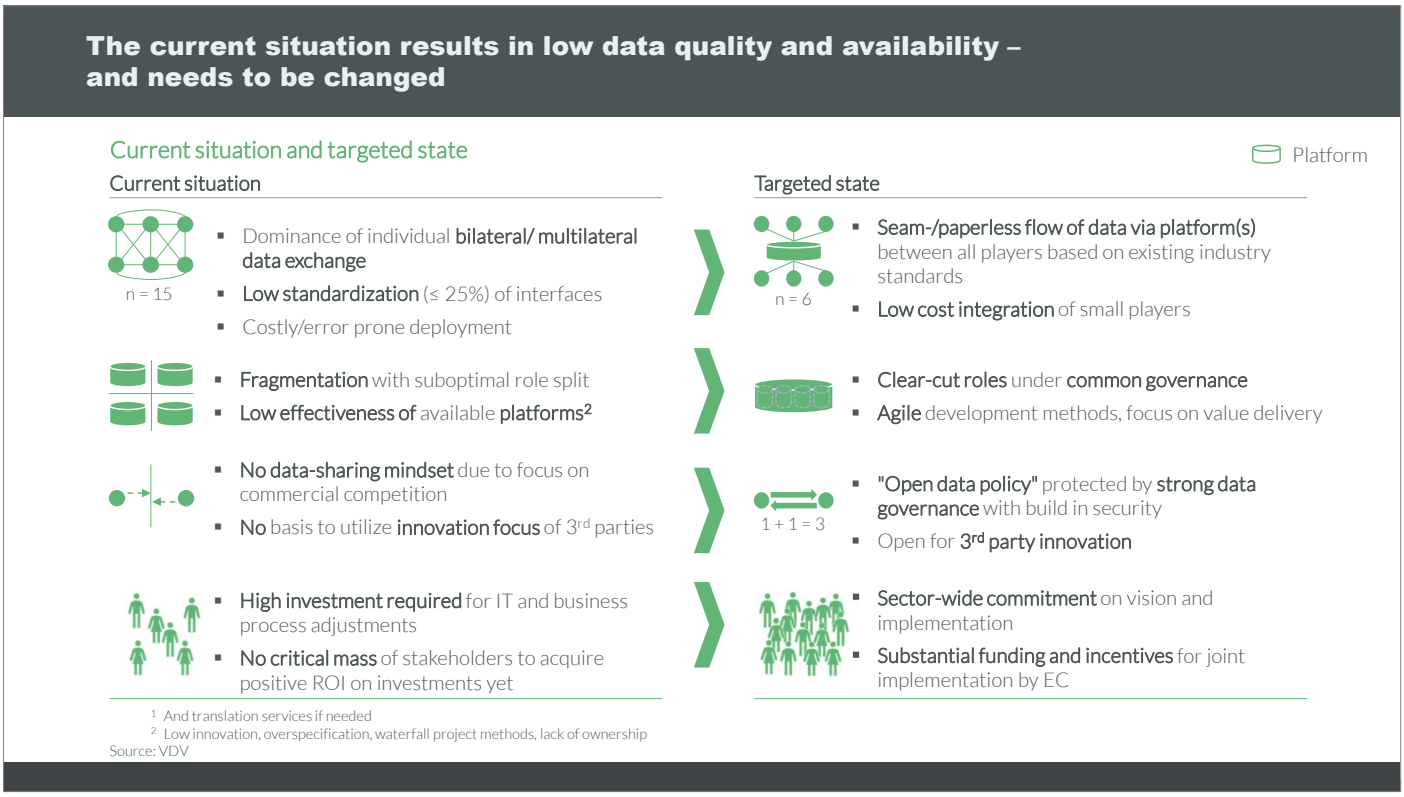
DISGUISED RU EXAMPLE



- Complex transport chains with several involved rail freight players are the norm, not the exception
- Share of international transports expected to grow further

Source: European RU (exemplary)

The reason why data integration supported by digital platforms is so crucial has to do with the complexity of rail freight operations. This example from a non-disclosed RU shows that over 90% of its international operations involves 4 or more RUs.



There is still a way to go from the current fragmented situation to the target picture where digital platforms connect into each other seamlessly.

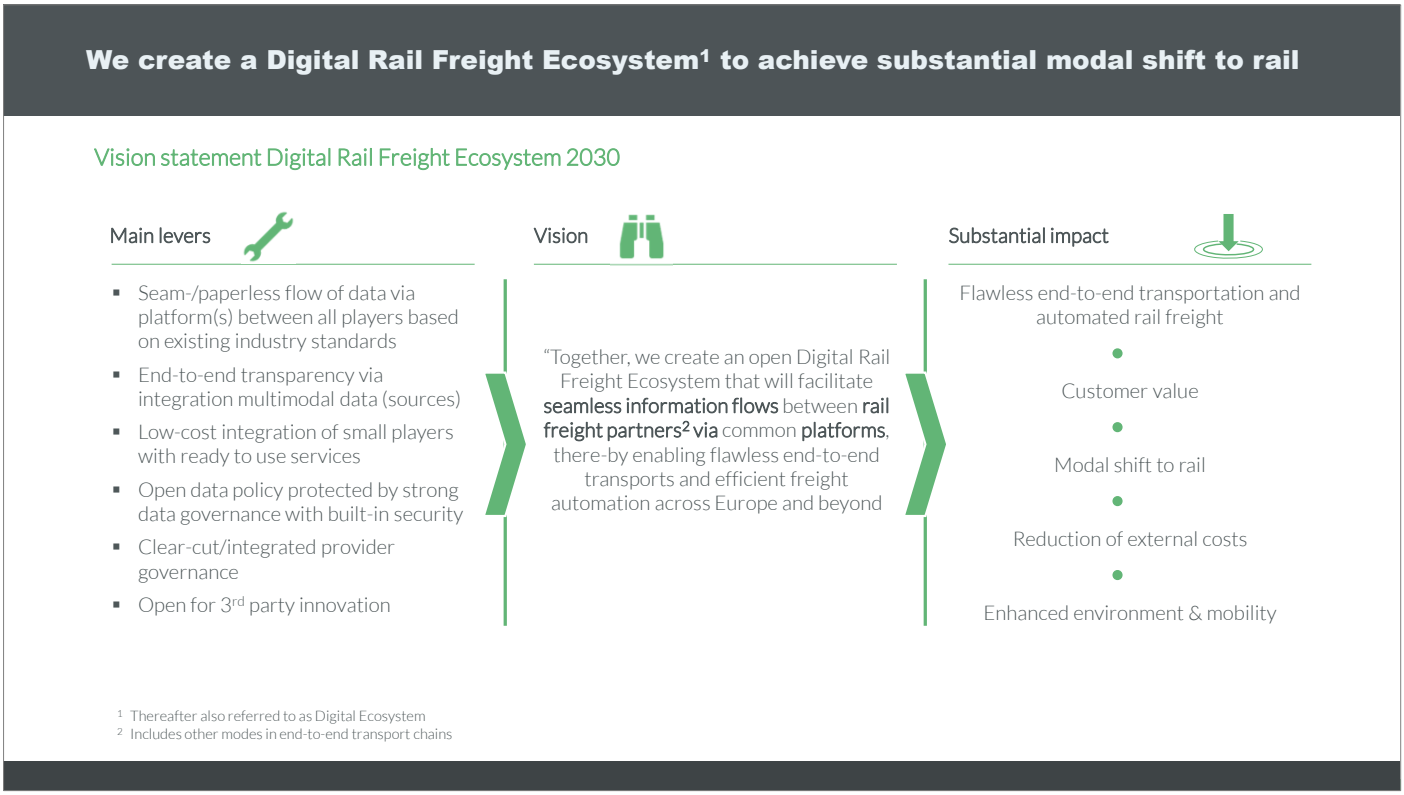
Currently relations between RUs are characterised by:
Many 1-to-1 relations with low standardisation, prone to error and far from cost effectiveness as each new relationship requires investments in new data exchange protocols.

Furthermore there is a lot of fragmentation. Each type of business and each stakeholder tends to develop its own applications, which creates inefficiency and intransparency.

A root cause is lack of data-sharing mindset. The ownership of data is considered to be a competitive advantage.

All this leads to a lack of critical mass which reduces the ROI of each investor, reducing the return on investment of digitisation initiatives, ultimately leading to the decision to not invest.

Such a digital platform will provide the connective tissue with existing company platforms.

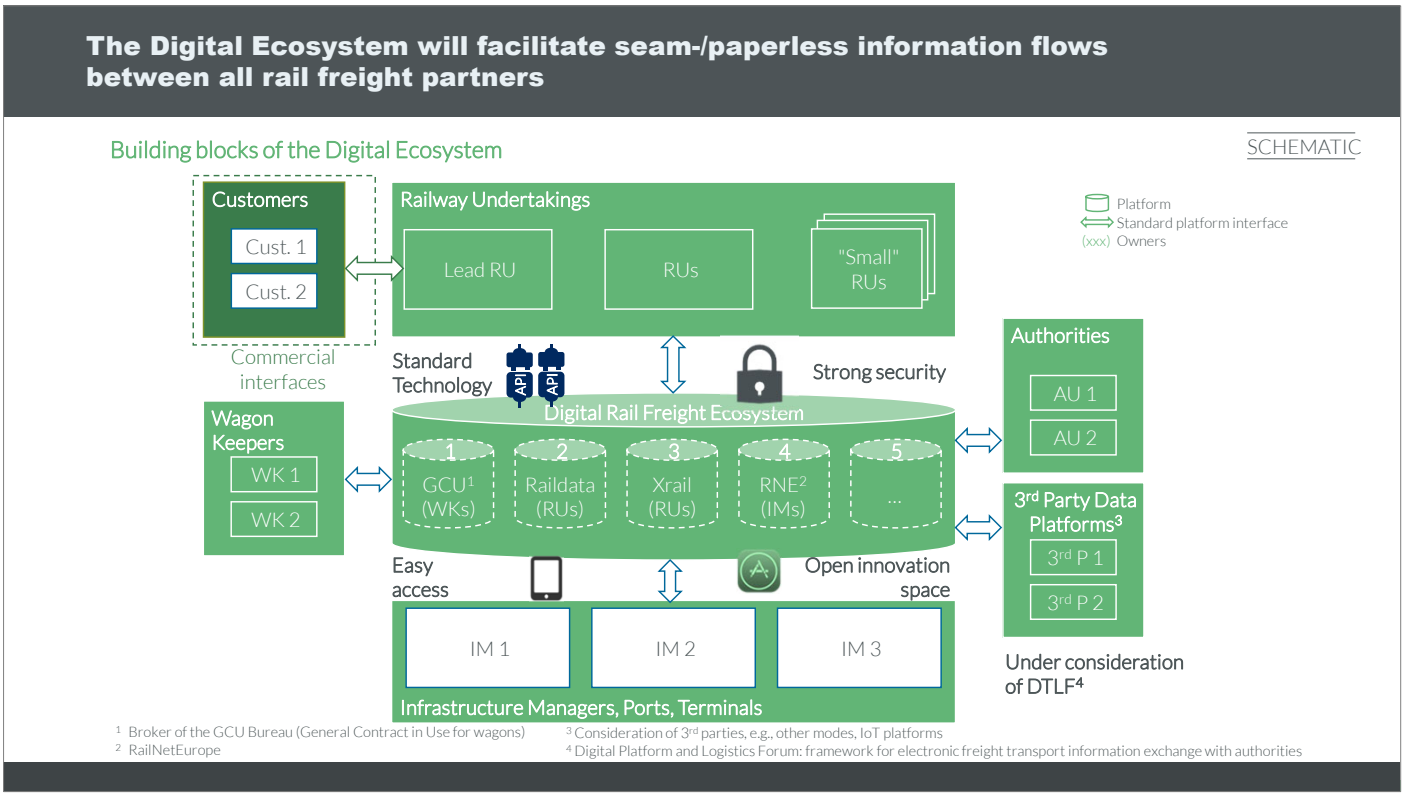


The vision is clear: The sector wants an open Digital Rail Freight Ecosystem that facilitates seamless information flows between rail freight partners[2] via common platforms. It will enable flawless end-to-end transports and efficient freight automation across Europe and beyond.

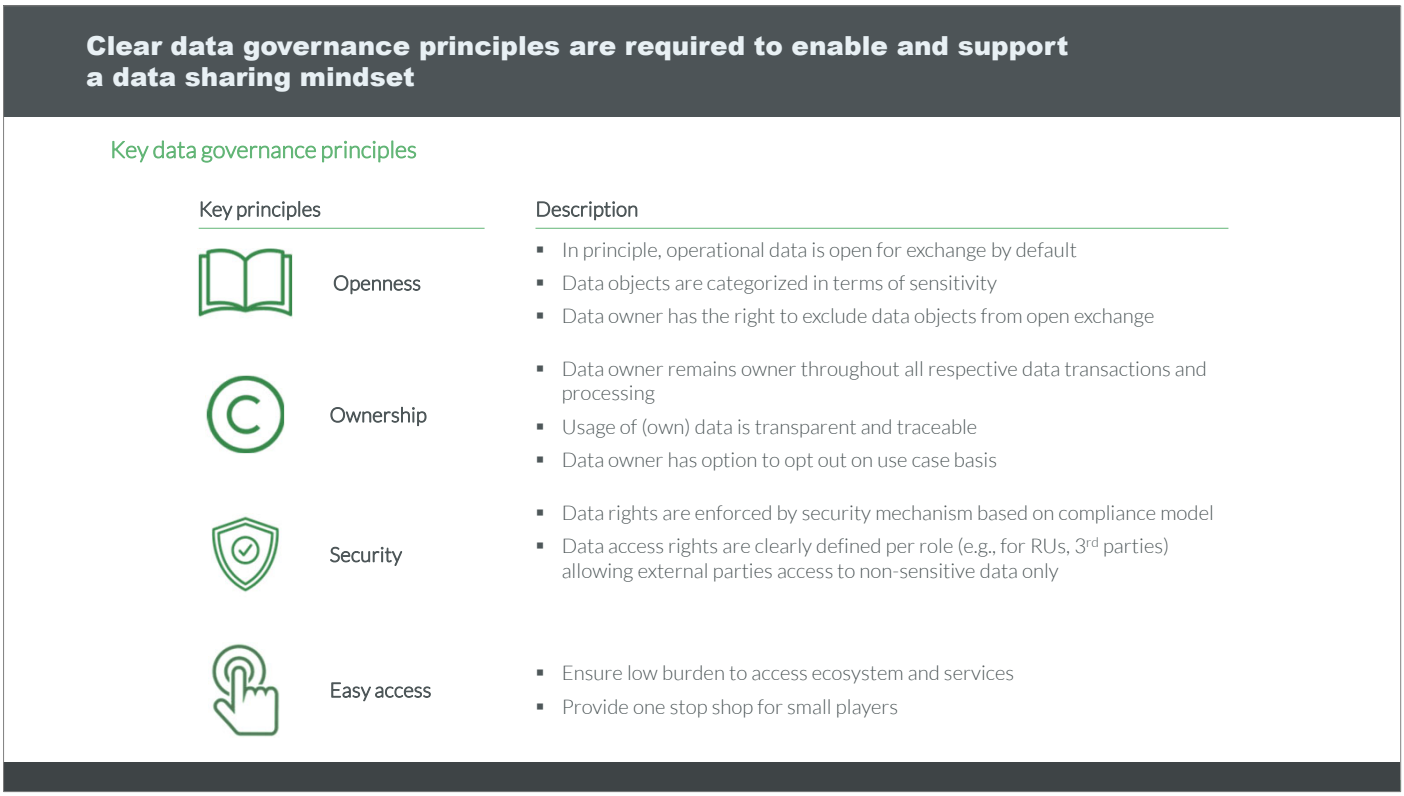
The leavers to realise this are known:

- The digital platform will not start from scratch but build upon existing interfaces. The main idea is to build standards which link across platforms.
- These standards will be open and integrated.
- The idea is to build on existing 3rd party development.

The impact will crystalize on the demand side of the business: the enhanced customer value will increase demand for rail freight services, leading therefore to reduced external effects on the environment.

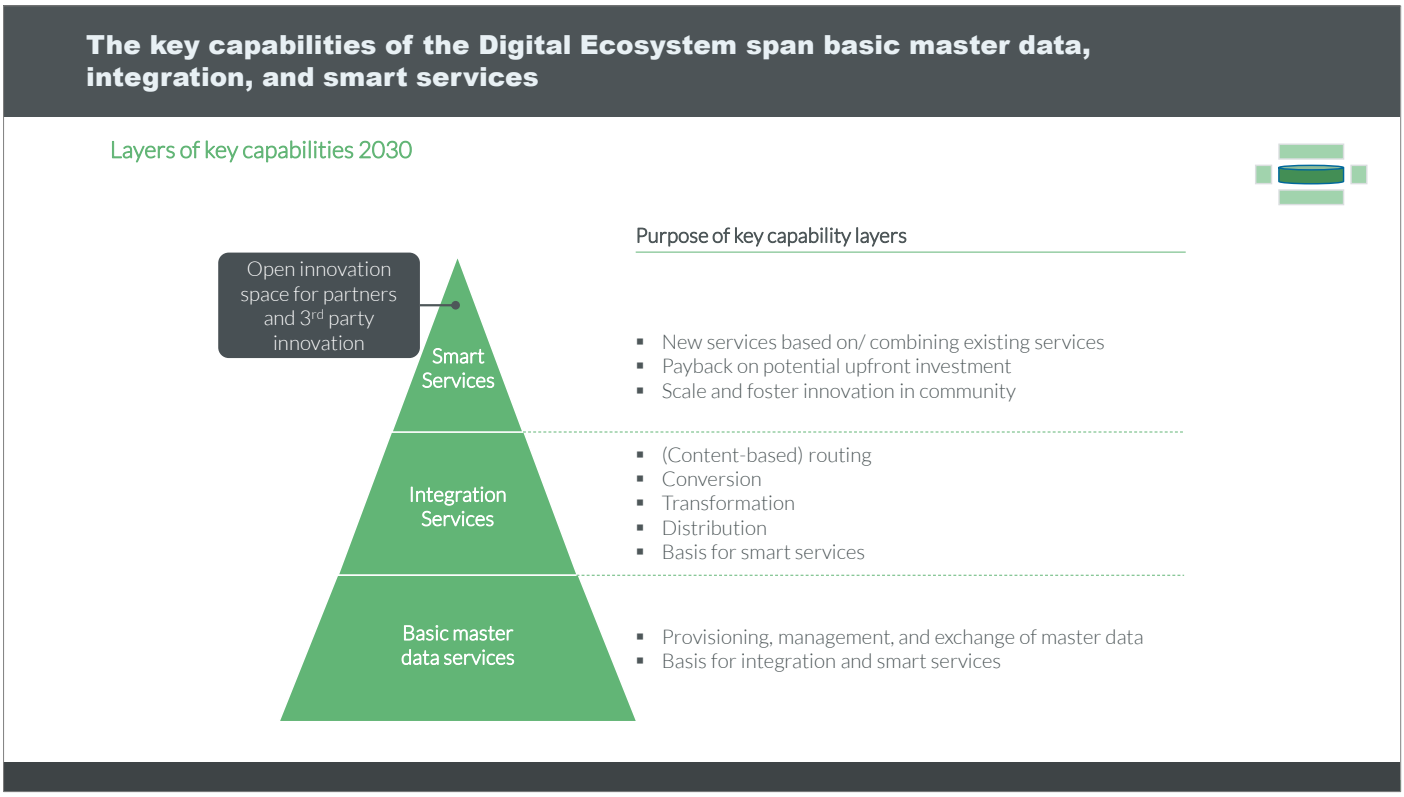


This picture represents the current landscape and fragmentation between the various actors of the chain and indicates where hte connective layer would improve this hurdle.



Governance is the key issues which requires a solution. It should be approached holistically and needs to comply with some key principles.

Operational data should in principle be open and easy to access as long as it does not touch on commercial interest. The ownership of the data remains with the initial owner. Obviously data transactions should adhere to the most rigorous security protocols.

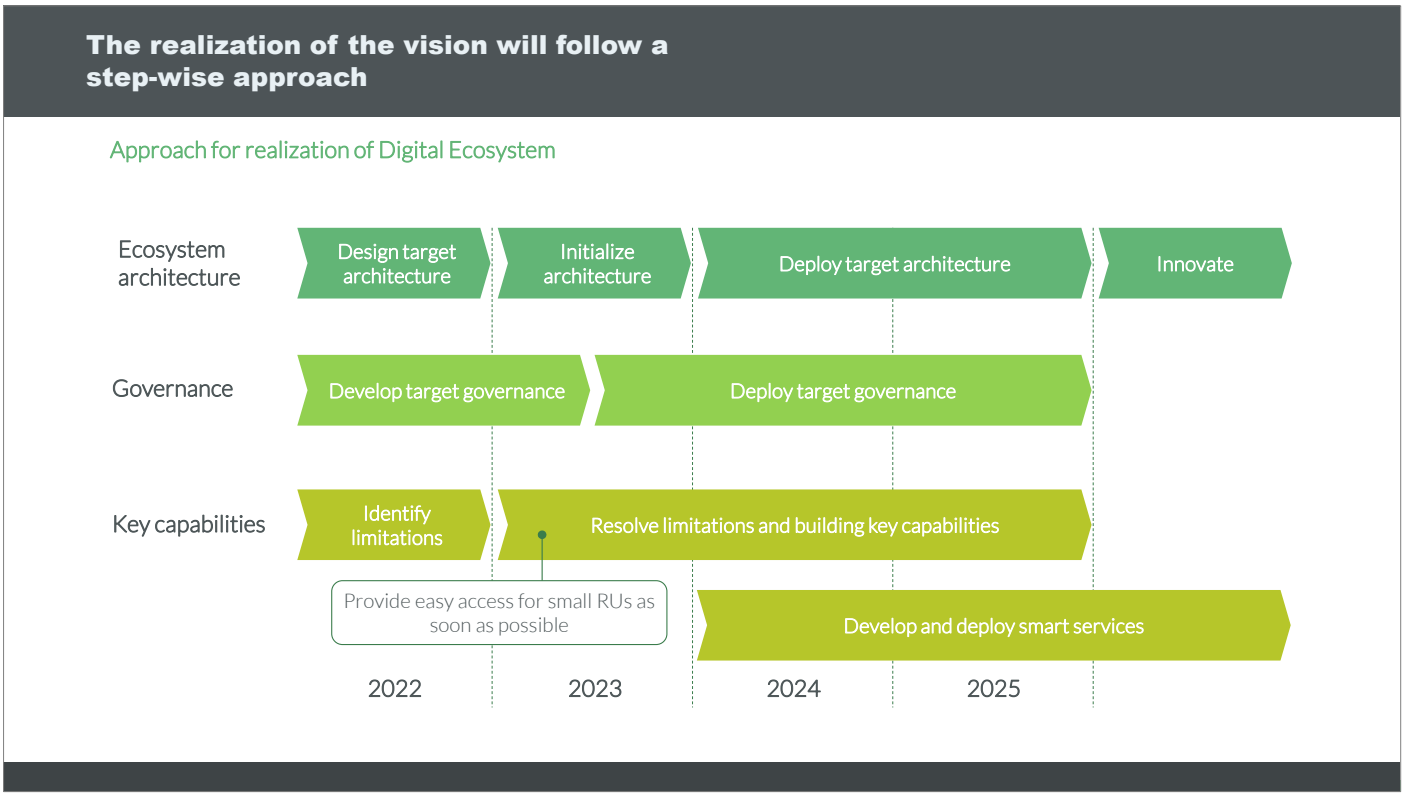


The digital ecosystem will have 3 layers. At the basis there will be master data services.

In a second layer is the integration of services.

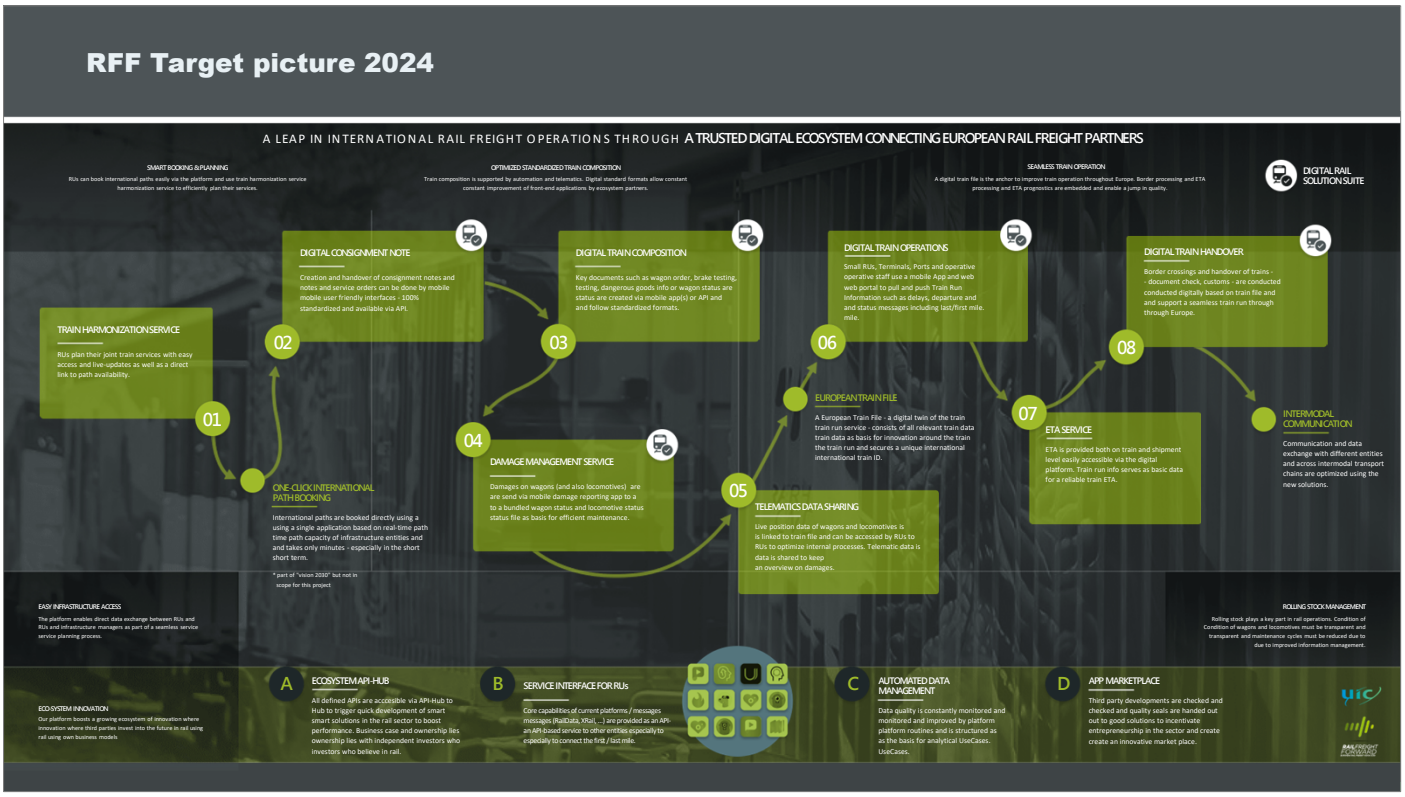
The top layer is the service layer. On this layer Apps can be developed by 3rd party providers. The whole concept can be compared with the mobile phone ecosystem. A number of digital platforms were developed clearly defining how data exchange is organised. On that platform a multitude of applications are provisioned, all addressing specific needs from one or a group of interested parties.

The potential smart services anchored on the digital platform should accelerate innovation. The smart services will become a marketplace and will use state-of-the-art architectural design.



The decade of rail is now. Digital platforms have a short lead-time and can enhance the attractivity of rail tomorrow.

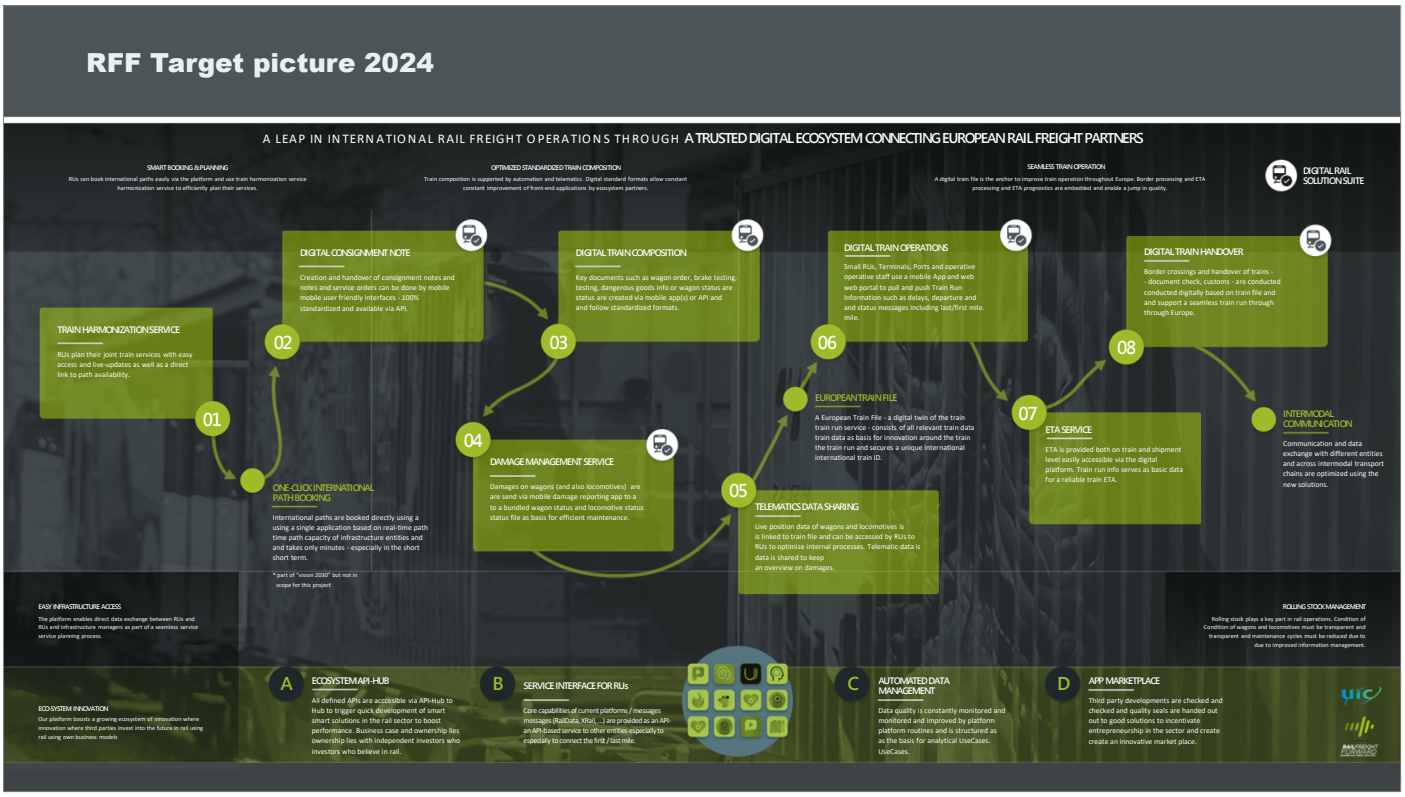
The key capabilities needing development in the short run have been decided. Decisions on governance and on the design of the eco system are being started



The timeline till 2025 foresees 8 applications to be developed.

The first rail subsystem which DP-RAIL proposes to address is daily freight train operations in Europe.

- **Today**: there is little or no integration of small Railway Undertakings (RUs), ports or transshipment terminals in the data exchange within the daily train operational processes. This causes particular problems for stakeholders involved in the first and last mile, where this information is usually conveyed manually. As an example, many terminals need to have near real-term visibility on train runs / delays in order to feed their marshalling yard management systems. The lack of electronic information can cause bottlenecks and service disruptions in the logistical chain linked to those terminals.
- **Tomorrow**: the 'digital train operations' (DTO) use case, will facilitate the information flows between all rail freight partners involved in the daily train operations. Information will be exchanged via standardised messages through a common digital platform, enabling interoperable digital train operations across Europe. The project aims to offer a solution which provides automated workflows of all relevant information in a digital format to the required stakeholders, including authorities (Custom/ Dangerous Goods/ Waste). All relevant stakeholders will have access to the documents via a mobile web application and can sign off on the documents even before the train arrives. The full process will be standardised across Europe.
- The objective is to provide RUs, terminals, ports and operative staff along the transportation chain with a mobile app and web portal to pull and push train run information. This allows for a seamless train run throughout Europe, ensuring reliable and on-time information. There is a specific focus on enabling and including nonincumbent railway undertakings which currently lack the IT capabilities to participate in the electronic exchange of data.

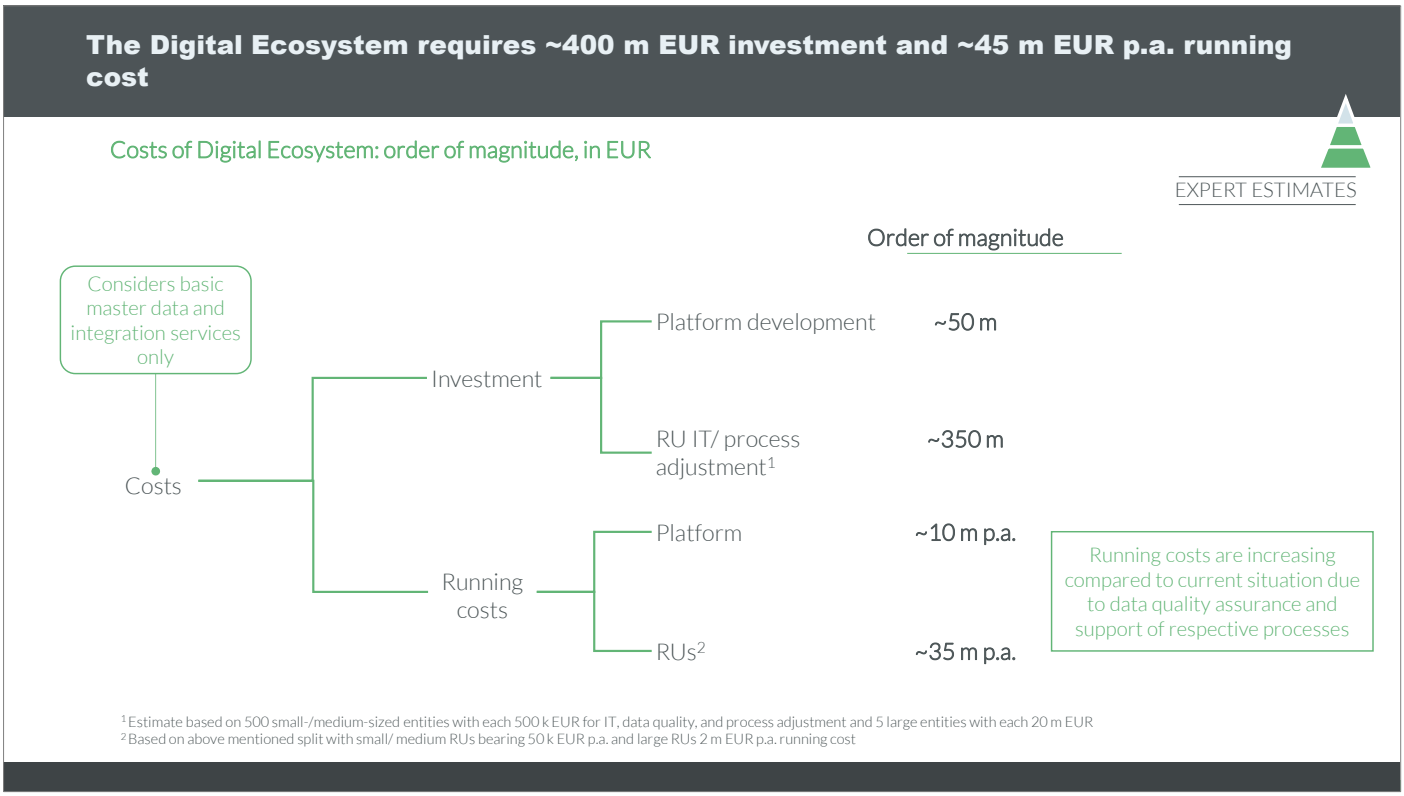


(continued)

Another example is the digital consignment note:

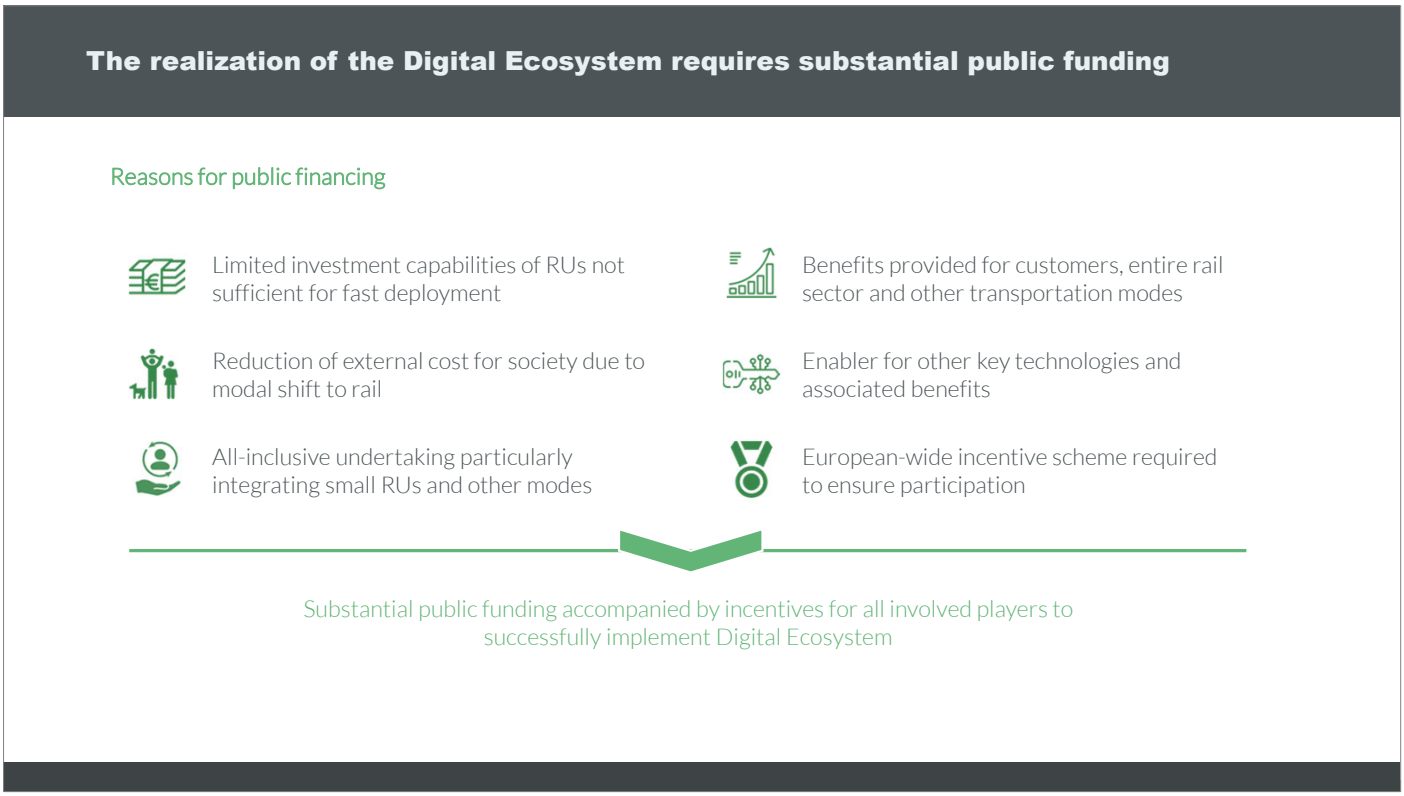
- **Today**: Digital consignment note creation and data exchange is currently mainly used by bigger RUs in bilateral traffic. The paper solution continues because of national legal requirement, business processes and technical constraints (use of different data formats etc.). Due to these constraints, Consignment Note data is still exchanged on paper, causing problems related to data quality and triggering costly manual intervention. Some RUs have also created proprietary solutions to exchange consignment data on a bilateral basis and some RU systems may not be able to support Electronic Consignment Note (ECN) capabilities. Some smaller RUs do not support electronic capabilities. Therefore, if they are already en route, paper documents must be generated at interchanges. Also, some governments require paper documents (Hungary, for example) and will not accept Electronic Consignment Notes.
- **Tomorrow**: In use case Digital Consignment Note (DCN), all RUs use 100% standardised digital consignment notes (CNs) that are available via API (Application Programming Interface) software to partner RUs. The creation and handover of CNs can be carried out via mobile user-friendly interfaces, especially for small RUs. With this workstream, DP-RAIL will provide an application on the digital platform which offers a digital consignment note for rail thereby eliminating paper handling and reducing overall transport times. The Consignment Note is a document that shall be signed by the consignor and the carrier. It must be forwarded to the RUs involved in the transport chain and contain the information which is needed for an RU to effect transportation in the period for which it is responsible for the carriage of the goods until handover to the next RU. This is stipulated in COTIF Appendix B. It is a legal document and shall be evidence of the conclusion and the conditions of the contract of carriage and the taking over of the goods by the carrier.
- **The objectives** and benefits of such a digital solution are as follows:
  - Reduction of transport times (especially waiting times), better service reliability and reduction of administrative costs for RUs;
  - Better data quality and availability for customer information along the full transport chain;
  - Significant increase in ability for Migration from Simplified Procedures to NCTS (New Computerised Transit Systems); allow all and in particular smaller stakeholders to comply with the ability for Migration from Simplified Procedures to NCTS (New Computerised Transit Systems); allow all and in particular smaller stakeholders to comply with the European regulation for interoperability and for exchanging with

administrations.



The development of the ecosystem requires only a fraction of the needed financial means for physical investments. Best estimates calculate the investment cost at 400 mln euro with a running cost of 40 mln euro per year.

This should be put in perspective with the possible benefits. A 1% cost reduction is worth around 200 m EUR p.a. (assuming a market size of 20 bln euro). These are only internal benefits and exclude the potential modal shift and saving in external costs or the better utilization of existing capacity. In previous videos we explained that a ratio of 1 on 30 of digitisation initiatives versus physical investments.



These are the main reasons why at least partial public funding is justified.

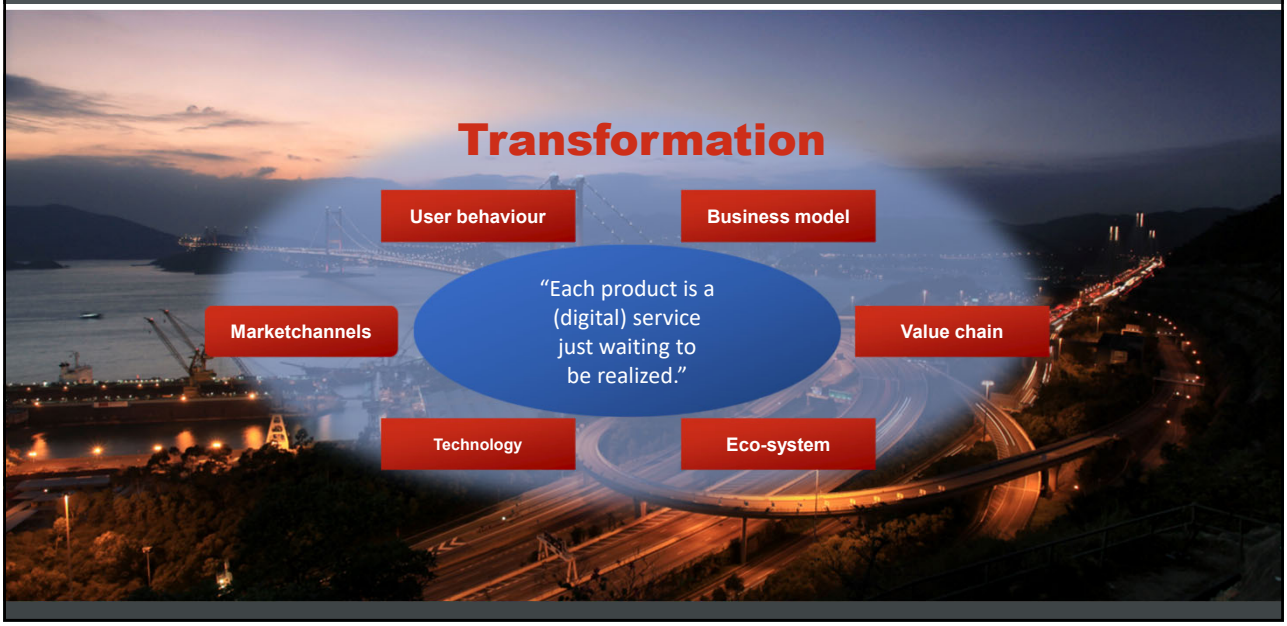
RAIL AND CYBERSECURITY

Presented by Bjorn Westerberg, Director WSP Rail Advisory

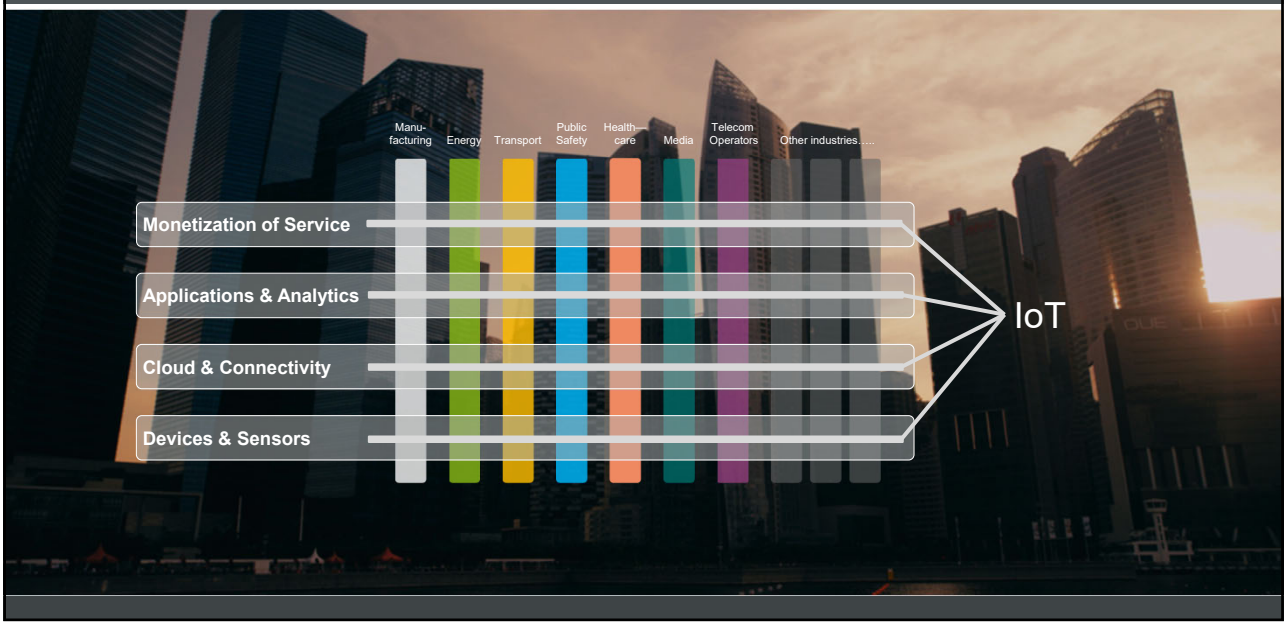
Agenda

- **Situation**
  - Digitalization and innovation
  - IoT - Internet of things
  - Terminology/Nomenclature
- **Complication**
  - Cyber attacks and cyber threats
  - Magnitude of the cybersecurity problem
  - Cybersecurity in railway operations
- **Resolution**
  - Cybersecurity in railways
  - Risk management for train operators
  - Summary

DIGITALIZATION – Much more than just technology



Internet of Things: Enabling technologies

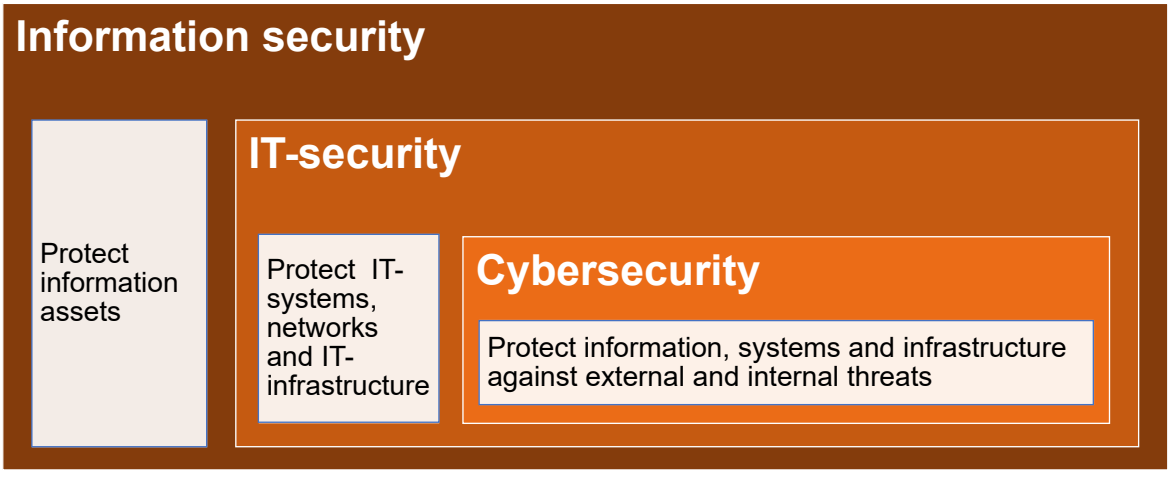


Rail becomes software

- Platform economy and app-based business models, cloud computing, big data analytics, IoT, artificial intelligence, 5G….
- Innovation, transformation and opportunities!

- **However….**
  - Low digital and cybersecurity awareness in the railway sector.
  - The railway sector designed for safety but starting to be aware of security - Safety > Security
  - Difficulty in reconciling safety and cybersecurity worlds..
  - Geographic spread of railway infrastructure and the existence of legacy systems.
  - Complexity of regulations for cybersecurity.

Terminology/Nomenclature – What is Cybersecurity?



Terminology/Nomenclature – Introduction to cybersecurity

Systems:

- **Safety-critical systems:** Failures can lead to damage to property, environment, or loss of life
- **Cyber-physical systems:** Physical processes are controlled or monitored by computer-based algorithms

Terminology/Nomenclature – Introduction to cybersecurity

Security design objectives

1. **Confidentiality:** The property that data is not disclosed to system entities unless they have been authorized
2. **Integrity:** The property that data has not been changed, destroyed, or lost in an unauthorized or accidental manner
3. **Availability:** The property that system provides services in a timely manner according to the system design whenever users request them
4. **Authenticity:** The property to verify that users are who they say they are and that each input arriving at the system came from a trusted source
5. **Non-repudiation:** Assurance that the sender of information is provided with proof of delivery and the recipient is provided with proof of the sender's identity

Terminology/Nomenclature – Introduction to cybersecurity (continued)

Vulnerability, threat, and risk

- Vulnerability: A system weakness that may provide an attacker the opportunity of unauthorized access to resources
- Threat: Attacker may identify a special vulnerability and use it against the organization or the individual, which constitutes a threat
- Risk: The likelihood of an attacker taking advantage of vulnerability and the corresponding business impact

Safety vs security

- Safety implies protection against random unwanted incidents that happen due to one or more coincidences
- Security is resistance to intentional, unauthorized act(s) designed to cause harm or damage

Rail and digitalization – Safety and security risks

Digitalization is one of the top priorities for the railway sector. Railways have historically focused on safety and we are now adding security and cybersecurity with a flood of software and applications, together with new telecom system (5G) and new signaling systems for EU (ERTMS). The railway sector is based on regulations defining interoperability and safety but the existing regulatory framework, does not fully consider security, particularly the cybersecurity issues in the sector. Rail was designed for safety, not for security, but safety and security are linked at the system level. There is increasing need for cyber resilience – to go from **fail to safe** to **fail to safe continuity**.

What are the risks concerning industrial connected information systems in a gradually deregulated sector?
The main risks are:

- Threats to people safety and unsafe situations
- Disruption to the rail network and services
- Economic loss to company and/or suppliers
- Reputational damage
- Loss of commercial or sensitive information

So, we have here both business (operational) risks and reputational risks at national and sector level.

Railway and critical assets

The increasing digitalization of the railway poses new challenges that need to be addressed to retain the dependability of the system. Railway stakeholders (Railway Undertakings RU and Infrastructure Managers IM)must strike a balance between operational requirements, business competitiveness and cybersecurity. Railway stakeholders also depend on suppliers with disparate technical standards and cybersecurity

The focus for attacks in the railway sector, are the critical operational systems for:

- Infrastructure, (IM)
- Rolling Stock (RU)
- Signalling, (IM)
- Operations (RU)
- Power supply (IM)
- Ticketing (RU)

The direct effects on RUs relates to rolling stock, operations and ticketing. Indirect effects are related to infrastructure, signalling and power supply.

Rail and critical operational systems

The railway system is a complex environment with many subsystems.

There are, according to (ENISA, 2020), essentially five categories of systems for the railway:

- Pre-operations systems,
- Systems for Operations,
- Security & safety & maintenance systems,
- Corporate & support,
- Development systems.

Rail and Pre-operational systems

Pre-operations systems

- **Timetable construction** systems are systems that creates commercial for customers (timetable for each train line) and to prepare resource (assets and staff).
- **Sales, distribution and customers relations** systems enables customers to buy tickets or book a train seat, as well as managing customer relations (claims, loyalty, marketing etc.).
- **Network allocation** include systems enabling railway operators to book infrastructure/train paths to operate their trains on the network. This enables the infrastructure manager to get information and to apply fees to the railway operator for using the infrastructure.
- **Asset procurement** systems enables railway operators and infrastructure managers to account for their assets (infrastructure, or trains), and to procure new assets and manage logistics.

Rail and systems for operations

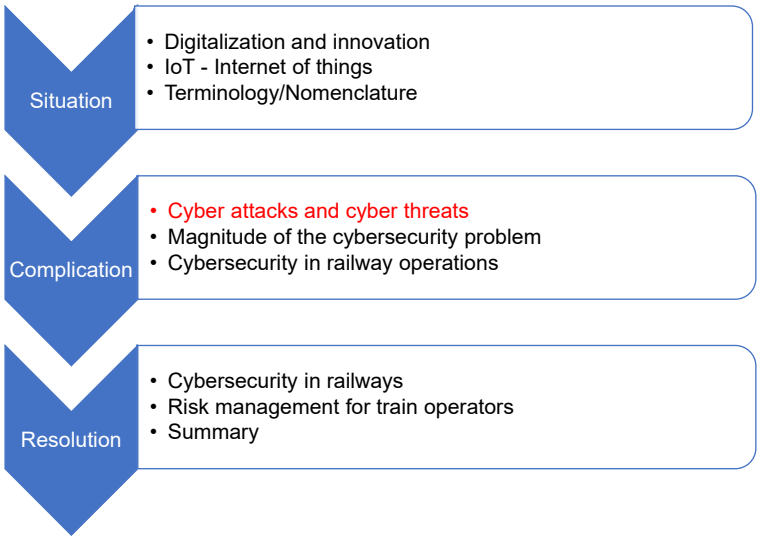
Operations include systems for Signaling, Command and control systems, Auxiliary systems, Passenger comfort and service systems, and Telecom Systems.

- **Signaling** systems are used to direct railway traffic, such as digital interlocking systems, Radio Block Centers (RBC), level crossing systems, etc.
- **Command and control:** Systems to enable movement of trains, e.g. Automatic Train Control (ATC), Automatic Train Supervision (ATS) and Energy Traction system.
- **Auxiliary Systems** such as Energy Systems, HVAC and Lighting Systems for emergencies
- **Passenger comfort and services** systems facilitate comfort and service to the passenger; Passenger Announcement Systems, Passenger Information Systems, HVAC and lighting systems, lifts and escalators, etc.
- **Telecom systems** enable communication; Radio systems dedicated to signaling and other systems, Wired systems for network communications, Voice communications, Time keeping.

Rail and systems for operations (continued)

- **Security, safety & maintenance** systems keep operations safe and secure. They include access control systems, video surveillance, fire detection, accreditation systems for personnel. Maintenance systems enable the railway operator and infrastructure manager to perform maintenance on all their assets. They include asset management, scheduling systems, fault reporting systems, resource allocation/planning systems, document databases, fault follow-up and escalation systems
- **Corporate & support** are systems to perform the ongoing business of railway operators and infrastructure managers. They include all the usual systems and functions for email, IT, PCs, finance, HR, communications, etc.
- **Development** systems include everything used to develop the operators business. They include bidding systems for the railway operator or infrastructure manager to answer invitations to tender for train operations or infrastructure management, as well as all the systems used for research and engineering.

Agenda

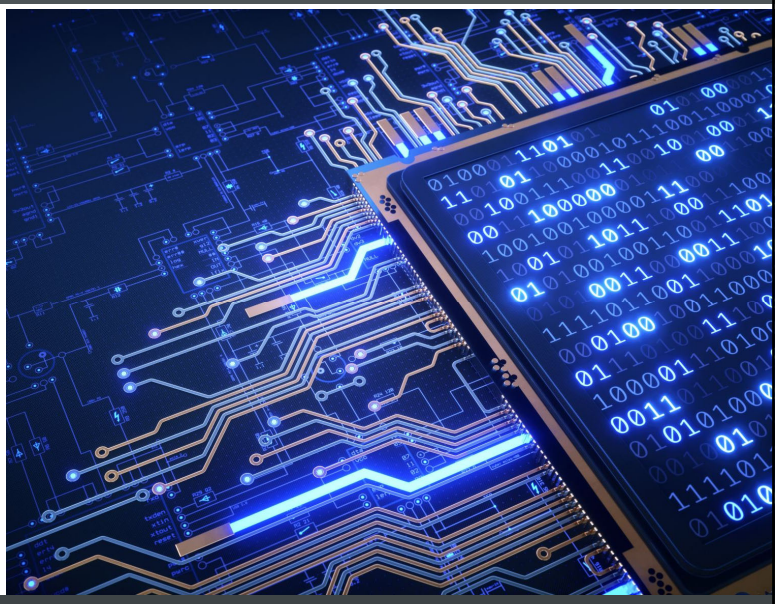



Breaking News!
YOU HAVE BEEN
HACKED


Cyberattacks ongoing 24/7
CYBER ATTACKS
VIRUS & RANSOMWARE
CONSTANTLY EVOLVING THREATS
SOCIAL ENGINEERING
FRAUD
HUMAN FACTOR
COMPLIANCE
AGEING IT-INFRASTRUCTURE
COMPLEX INTEGRATION AND ECOSYSTEMS
UNAPPROVED SOFTWARE
LACK OF CYBER SECURITY POLICY
LACK OF TRAINING & RECOVERY PLAN
LACK OF AWARENESS
UNSAFE DOWNLOAD
EMPLOYEE MISUSE
INFORMATION THEFT
PHISHING
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Solutions and Services ensuring long-term Continuity and 24/7 Protection

Solarwind
Sony
Kaseya
MS Exchange
Lockbit
Yandex
Fortinet…….

Increasing…
- Phishing,
- Malware,
- Ransomware,
- Distributed Denial of Service (DDoS)



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- Digitalization and innovation
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Magnitude of the Cybersecurity problem

Hyper connected and collected Society

The declining cost of collection, storage, and processing of data, combined with new sources of data like sensors, cameras, and geospatial technologies, mean that we live in a world of near-ubiquitous data collection.

Magnitude of the Cybersecurity problem

The marketplace delivers with principle — *field it fast, fix it later*

Melissa Hathaway

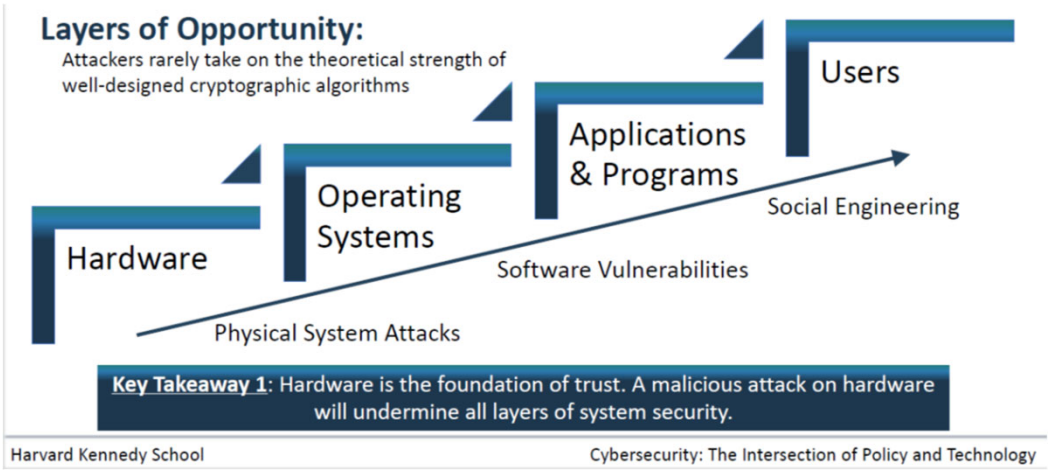
HARVARD Kennedy School

Magnitude of the Cybersecurity problem

HARVARD Kennedy School
JOHN F. KENNEDY SCHOOL OF GOVERNMENT

Hardware Security and Supply chain

The Cybersecurity Landscape



CIA of Data

- Confidentiality
- Integrity
- Availability

Agenda

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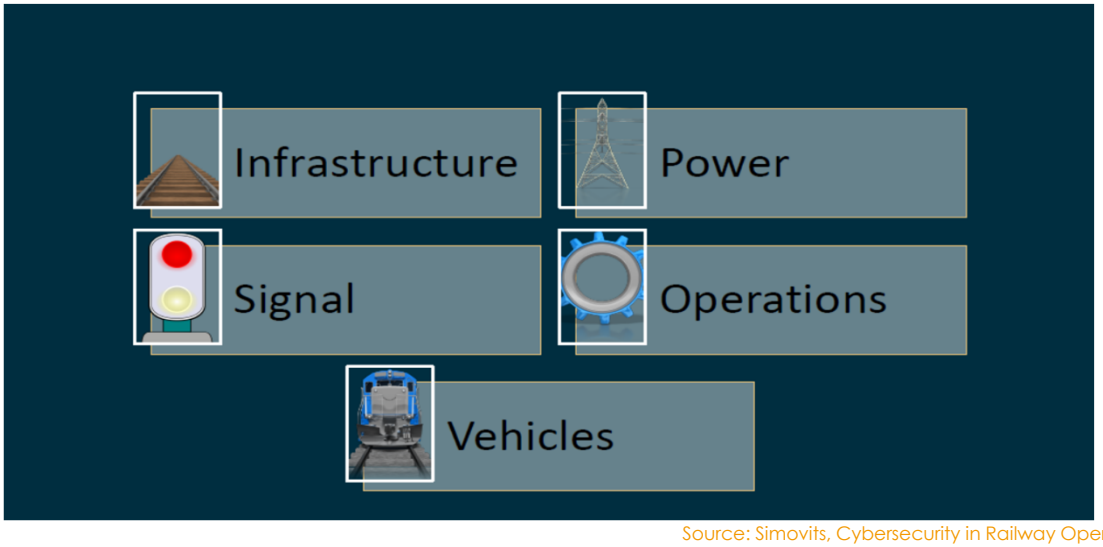
Cyber Security in railway operations

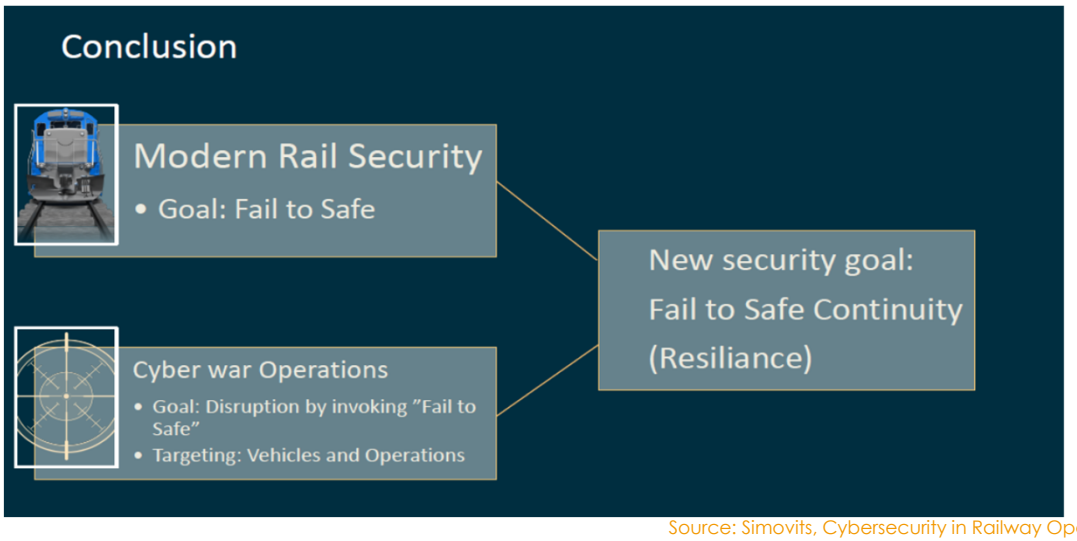
Source: Simovits, Cybersecurity in Railway Operations

Cyber Security in railway operations



Source: Simovits, Cybersecurity in Railway Operations

Cyber Security in railway operations



Source: Simovits, Cybersecurity in Railway Operations

Cybersecurity in railways
ENISA – Regulators overview and stakeholder map

Figure 1: Regulators overview

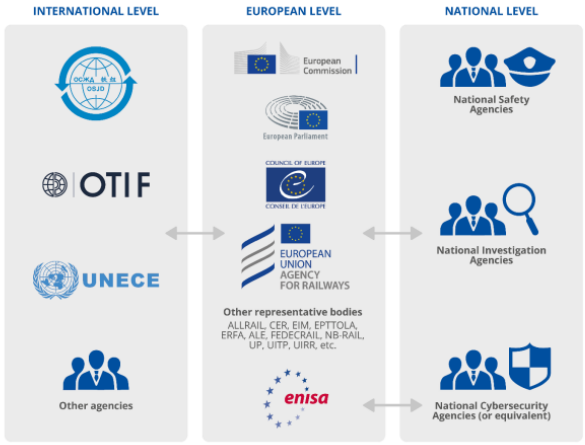
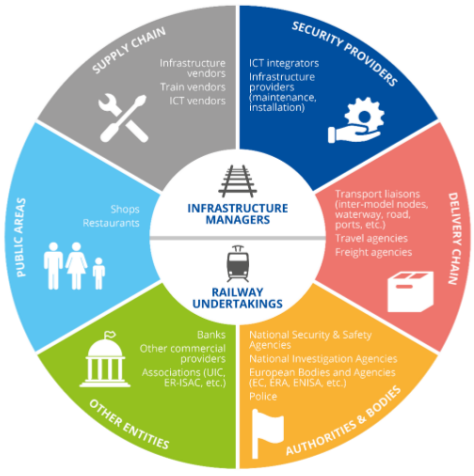


Figure 3: Railway stakeholder map



Source: ENISA, Railway Cybersecurity

Cybersecurity in railway operations – Rail cybersecurity threat environment

Threat vectors

i. Threat motivations

1. Politically motivated (terrorists/states-sponsored)
2. Criminal non-political (financial purposes)
3. Business-oriented attackers
4. Hacktivists
5. Insider threat agent (employees/contractors/operational staff)

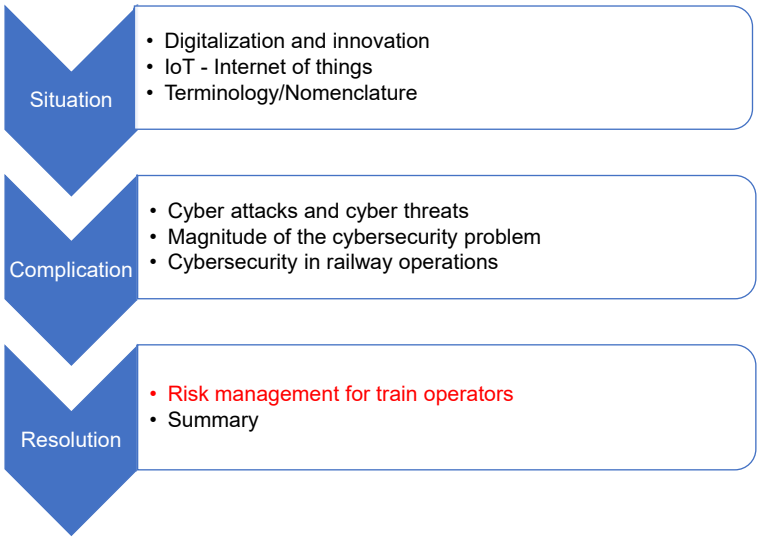
ii. Types of threats

1. Data Theft (DBs, backup storage locations, app servers, system admins)
2. Data integrity breaches (e.g., maintenance history and failure data)
3. Availability - rejection of access

iii. Origin of vulnerabilities

1. Policies/procedures
2. Architecture/design
3. Configuration/maintenance
4. Physical intrusion
5. SW development process
6. Communication/network
7. Lack of training/awareness

Agenda



Risk management for Train Operators – Making Cyber security a top priority
Examples from operators

- **Risk assessment**
  - Assets, Threats, Vulnerabilities, Impact
  - Threats: nation states, cyber criminals, and insiders by using D-DOS, Ransomware, Phising attacks
  - Vulnerabilities – Networks, data (CIA), software, hardware, physical risk, third party, GDPR, etc.
  - Impact - Loss of public confidence, public embarrassment, legal actions against the company, data inaccuracy, loss of safety, loss of reliability and loss of availability
- **Cybersecurity leadership plan**
  - The governance of cybersecurity start with ISO 27001, the management system for information security
  - The European NIS directive establishes security work at the level of ISO 27000 framework
  - Assign leadership roles and responsibilities, appoint a designated cybersecurity officer (CISO)
  - Annual reporting wheel and metrics, such as ROM - Return on Mitigation
- **Develop the cybersecurity incident response plan**
  - Prevention – Planning – Preparation – Detection – Analysis – Containment – Communication – Eradication - Recovery
  - CSIRT – Cybersecurity Incident Response Team
- **Purchase Cybersecurity insurance**
- **Cybersecurity culture**
  - Transparency - Accountability - Appropriate system knowledge - Compliance – Communication channels
- **Cybersecurity awareness training**
  - Analyze-Plan-Deploy-Measure-Optimize
- **Use best practice, for example, the SANS platform**

Risk management for Train Operators –
Which four factors should be included in a risk assessment?

Risk assessment

1. Assets: Critical assets?
2. Threats: nation states, cyber criminals, and insiders by using D-DOS, Ransomware, Phising attacks
3. Vulnerabilities
   - Networks,
   - Data (CIA),
   - Software,
   - Hardware,
   - Physical risk,
   - Third party,
   - GDPR, etc.
4. Impact
   - Loss of public confidence,
   - Public embarrassment,
   - Legal actions against the company,
   - Data inaccuracy,
   - Loss of safety,
   - Loss of reliability,
   - Loss of availability

Risk management for Train Operators – Can you protect yourself from cyber attacks?

- Probably not – but you can reduce your vulnerabilities
- Systematic and risk-based information security work
- Follow the NIS-directive and GDPR
- SOC- Security operation center
- Patch management
- Back-up strategy
- Contingency plans with suppliers
- Plan-Do-Check-Act

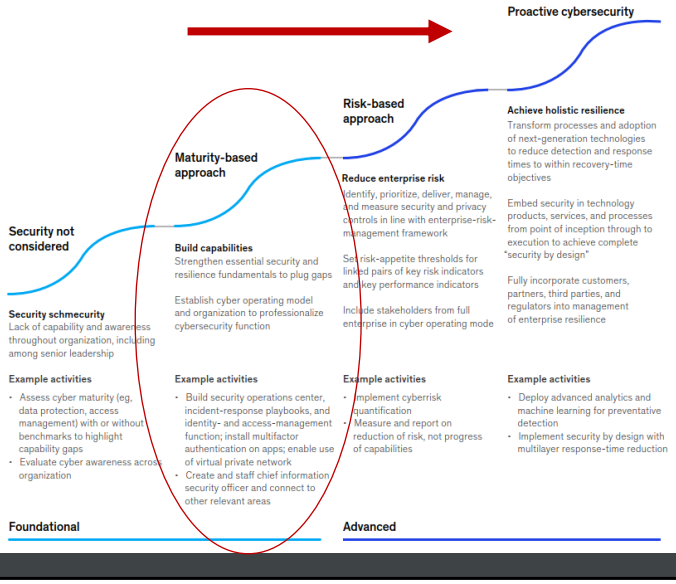
Risk management for Train Operators – The most common types of attacks

Types of attacks

1. Crash the service (crashing the TCP stack or application)
2. Starve the resources (network bandwidth, memory, CPU cycle, etc.)
3. Denial of Service (DoS) and Distributed DoS (reflection attack vs amplification attack)
4. Man-in-the-middle attacks
5. Access control attacks (password attacks)
   i. Dictionary attacks
   ii. Brute-force attack
   iii. Birthday attack
   iv. Rainbow table attacks
   v. Sniffer/snooping attacks
   vi. Spoofing attacks
   vii. Social engineering attacks
   viii. Phishing (spear phishing, whaling)

Risk-based approach is the next stage

For many companies, the risk-based approach is the next stage in their cybersecurity journey.



Source: McKinsey & Co

Agenda

Situation
- Digitalization and innovation
- IoT - Internet of things
- Terminology/Nomenclature

Complication
- Cyber attacks and cyber threats
- Magnitude of the cybersecurity problem
- Cybersecurity in railway operations

Resolution
- Cybersecurity in railways
- Risk management for train operators
- Summary

Rail & Cybersecurity, summary

- The railway sector is based on **regulations defining interoperability and safety** but the existing regulatory framework, does not fully consider security, particularly the cybersecurity issues in the sector.
- Rail was **designed for safety, not for security**, but safety and security are linked at the system level.
- There is increasing need for **cyber resilience** – to go from **fail to safe** to **fail to safe continuity**.
- The main risks concerning **industrial connected information systems** in a gradually deregulated sector
  - Threats to people safety and unsafe situations
  - Disruption to the rail network and services
  - Economic loss to company and/or suppliers
  - Reputational damage
  - Loss of commercial or sensitive information
- There are both **business (operational) risks** and **reputational risks** at national and sector level.
- The most common threat actors to the railway sector are **nation states, cyber criminals, and insiders**.
- The potential danger for the railway sector and methods of attack differ based on the intentions of these actors; **D-DOS, Ransomware, Phising,** etc

Rail & Cybersecurity, summary (continued)

- The sector is undergoing digital transformation, and a **wide range of IT and connected devices (IoT)** are introduced to railway systems, the need for cybersecurity increases and operators must therefore strike a balance between **operational requirements, business competitiveness and cybersecurity**.
- These changes introduce **new vulnerabilities** and highlight the need for operational systems to comply with the same, or even higher, cybersecurity provisions as IT systems.
- Railway stakeholders also depend on **suppliers** with disparate technical standards and cybersecurity capabilities, especially for operational technology.
- Since all digitization is based on access to information and therefore operators need to apply the **CIA framework** – Confidentiality, Integrity, Availability
- In the railway system, the information cannot be allowed to be wrong **(integrity).** Therefore, we need to **protect the data**. The railway operators must also secure access to information **(availability).**
- If information is not available, the trains stops, since safety is the key governing principle of railways.
- One of the biggest challenges in creating a **cyber risk mitigation strategy** is **communicating** its importance to the top management.

Risk management for Train Operators – Making Cyber security a top priority
Examples from operators

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DIGITAL COMMUNICATION TECHNOLOGIES FOR RAIL –

TELECOMMUNICATIONS

Les Granfield, Wray Castle

TELECOMMUNICATION 1

GSM-R

GSM-R

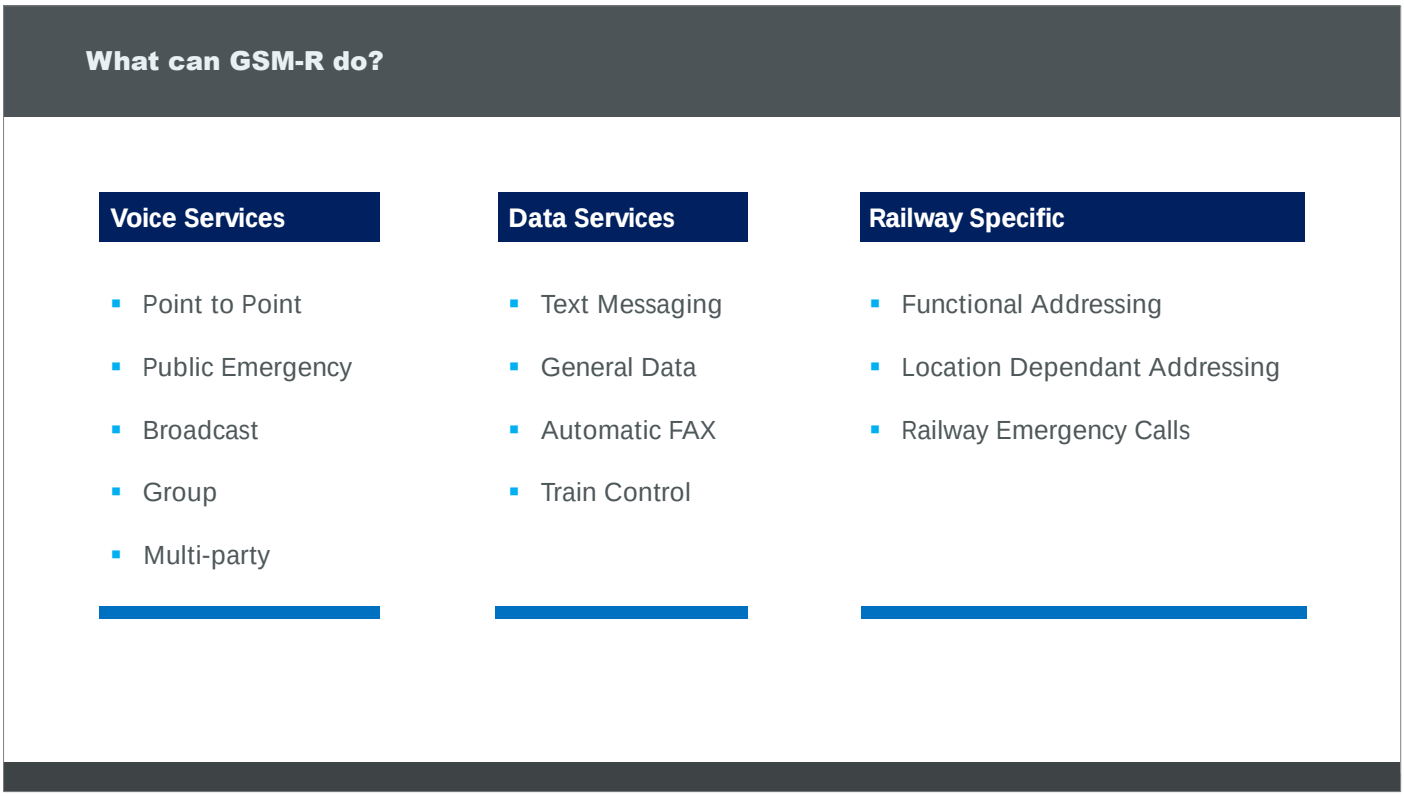
What is GSM-R?	**Global System for Mobile communications – Railways**
Why is it needed?	**To provide a cross border radio communications system for railways**
Who introduced GSM-R?	**International Union of Railways – UIC**
When was it launched?	**1992**
Why is it special?	**It is a standards based digital radio system designed specifically for railways**

GSM-R stands for Global System for Mobile communications for Railways and is based on the commercial GSM systems that were first launched in the early 1990s.

GSM-R was introduced for one of the same reasons that commercial GSM networks came to being and that was to create a pan European mobile telephone system to replace all of the dissimilar systems that where incompatible with one another. Likewise, GSM-R was introduced to replace all of the dissimilar analogue radio systems used by different railway operators in different countries. GSM-R will therefore provide a common communications system invaluable when crossing international borders.

The International Union of Railways (UIC) launched a project in 1992 together with the European Commission (EC) and the railways known as EIRENE (European Integrated Radio Enhanced Network). The aim of this project was to specify the functional and technical requirements for a radio communications system for railway networks.

The European and global success of GSM-R is that it is based on global standards published by the European Telecommunications Standards Institute (ETSI). Theses standards define functionality and the use of open interfaces, creating a wide commercial arena of GSM equipment manufacturers, promoting competition and driving costs down. The UIC have worked closely with ETSI to develop the GSM-R standards.



GSM-R has specific requirements over and above a commercial GSM network. These features had to be described, developed and standardized and are referred to as ASCI (Advanced Speech Call Items). These features are then used to support the communications requirements of railways.

The UIC FRS (Functional Requirement Specification) describes the Network Requirements in terms of the services necessary to meet a range of UIC requirements. These include Voice Services, Data Services and Railway Specific Services.

Voice services describe a generic voice telephony service which shall or should be supported in a GSM-R network including:

- Point-to-point voice calls
- Public emergency voice calls
- Broadcast voice calls
- Group voice calls
- Multi-party voice calls

Data services include the following:

- Text messaging
- General data applications
- Automatic FAX
- Train control applications

The Railway specific services include:

- Functional addressing
- Location dependant addressing
- Railway emergency calls

GSM-R provides improved safety by enabling direct communication between a signaller and driver at all times even when the train is in deep cuttings or travelling through tunnels. Should an emergency situation arise it is possible for a driver or signaller to instigate a Railway Emergency Call (REC), which may result in the stoppage of train movements in an area until the incident has been brought under control.

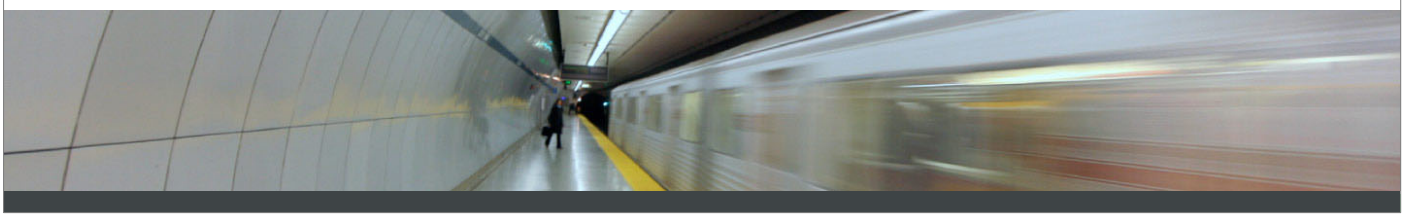
Replacing legacy communications systems with a modern digital system will reduce the on-going OPEX (Operational expenditure) and at the same time improve reliability.

The digital GSM-R system not only supports voice communications but it has an inherent ability to support other forms of communications such as point-to-point messaging, train registration procedures and supports automatic train control systems such as ETCS.

GSM-R complies with European standards providing interoperability across international borders. This removes the need for trains to be equipped with different communications systems for each country in which it travels.

The Benefits of GSM-R

- Increased Safety
- Improved Performance
- Enhanced Passenger Experience
- Digital Future

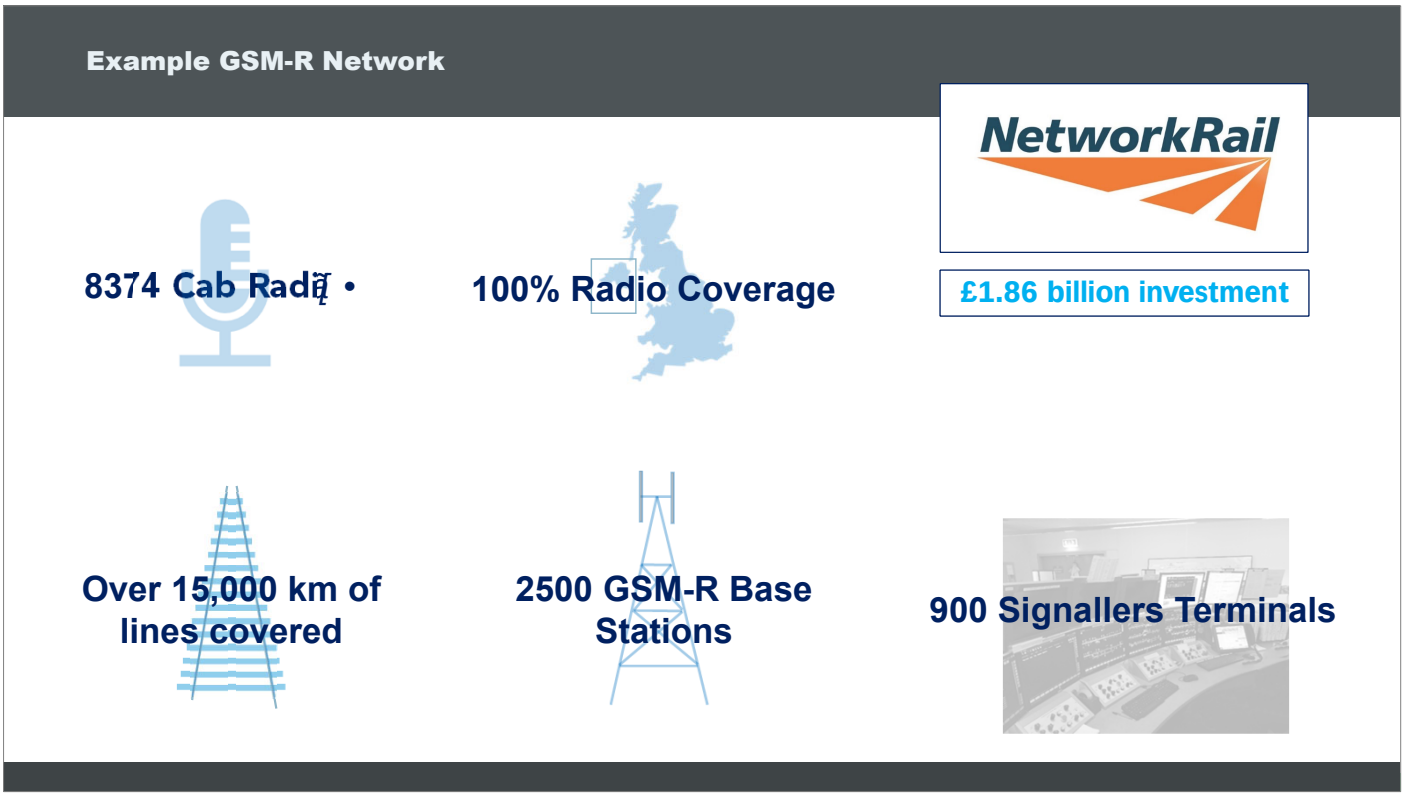


GSM-R increases safety by providing the driver of a train with an in-cab radio. The driver will no longer be required to step off the train to communicate with a signaller using a lineside telephone, thereby reducing risks. Drivers can notify signallers of any observed risks such as obstructions on the line, or bring train movement to a stand should an REC be initiated. The GSM-R system incorporates the ability to carry out remote management reducing the need for teams of engineers to be working trackside.

Real time communications afforded by GSM-R can improve the performance of a railway through situation awareness. Drivers can be forewarned of problems such as poor rail adhesion and take appropriate action, resulting in fewer delays. Wide area radio coverage allows potential delay causing problems to be pin-pointed and remedied. When delays occur the system can provide a better understanding of the causes ensuring incidents are not repeated.

Communications between drivers and signallers can keep passengers better informed about events or delays, minimizing passenger frustration. GSM-R can also support on board passenger information displays and signallers can communicate with passengers via the public address system if need be.

GSM-R has always been intended to be the bearer for ETCS signalling. ERTMS is the UIC strategy to replace all of the legacy railway signalling systems with a common system – ETCS, paving the way for a digital future.



Network Rail operate the GSM-R network in the UK. The system was phased in over a period of years beginning in 2007 replacing two legacy analogue radio systems known as Cab Secure Radio (CSR) and the National Radio Network (NRN). The project was completed in 2016 and provides 100% coverage of over 15 000 km of tracks using 2500 base stations. Over 8373 cab radios have been installed along with over 900 signallers terminals. Critical components have been duplicated and the project represents a £1.86 billion GB pounds.

TELECOMMUNICATION 2

ERTMS

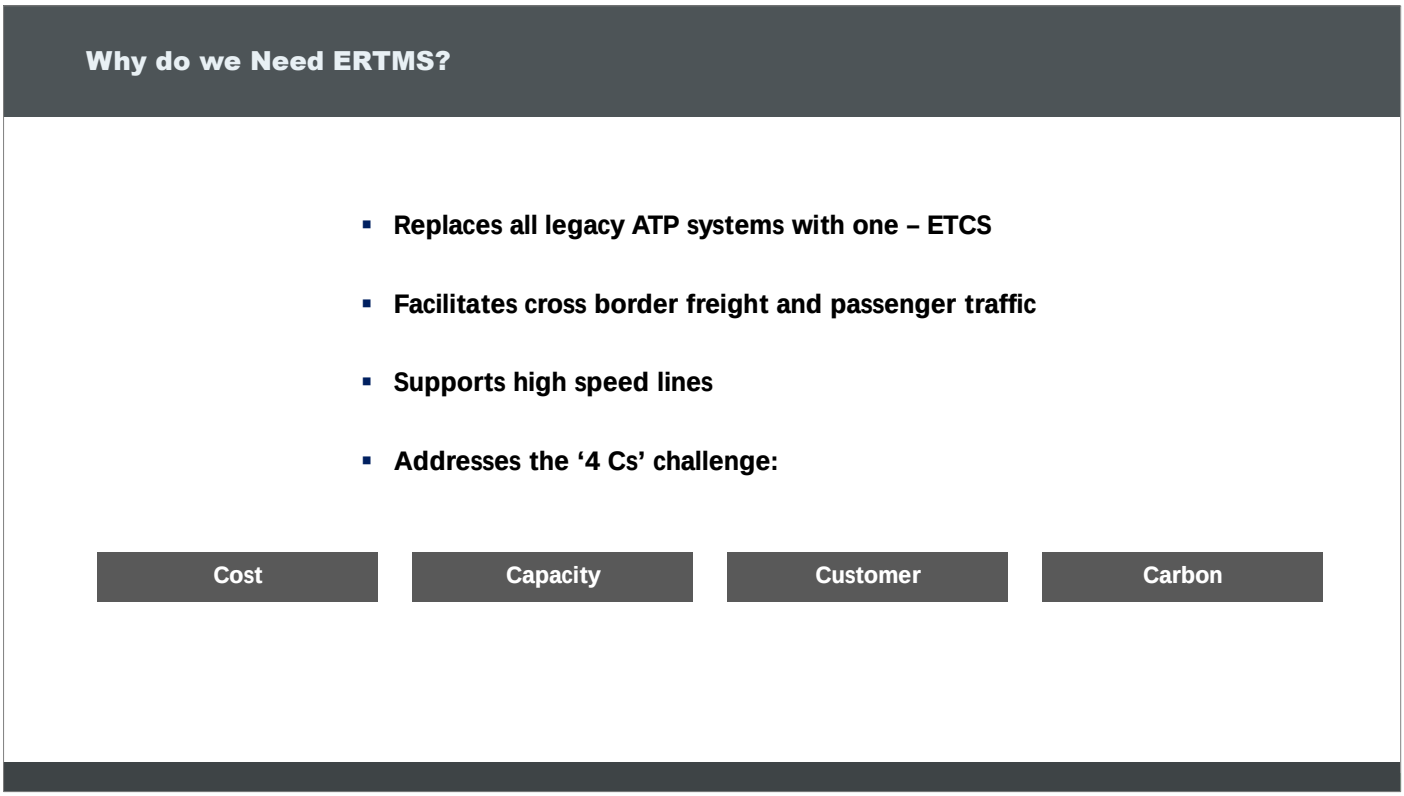
What is ERTMS?

- **European Rail Traffic Management System**
- **A major European Industrial Project**
- **Driven by members of UNIFE**
- **A pan-European Automatic Train Protection system**
- **Designed to replace legacy ATP systems**
- **Two parts: ETCS and GSM-R**
- **Will also work with FRMCS in the future**

ERTMS is the European Rail Traffic Management System which is a major European industrial project underway in Europe and many other parts of the world. The project is driven by members of UNIFE (Union des Industries Ferroviaires Europeenes) which include Alstom Transport, Ansaldo STS, AZD Praha, Bombardier Transport, CAF, Mermec, Siemens Mobility and Thales. The project is not expected to be completed before 2040.

ERTMS is defined as an advanced Automatic Train Protection (ATP) system which is intended to replace the 20 dissimilar train control systems in use across Europe, thereby providing a common signalling system for the railways.

There are two parts to ERTMS namely ETCS (European Train Control System) which is the technology to control the movement of trains and secondly GSM-R which will deliver the train Movement Authorities. In the future, ETCS signalling will be conveyed using FRMCS - the Future Railway Mobile Communications System.



Trains travelling across Europe need to be equipped the train control system used in each country. This is expensive, demands extra training for drivers and can be time consuming if traction engines have to be swapped at borders.

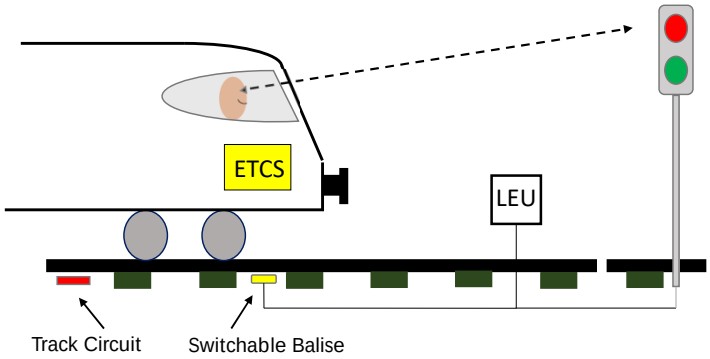
ERTMS will provide a common signalling system – ETCS and will facilitate safe border crossing for both freight and passenger traffic.

ERTMS was originally designed to support high speed lines with speeds up to 500km/h but it can also be used on conventional lines too.

ERTMS addresses the '4 Cs' challenge of Cost, Capacity, Customer satisfaction and Carbon emissions. It is anticipated that the deployment of ETCS as a replacement for legacy systems will result in a 50% reduction in costs. The capacity of rail networks is expected to double, without laying any extra lines. Customer satisfaction in Europe will increase from 90% to 99% and Carbon emissions will be halved.

What are the ETCS Levels?

ETCS Level 1



- Overlay to existing signalling system
- Movement Authorities passes via Eurobalise
- Train Integrity and position using track circuits

Main Benefits

- Interoperability – suppliers and countries
- Safety

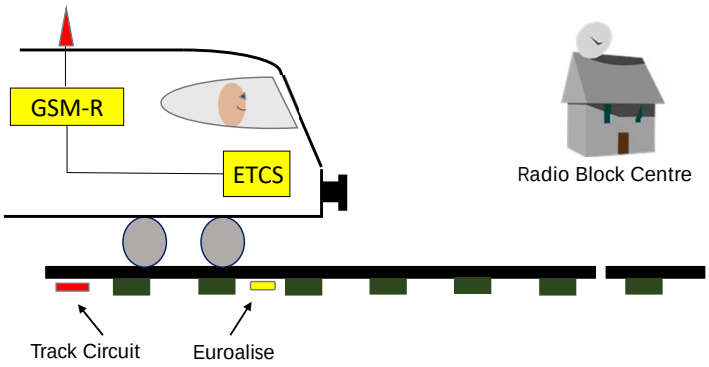
ERTMS operates using a number of ETCS Levels allowing a railway operator to choose the most appropriate configuration or gradually phase-in ERTMS over a period of time.

The first ETCS Level is known as Level 1 is an overlay onto an existing train control system. The existing system will permit non-ETCS equipped trains to run on the line along with ETCS equipped trains. Movement Authorities are passed to the train as it moves over a Eurobalise located between the rails. This is a switchable balise connected to the conventional signalling system. The position of the train and its integrity are secured using track side circuits.

The main benefits of Level 1 is the interoperability between neighbouring countries and the ability to mix and match different vendor equipment both on-board and trackside. Ultimately safety is the greatest benefit.

What are the ETCS Levels?

ETCS Level 2



Eurobalise + Euroradio + Radio Block Centre

- Trackside signals can be removed
- Train position using Eurobalise
- Movement Authorities from RBC via GSM-R

Main Benefits

- Interoperability – suppliers and countries
- Safety
- Increased capacity
- Reduced maintenance costs

With ETCS Level 2 the legacy trackside signalling can be removed and two additional components are included, namely the Euroradio (GSM-R) and Radio Block Centre (RBC).

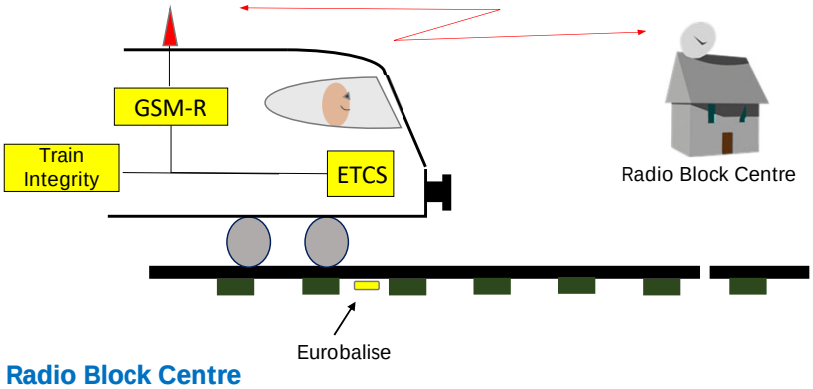
The train position is ascertained using Eurobalises and reported by the train to the RBC. The RBC then issues the train with a Movement Authority vis the GSM-R network.

The main benefits include interoperability and safety, but the RBC can supervise a number of trains in a given area, safely minimizing the headway between trains resulting in increased capacity.

Replacing the legacy ATP systems with ERTMS will also reduce maintenance costs.

What are the ETCS Levels?

ETCS Level 3



Eurobalise + Euroradio + Radio Block Centre

- Train position using Eurobalise
- Movement Authorities from RBC via GSM-R
- No trackside circuits
- On-board Train Integrity
- Moving Block

Currently a concept

ETCS Level 3 allows for the removal of trackside circuits. Train positioning is provided by the Eurobalise. However, to guarantee train integrity an additional Train Integrity System will be required. This is current being researched therefore ETCS Level 3 is an aspiration.

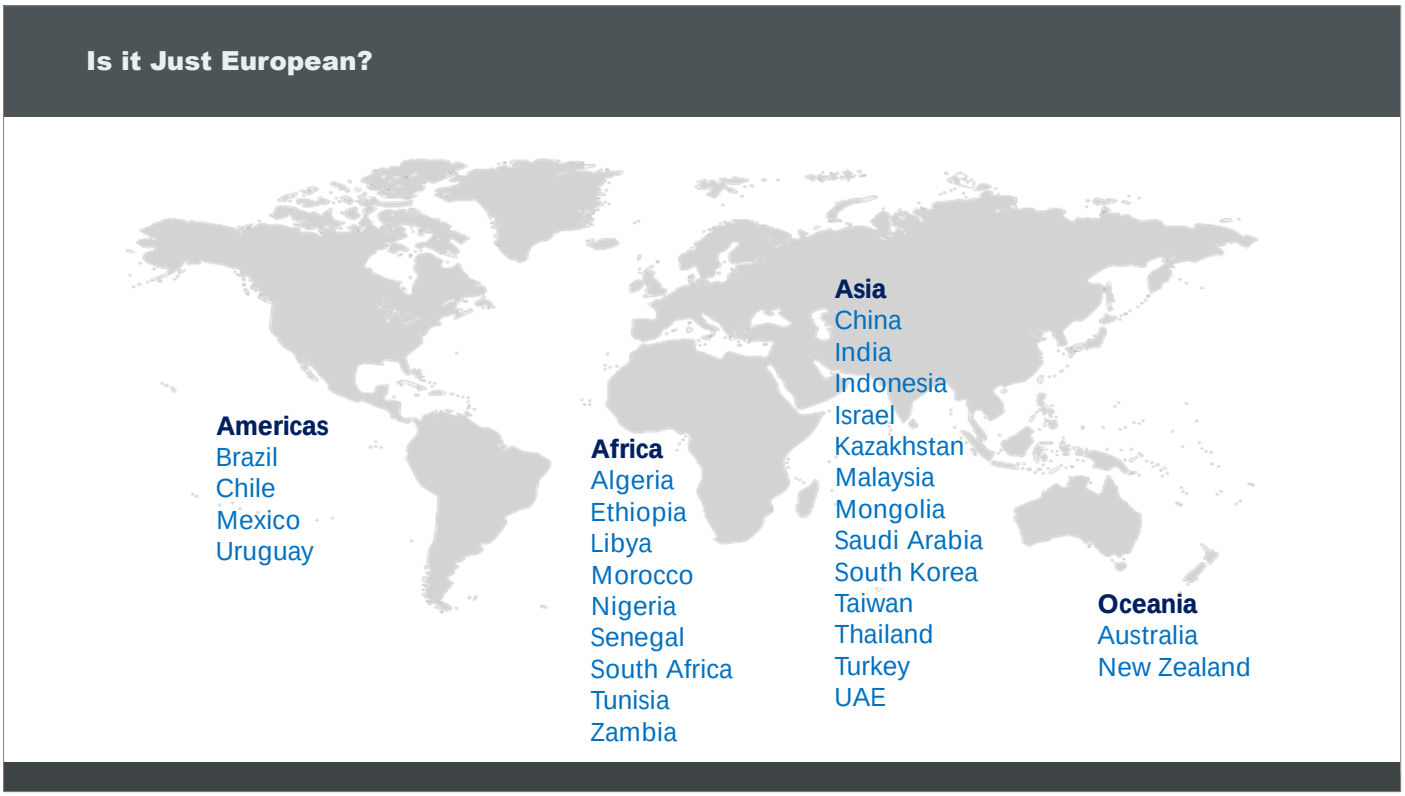
In conventional ATP systems the lines are divided into fixed block sections with a simple rule that a block section can only be occupied by one train at a time. Entry into a block section is only permitted with a Movement Authority. With ETCS Level 3, fixed block sections will not be required. Instead the RBC will calculate a safe space in front of and behind the train. This logical block section will move with the train.

Is it Just European?

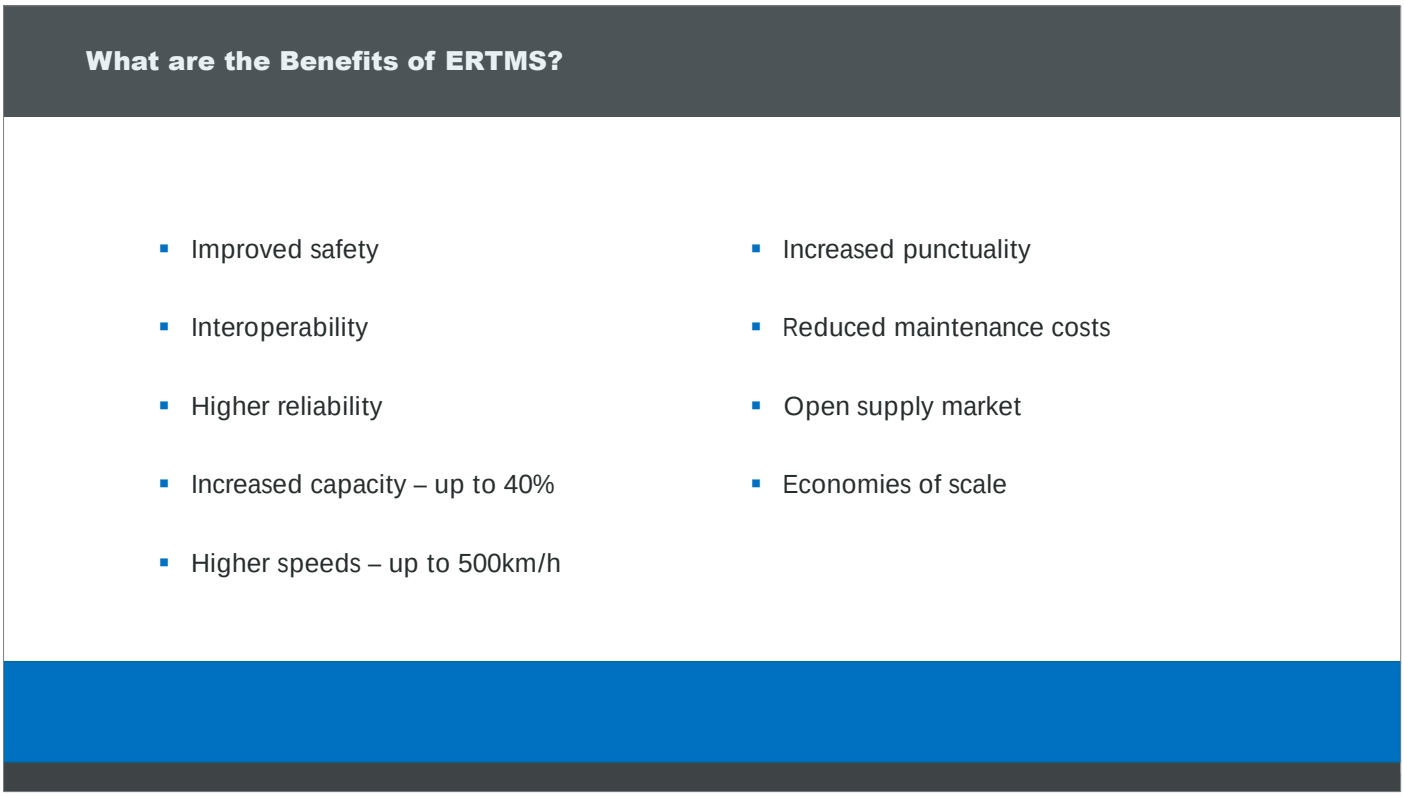
ERTMS in Europe:

Austria	Germany	Portugal
Belgium	Greece	Romania
Bulgaria	Hungary	Slovakia
Croatia	Italy	Slovenia
Czech Republic	Luxembourg	Spain
Denmark	Macedonia	Sweden
Finland	Norway	Switzerland
France	Poland	UK

Is it just European?



Even though ERTMS is defined as the European Rail Traffic Management System it is also applicable in other world regions. According to the ERTMS website there are 24 countries that have deployed or are in the process of deploying ERTMS in Europe. Additionally the ERTMS website identifies 4 world regions where ERTMS is being deployed including the Americas, Africa, Asia and Oceania. The Asia region includes not only Asian countries but also countries considered to be in the Middle East.



First and foremost is that ERTMS will improve safety. ETCS can offer continuous supervision of trains so train separation can be maintained at all times.

ERTMS provides interoperability in terms of equipment, train borne and trackside components can interwork even when supplied by different manufacturers. Additionally interoperability refers to the ability rail traffic to cross international borders seamlessly.

The ERTMS system will replace ageing electromechanical systems with a modern digital train control system providing higher reliability.

It is estimated that by using continuous supervision of trains it will be possible to safely reduce the required headway allowing more trains to travel on the same line leading to a capacity increase of up to 40%.

Initially ERTMS was designed to support high speed lines where trains may be able to run at speeds of up to 500km/h. But ERTMS is also applicable to conventional lines as well.

Continuous supervision will allow train speeds to be altered dynamically improving the punctuality of trail traffic.

The replacement of legacy train control systems with a more modern digital system will reduce maintenance costs.

Being based on international standards will create an open market allowing railway operators to mix and match ERTMS equipment on the lines and take advantage of the economies of scale.

ERTMS Deployment in Spain

- Over 2900 km lines in service
- Additional 2000 km planned or under construction
- Infrastructure manager ADIF (Administrador de Infraestructuras Ferroviarias)
- Six UNISIG suppliers
- Rail gradually replacing air as the transport of choice
- Madrid-Barcelona line market share increased from 48% to 63%
- Madrid-Malaga line 88% passenger growth
- Punctuality times reaching 98% second only to Japan
- 1/6th of the carbon emissions compared to road and air travel
- International travel across Spanish-French border

Figures from ADIF via https://www.ertms.net

According to the ERTMS website, Spain is considered 'a worldwide reference and leader in ERTMS deployment'. Over 2900 km of lines are covered by ERTMS and in service. There is an additional 2000 km of line being planned or under construction. The infrastructure manager for the lines is ADIF (Administrador de Infraestructuras Ferroviarias) who has been working with six UNISIG suppliers, demonstrating equipment interoperability.

It has been observed that rail is replacing air as the transport of choice by the Spanish population where the Madrid-Barcelona line has seen a market share increase from 48% to 63%. On the Madrid-Malaga line there has also been recorded a 88% passenger growth. Punctuality times have reached 98% which is second only to Japan. Compared to road and air travel, rail travel has only 1/6th of the carbon footprint. ERTMS has also enable the smooth travel across the Spanish French border.

TELECOMMUNICATION 3

5G

What is 5G

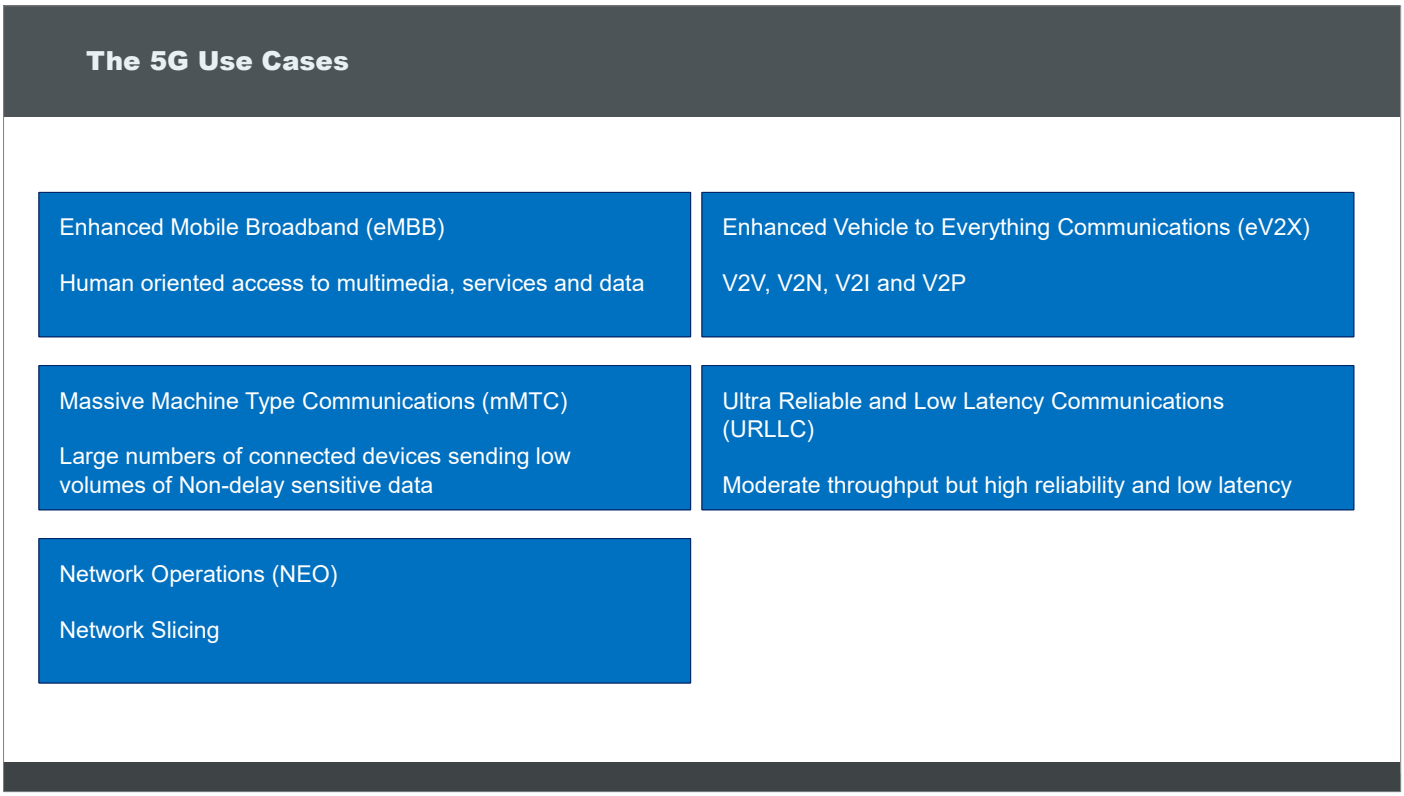
- **It is the 5th Generation mobile telephone technology**
- **Specified by the 3rd Generation Partnership Project (3GPP)**
- **Has a long pedigree**
- **Comes from the same stable as GSM-R**
- **Application agnostic**
- **Supports a wide variety of use cases**
- **First launched in 2019**
- **Long term support over the next ten years and beyond**

5G is the 5th Generation mobile telephone technology, its predecessors being 2G GSM (including GSM-R), 3G UMTS and 4G LTE (Long Term Evolution). In fact 5G is an evolution of 4G LTE.

The technology is specified by the 3rd Generation Partnership Project (3GPP) – a European standards body that encompasses standards organizations from around the world.

5G is described as being Application Agnostic, in other words it is a technology that can simply carry data, reliably and at high rates, irrespective of what that data may be. However, it has been designed to support a variety of Use Cases to suit virtually any application.

5G was first launched in 2019 in what is referred to as Release 15 of the 3GPP specifications. Long term support over the coming years will see further releases of the specification bringing new capabilities and features of 5G.



3GPP have identified 5 groups of Use Cases which will address the needs of commercial mobile operators but are equally applicable to the railways. They include:

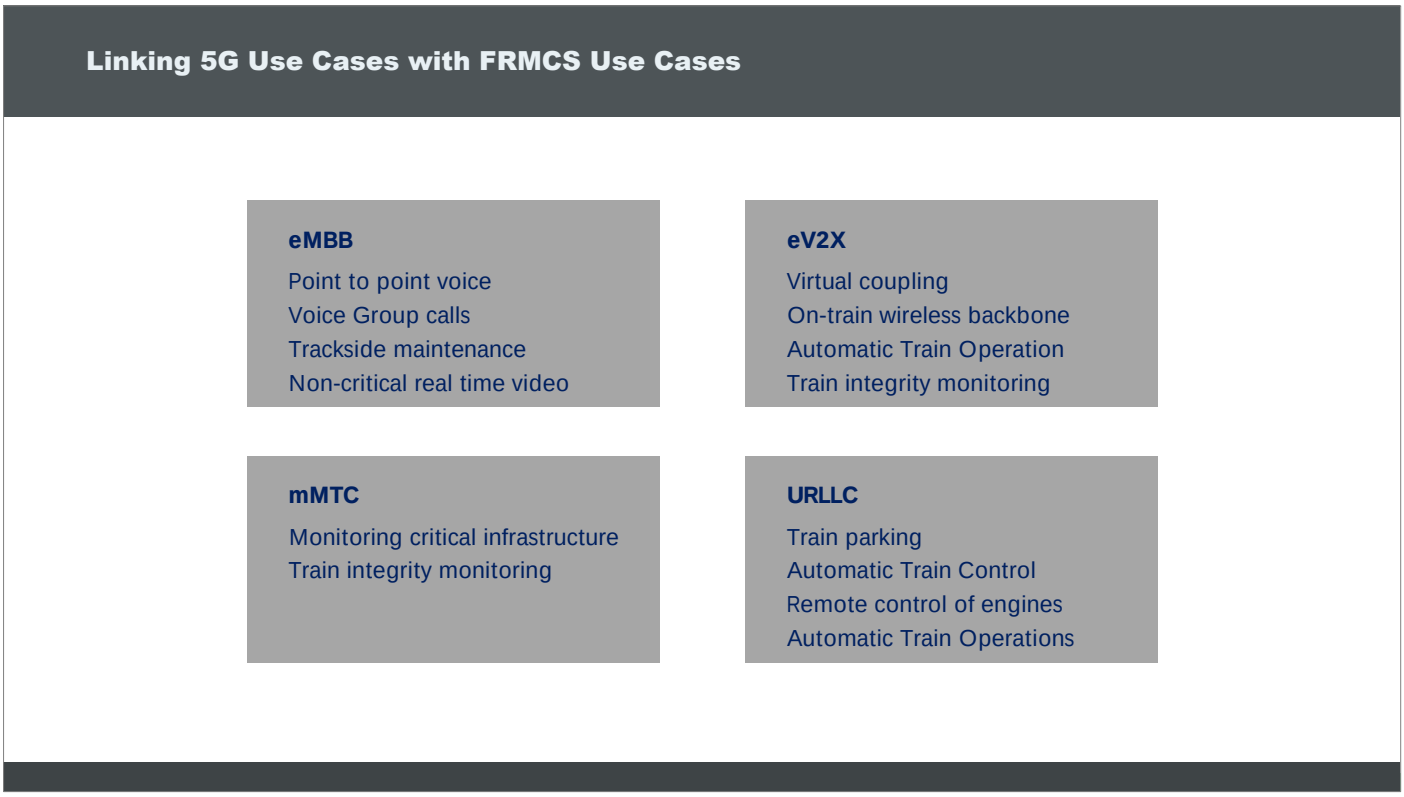
Enhanced Mobile Broadband (eMBB) – which is defined as being human oriented access to multimedia services and data at speeds never achieved before.

Massive Machine Type Communications (eMTC) – where large numbers of connected devices can send low volumes od non-delay sensitive data.

Enhanced Vehicle to Everything (eV2X) communications – which include Vehicle to Vehicle (V2V), Vehicle to Network (V2N), Vehicle to Infrastructure (V2I) and Vehicle t Person (V2P).

Ultra Reliable and Low Latency Communications (URLLC) – offering moderate bit rates but high reliability and low latency.

Network Operations (NEO) – Offering Network Slicing.



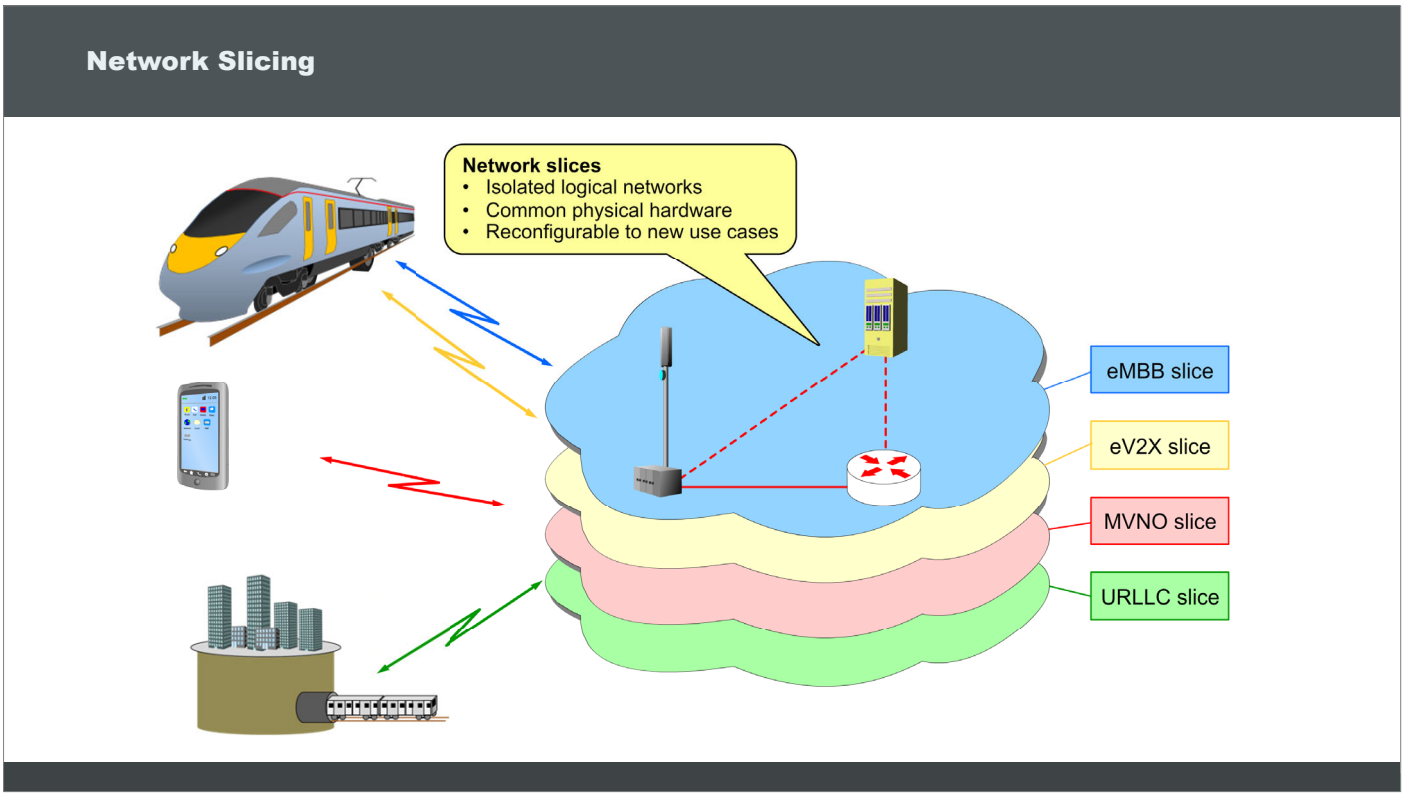
The UIC defined Use Cases may be mapped to one or more 3GPP defined Use Cases with the diagram illustrating some examples but not all.

Voice calls including point to point and group calls fit into the category of eMBB along with voice calls for shunting operations and trackside maintenance. Non-critical real time video would also fit into the eMBB category.

Enhanced Vehicle to Everything (eV2X) would support the requirements of train to train communications needed for virtual coupling. Replacing inter-carriage cabling using 5G to create the on-train wireless backbone also fits into this category. Automatic Train Operation relies on communications between the vehicle (train) and trackside (Infrastructure) or V2I. To support Level 3 in ETCS Train Integrity Monitoring can also be classed as eV2X.

Under the heading of massive MTC the monitoring of critical infrastructure such as track circuits, axle counters and level crossing barriers are good examples. As well as train integrity monitoring.

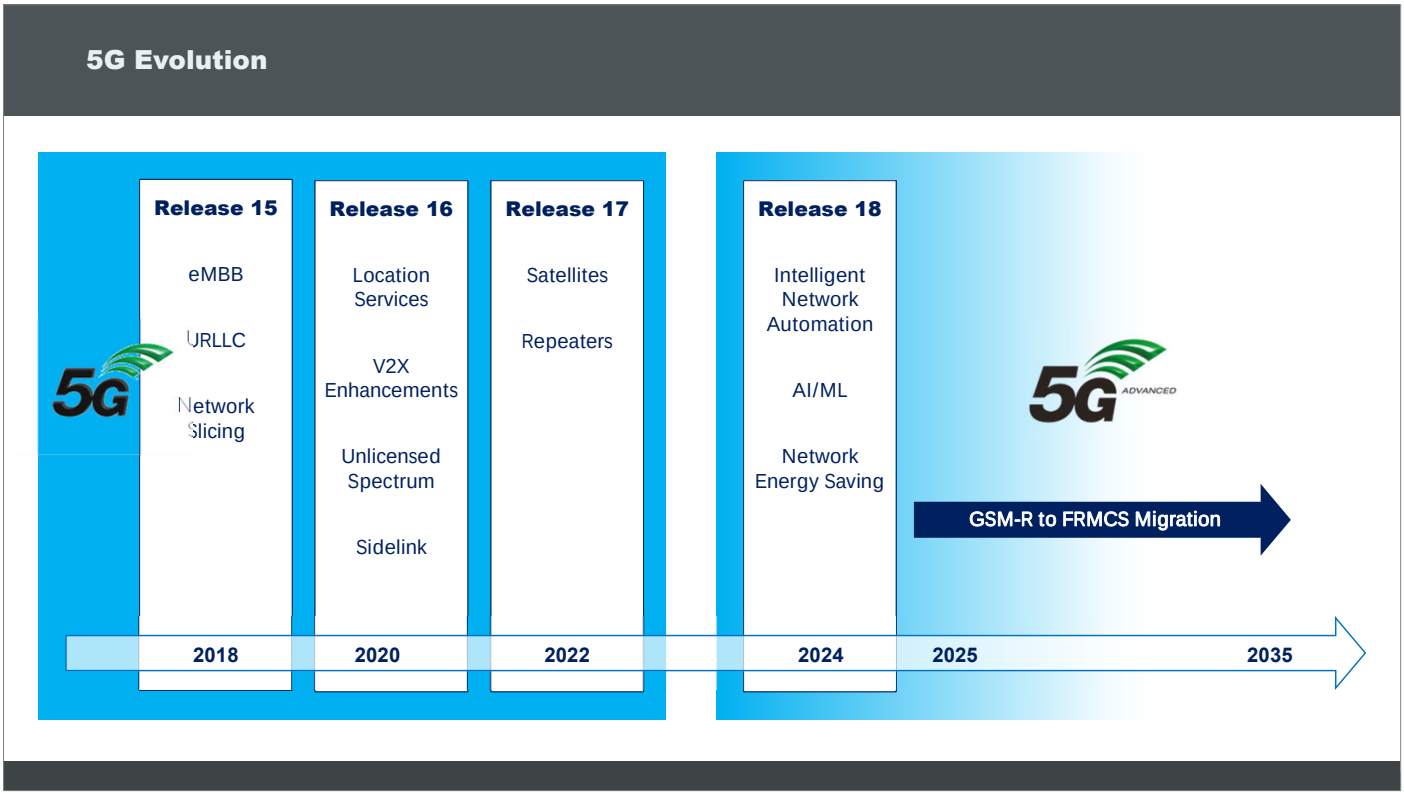
URLLC is the heading under which latency critical applications sit, including train parking, ATC, remote control of engines and ATO.



A network slice is a virtual logical network, which runs on common underlying physical infrastructure, and whose capabilities are optimised for a particular use case. Examples might include slices providing voice communications, Automatic Train Control or monitoring critical infrastructure, or a slice that is optimized for the delivery of streaming video.

Different network slices are isolated from one another, notably in respect of data transport (so that congestion in one slice does not affect any of the others) and security (so that an attack on one slice does not affect any of the others). An individual Mobile device attaches to one or more network slices, depending on the resources that it requires.

The Mobile Network Virtual Operator (MVNO) slice could be a slice of a commercial 5G network that has been created for railway applications.



The first release of the 5G specifications is known as Release 15 and was made available in 2018. One year later the first 5G networks began to be deployed. There is usually a gap of about one year before the features in a Release can be deployed because it takes time for the manufacturers to build and test the features before being made commercially available. Release 15 provided the framework for 5G and included support for eMBB, URLLC and Network Slicing amongst others.

In 2020 3GPP published Release 16 including many features and enhancements. Those which are of interest for FRMCS include Location Services allowing for the positioning of trains. Radio spectrum is a rare commodity so the use of licence free spectrum could also be used for FRMCS. The UIC have also stated that communications should still be possible without 5G radio coverage, perhaps due to failure, so the Sidelink feature will allow 5G devices to communicate directly.

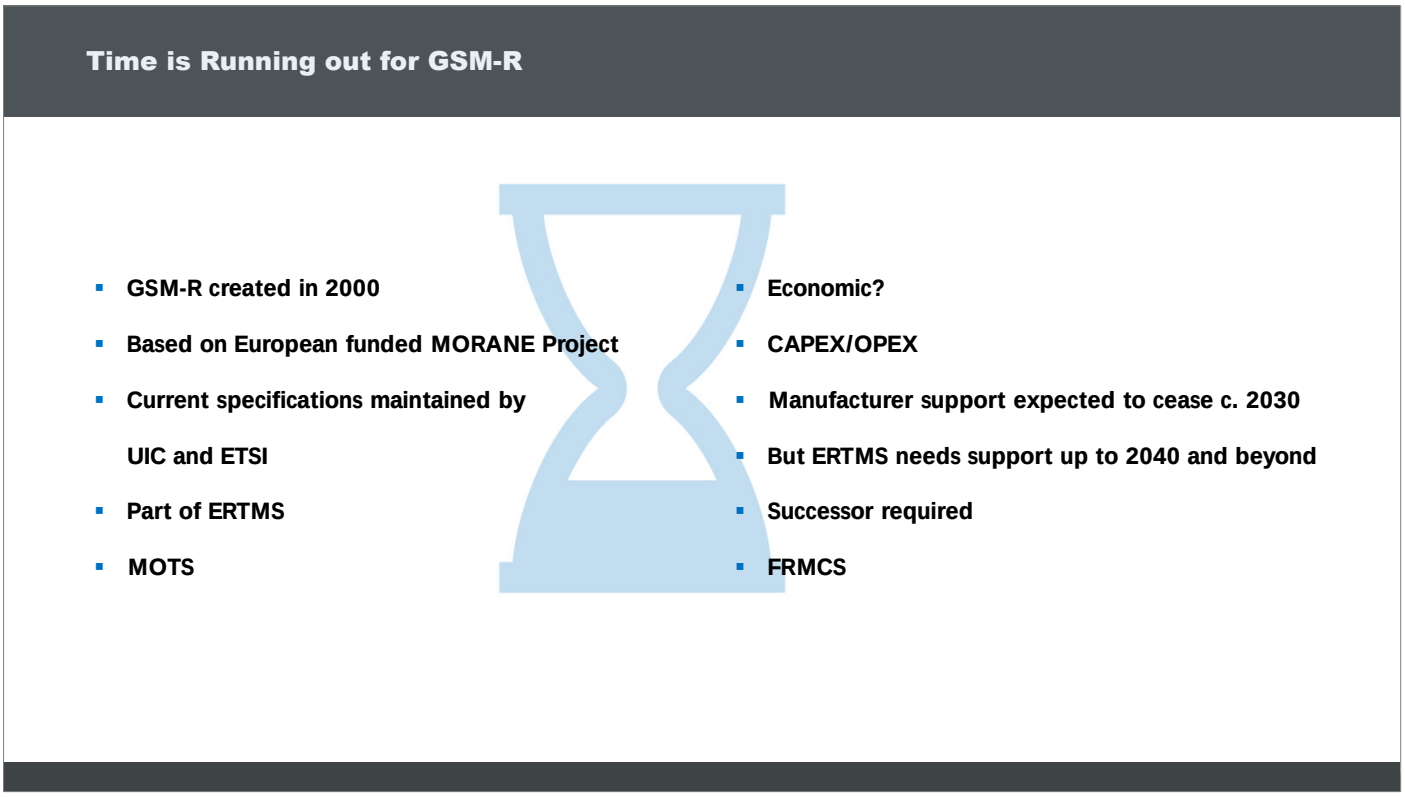
Release 17, which was delayed by the Pandemic includes a satellite component which may be useful for providing FRMCS in remote parts of the world such as the Australian outback. Repeaters are commonly used in GSM-R to provide better coverage in tunnels, so in Release 17 the 5G repeater is introduced.

Release 18, known as 5G Advanced is anticipated for the year 2024 and will include many enhancements of the previous features but includes Intelligent Network Automation, Artificial Intelligence and Machine Learning (AI/ML) as well as Network Energy Saving.

It is expected that FRMCS will be based on Release 18 and will allow the migration from GSM-R to FRMCS over the time period between 2025 to 2035.

TELECOMMUNICATION 4

FRMCS



GSM-R was developed to provide a common radio communications system across European railways. The specifications were finalised in 2000 after ten years of collaboration between various European railway companies. GSM-R is based on the European-funded MORANE (Mobile Radio for Railways Networks in Europe) project with the specifications often referred to as the EIRENE (European Integrated Radio Enhanced Network) specifications. The EIRENE specifications being maintained by the Union Internationale des Chemins de Fers (UIC) or International Union
of Railways. GSM-R is part of project ERTMS (European Rail Traffic Management System).

GSM-R is a MOTS (Modified Off The Shelf) technology system based around manufacturers' commercial GSM equipment with modifications required to provide railway functionality. Most of the equipment utilised for GSM-R consists of manufacturers' special-build equipment and/or software variants. The use of MOTS technology for GSM-R was initially thought to be an economic way to build a pan-European system but has proven expensive for the railways, in terms of capital expenditure (CAPEX) and operational expenditure (OPEX).

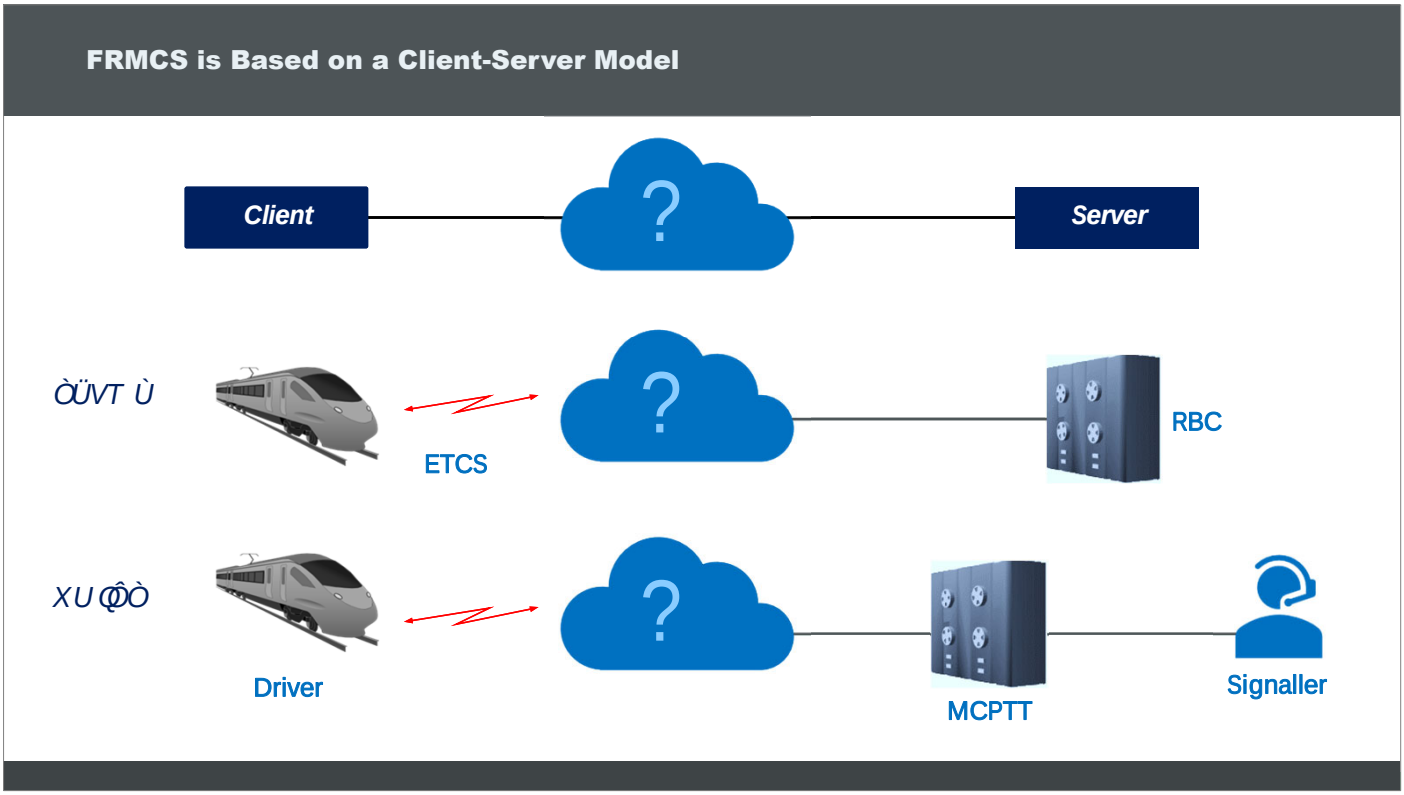
It is predicted that GSM-R will be obsolete by 2030. The reasoning being that it becomes uneconomical for manufacturers to produce and maintain this legacy system. That combined with the long term life expectancy of ETCS (2050) and the Railway business needs, have led to the European Railway community initiating work to identify a successor for GSM-R. The successor has to be future proof, learn from past experiences/lessons and comply with Railway requirements. These are the foundations for the Future Railway Mobile Communications System (FRMCS).

What is FRMCS?

- Future Railway Mobile Communications System
- A UIC Project
- Began in 2012 with the publication of the User Requirement Specification (URS)
- URS captures the communications requirements for railways
- Version 5.0 published in 2020
- URS used to create Use Cases
- Use Cases will drive the standardization of FRMCS

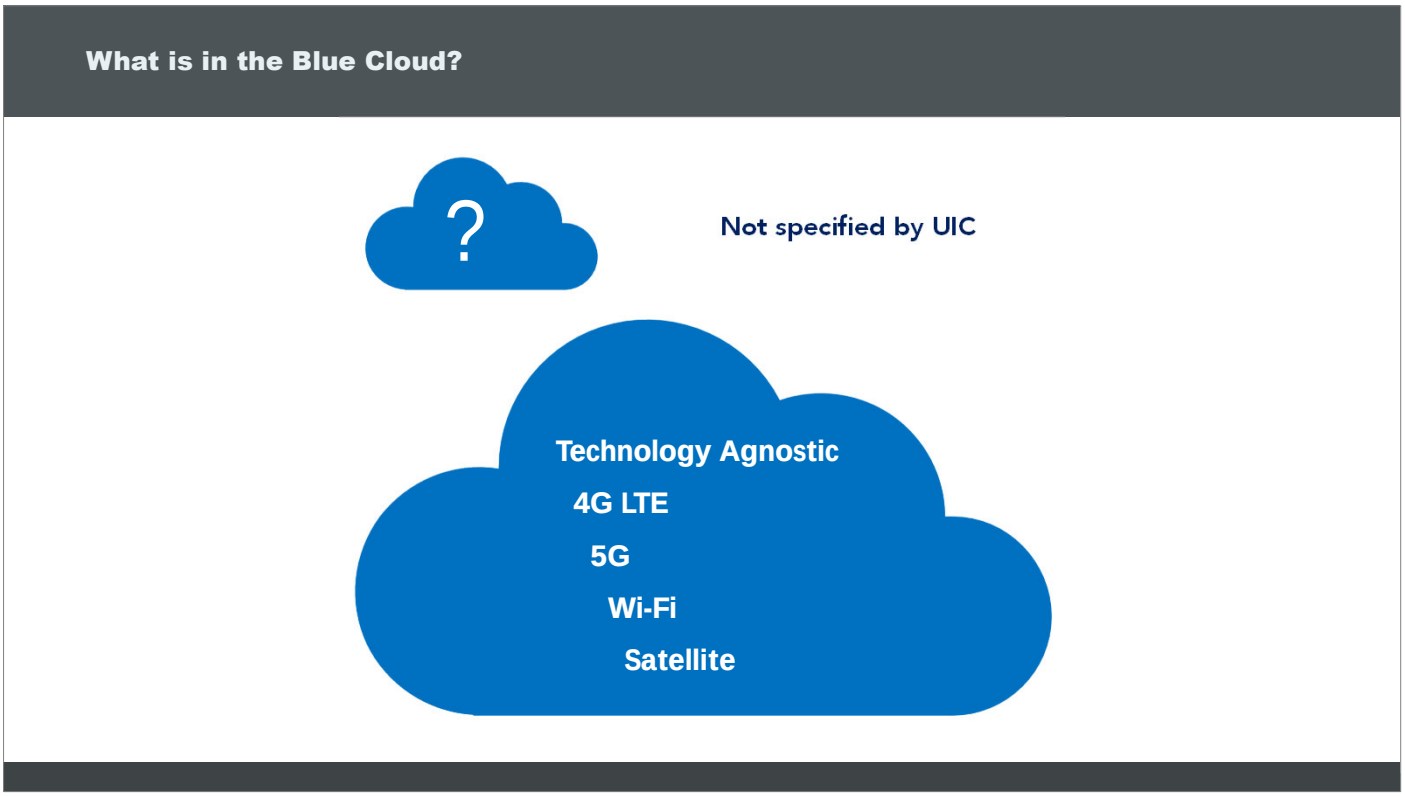
FRMCS is the Future Railway Mobile Communications System and is a project created by the UIC. This project began in 2012 with the publication of a UIC document called the 'User Requirement Specification (URS). The URS captures the communications requirements for railways and has categorized them into three groups. The latest version of the document is v5.0.0 which was published in 2020.

The URS will be used to define the Use Cases which will be submitted to the standards organizations-TC RT (Technical Committee for Railway Telecommunications) part of ETSI (European Standards Technical Institute) and the Third Generation Partnership Project (3GPP). These organizations will perform a gap analysis, identifying what standards already exist and what needs to be created to satisfy the needs of railways.



Unlike GSM-R where the functionality of the network is baked into the network architecture, FRMCS focuses on railway applications and uses the Client-Server model.

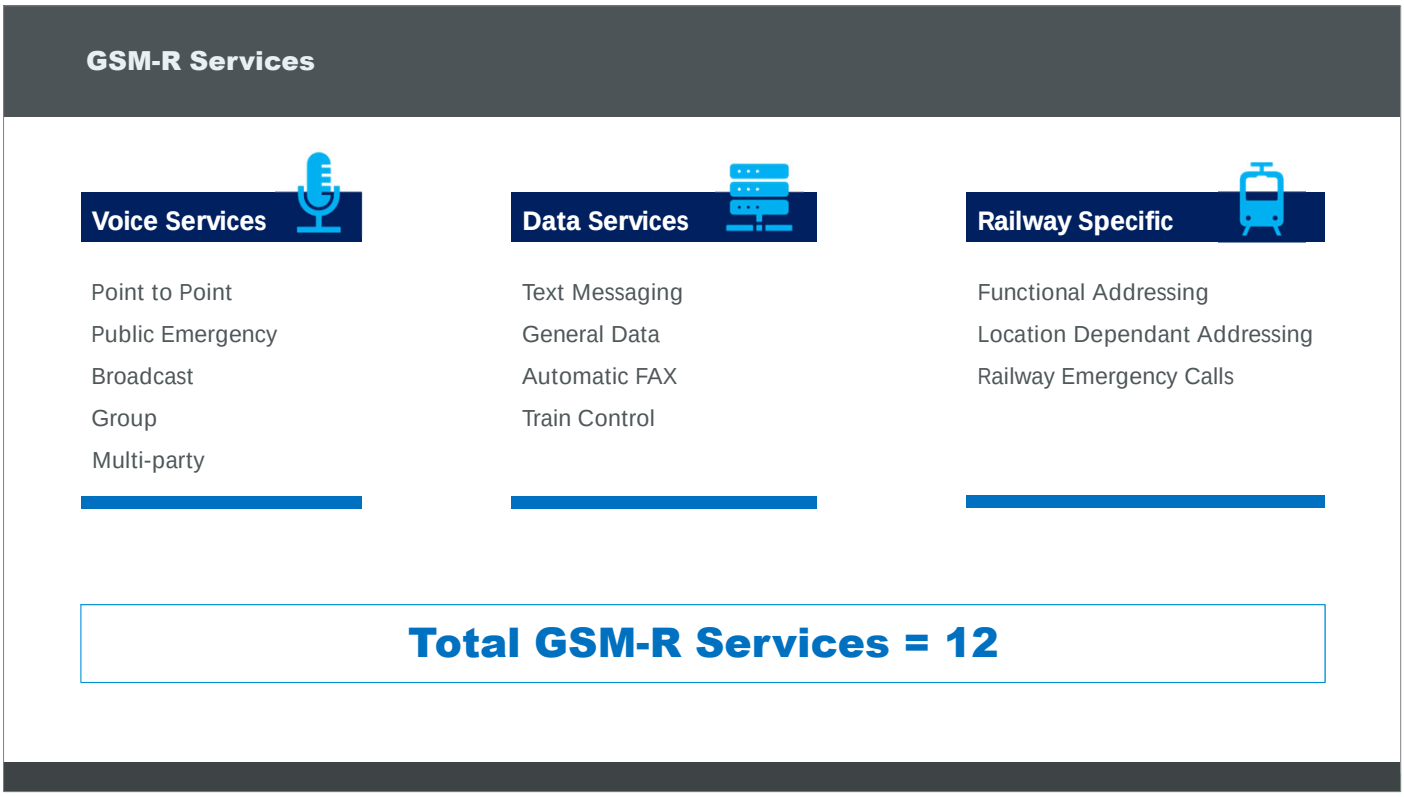
As an example in ERTMS the ETCS application is run on a processing platform on board the train and it currently communicates via GSM-R to the Radio Block Centre which is a application running on a server located trackside. Likewise, a voice call between a train driver and signaller will be facilitated by an application running on a device on the train and the 3GPP defined Mission Critical Push To Talk (MCPTT) server which in turn connects to a signaller terminal equipment



The blue cloud in the diagram represents the communications network which is currently GSM-R, but what will it be in FRMCS? The UIC have not specified the technology except to say FRMCS is technology agnostic.

The technology could be 4G LTE (Long Term Evolution), based on the commercial LTE networks but adapted to support 3GPP Mission Critical functionality, as used in South Korea for LTE-R and mission critical networks for public safety including FirstNet in the USA or ESN (Emergency Services Network) in the UK.

In the commercial mobile arena 4G LTE is being succeeded by 5G and the railway industry is likely to adopt 5G as the technology of choice. However, this does not preclude Wi-Fi which may be a useful bearer in certain applications or satellites in more remote parts of the globe.



The UIC FRS describes the Network Requirements in terms of the services necessary to meet a range of UIC requirements. These include Voice Services, Data Services and Railway Specific Services. Voice services describe a generic voice telephony service which shall or should be supported in a GSM-R network including:

- Point-to-point voice calls
- Public emergency voice calls
- Broadcast voice calls
- Group voice calls
- Multi-party voice calls

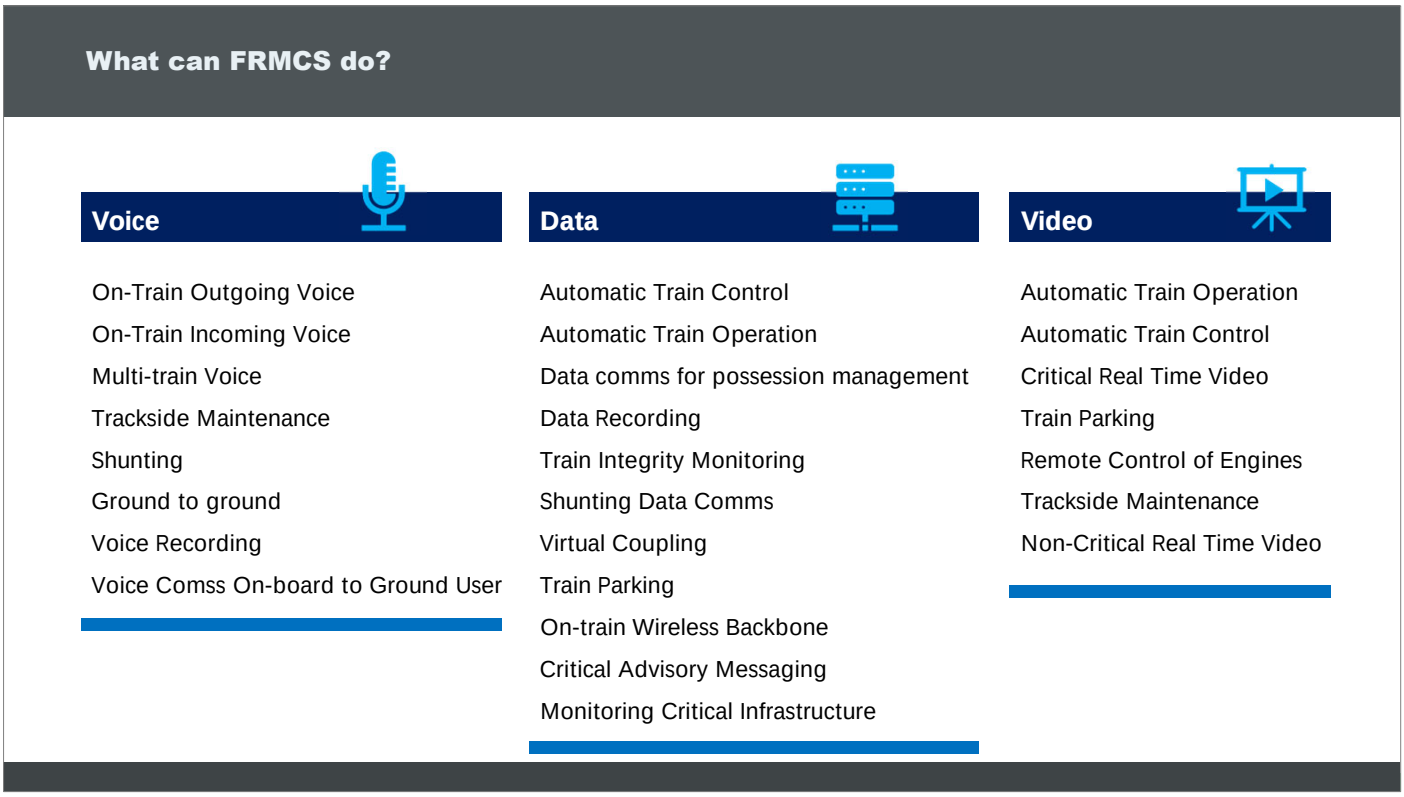
Data services include the following:

- Text messaging
- General data applications
- Automatic FAX
- Train control applications

The Railway specific services include:

- Functional addressing
- Location dependant addressing
- Railway emergency calls

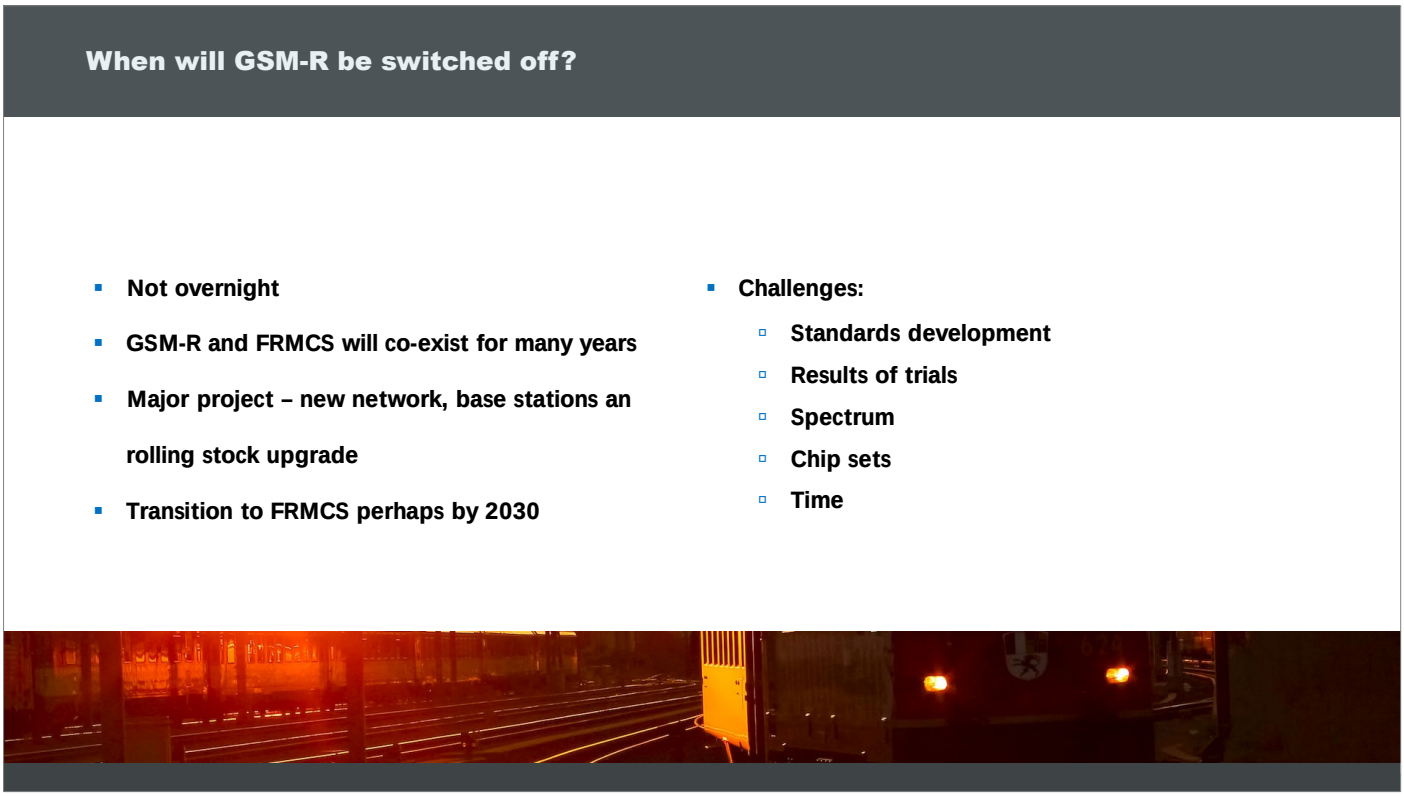
A total of 12 GSM-R services.



There are 31 Critical communications applications described on version 5.0.0 of FU-7100 (URS) and can be divided broadly into voice, data and video communications. The URS identifies the applications that will be largely used on a railway network and presenting the use cases to the standards bodies ETSI and 3GPP allows for gap analysis. Any functionality that is not addressed by existing standards can be studied in order to develop new standards for the
railways.

Many of the applications are currently supported by GSM-R as they are fundamental to railway operations, but some applications are designed to meet additional needs. Not all applications are likely to be used by a railway, for example banking voice communications may only be used in mountainous regions where two or more locomotives are needed to push trains. Shunting voice communications is supported by GSM-R, but is not widely used. Automatic Train Control (ATC) will provide to support ERTMS which is an important application for FRMCS. This technology will also enable future Automatic Train Operations (ATO).

Other data communications applications includes the remote control of trains, monitoring critical infrastructure, possession management, train integrity monitoring, virtual coupling and critical advisory messaging. Voice communications includes the Railway Emergency Call (REC), public train emergency, railway staff emergency communications as well as means to record these messages. There is also a need to support critical video streams



GSM-R will not disappear overnight. The railway industry is huge and slow moving. GSM-R and FRMCS will need to co-exist for a number of years. It will take time to refit rolling stock with the new FRMCS equipment, It will take a number of years for the new radio infrastructure to be rolled out and it will take time to build the new FRMCS network. Not all countries will be following the same timetable so trains crossing international borders will need to support both GSM-R and FRMCS, but a transition to FRMCS is expected in 2030.

The FRMCS project faces a number of challenges. Firstly the standards for the system are not complete as of August 2022. Assumptions have been made that it will be a 5G solution and trials of the technology are underway on test tracks in Germany. Lessons learnt will shape the development of FRMCS. Another issues is radio spectrum, in particular, the lack of it. Decisions have to be made about re-using GSM-R spectrum and the use of new spectrum. If new spectrum is made available, will chip set manufacturers support it without it being too costly. One of the biggest challenges is time.

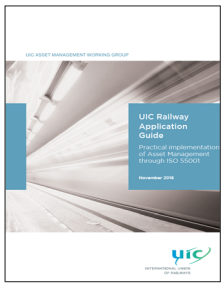
DIGITAL AND INTELLIGENT ASSETS IN THE RAILWAY SECTOR

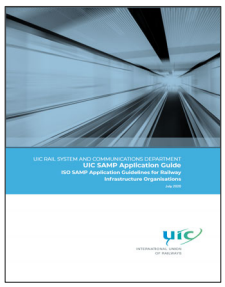
UIC ASSET MANAGEMENT GUIDE

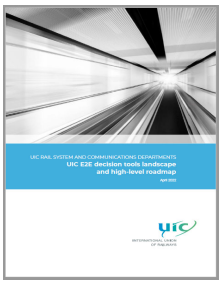
Mercedes GUTIERREZ FERRANDIZ, UIC
Andy KIRWAN, Network Rail

Content

- The role of asset management and its benefits
- UIC Railway Application Guide for ISO 55001
- ISO SAMP Application Guide
- END 2 END decision tools landscape and high-level roadmap
- Maximising the benefits of big data for Asset Management







In this material we will briefly show the role of Asset Management and how the UIC Asset Management Working Group (AMWG) has been guiding the railway community though the last years.

The main **objective** is to explain the of Asset management philosophy for Railway Infrastructure Managers, from adapting existing standards to decision tools and big data opportunities.

The **structure** is as follows:

- **UIC Railway Application Guide for ISO 55001**. Firstly, UIC developed a UIC ISO 55000 Guidelines document to promote a consistent approach for railway infrastructure organisations to more efficiently and effectively align their existing Asset Management capability with the Asset Management System requirements of ISO 55001.
- **ISO SAMP Application Guide**. Members seeking ISO 55001 were encountering problems in interpreting Strategic Asset Management Plan (SAMP) requirement. They need railway specific guidance. AMWG decided to produce a railway application guide which was published in July 2020. One of the most useful outputs from this work was an agreed Value Framework for railway Infrastructure Managers.
- **E2E decision tools landscape and high-level roadmap**. The purpose of this work is, firstly, to establish the current status of how decision support tools are used by railway infrastructure managers. This will be used as a baseline to identify gaps and to assess the methods, tools and technologies that are emerging in asset management but also in other relevant fields. The ultimate objective is to draw a future landscape of decision support tools and to design a high-level roadmap that IMs could adopt in their own organisations.
- **Maximising the benefits of big data for Asset Management**. This part focuses on **Big data opportunities** in railways for AM strategic decision-making processes to grant the balancing of costs, risks, and performances over the whole asset life cycle. It provides an overview of the main results obtained from the analysis and a list of recommendations to be used as a roadmap for adopting Big data to support strategic Asset Management decisions by railway Infrastructure Management organisations.

All the information provided is extracted from UIC documents published by the AMWG at UIC ETF shop: https://www.shop-etf.com/. UIC suggests consulting this documentation and contact the AMWG for further explanations.

The role of asset management and its benefits

Opportunity | Relevance | Benefits

What Asset Management does:
- Establishes line of sight between organisational objectives and the delivery of work
- Links decisions to the value provided to passengers, freight customers and communities
- Embeds an evidenced based whole-life, whole system approach

What Asset Management delivers:
- Improving train performance
- Reducing costs
- Providing customers and funders with informed choices based on scenarios
- Assuring that risks are being managed effectively,
- Making decisions more transparent

Asset Management is fundamentally about achieving an appropriate **balance of asset cost, risk and performance** to meet organisational objectives and deliver value from the assets to an organisation and its stakeholders.

Opportunity. Railways are not yet operating at their full potential in terms of **providing customers and funders** with a safe, quality service that is demonstrably value for money.

Relevance. Asset Management is the only system-wide approach that has the breath, depth and **whole life focus** necessary to help infrastructure managers to realise this potential.

Benefits. Asset Management integrates **decisions and activities**, and it creates a clear line of sight or alignment between **organisational objectives** and the **delivery of work** on the ground. It is the only management system that puts the asset portfolio and its operation at the centre of activities. It also has an emphasis on the importance of risk-based decisions taken over the asset life cycle, and the critical role of information in supporting such decisions.

The directly **measurable returns for Railway Infrastructure Organisations** are long term and may be difficult to isolate from other improvement initiatives that may be taking place in the Organisation. However, a body of evidence on benefits is emerging from asset intensive organisations who have already adopted Asset Management as a core mechanism for business improvement. These benefits include:

- **Improving train performance** by focusing asset reliability initiatives on critical parts of the network, supported by information on the condition of assets and better understanding of the likelihood and consequence of failure over their lifecycle.
- **Reducing costs** by doing the right work in the right place at the right time, with interventions co-ordinated to achieve the optimum balance between maintenance, renewal and enhancement across the across the asset base.
- **Providing customers and funders with informed choices based on scenarios** that describe how the infrastructure will perform over the long term, under varying levels of expenditure, traffic growth, length of engineering possessions, and deployment of automation.
- **Assuring that risks are being managed effectively**, for example risks to safety from infrastructure failures, risks to train performance from the introduction of new technology, and risks from outsourcing infrastructure work.
- **Making decisions more transparent**, helping to build credibility with customers and stakeholders, including funders and regulators.

Compared with traditional approaches, Asset Management **focuses on the major decisions and activities that need coordination across multiple functions and which affect multiple stakeholders**. The challenge of adopting such a holistic approach is considerable.

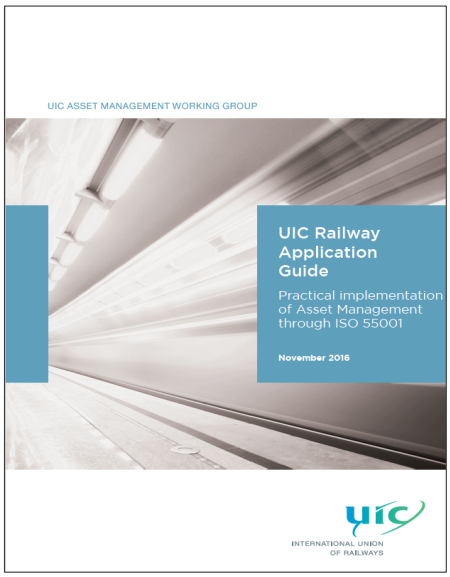
UIC Railway application guide for ISO 55001

UIC Railway application guide for ISO 55001

Target audience for the guidelines

- **Individual railways**
- **Regulators**
- **Funders**
- **Benchmarking Groups**
- **Research programmes**

https://www.shop-etf.com/en/uic-railway-application-guide-practical-implementation-of-asset-management-through-iso-55001?ref=1



The Asset Management ISO standards

The International Standards Organisation (ISO) published its 55000 Asset Management Series. The series consists of three parts:
- ISO 55000 – Asset management – Overview, principles and terminology
- ISO 55001 – Asset management – Management systems – Requirements
- ISO 55002 – Asset management – Management systems – Guidelines for the application of 55001

The ISO 55000 series of documents is important for the railway industry, not just for their content, but also because they represent a global consensus on what Asset Management is and what can do to increase the value generated by all organisations. They provided an internationally recognised definition of competent and good practice Asset Management, based around an integrated and continually improving management system. ISO 55001 defines the requirements of a "management system for asset management".

UIC Asset Management Working Group (AMWG) has been working during the last years to **understand** the standards, **adapting them to the particularities of the railway sector** and **working together** during the implementation in railway organisations.

Firstly, UIC developed a UIC ISO 55000 Guidelines document to promote a consistent approach for railway infrastructure organisations to more efficiently and effectively align their existing Asset Management capability with the Asset Management System requirements of ISO 55001.

This document provides practical guidance to railway infrastructure managers who wish to improve their existing Asset Management capability. It is based on a standardised approach that is being widely adopted in railways and other asset intensive sectors around the world.

The **target audience** for the guidelines is:

- Individual railways
- Benchmarking Groups
- Research programmes

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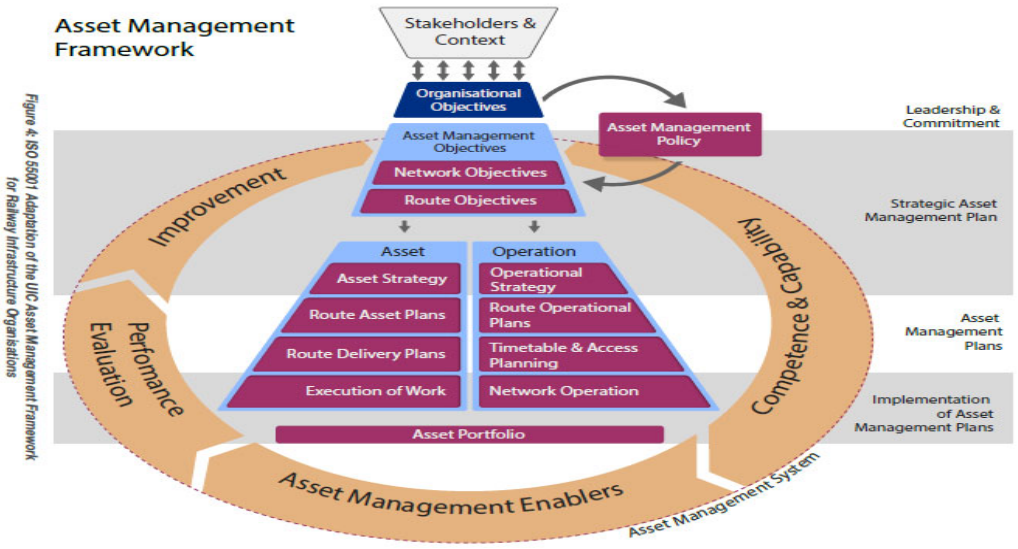
UIC Railway application guide for ISO 55001



Asset definitions

ISO 55000 defines an asset to be “an item, thing or entity that has potential or actual value to an organisation”. The definition of an asset will vary between railway infrastructure organisations and may include physical or non-physical assets. Physical railway infrastructure assets are also defined in the UIC Lasting Infrastructure Cost Benchmark (LICB) project.
The LICB defines railway infrastructure as consisting of the following items, assuming they form part of the permanent way, including sidings, but excluding lines situated within railway repair workshops, depots or locomotive sheds, and private branch lines of sidings:

- Ground area
- Track and track bed, etc.
- Engineering structures: bridges, culverts and other overpasses, tunnels, etc.
- Level crossings, including appliances to ensure the safety of road traffic
- Superstructure, in particular: rails, grooved rails, sleepers, small fittings for the permanent way, ballast, points and crossings
- Access way for passengers and goods, including access by road
- Safety, signalling and telecommunications installations on the open track, in stations and in marshalling yards, etc.
- Lighting installations for traffic and safety purposes
- Plant for transforming and carrying electric power for train haulage: sub-stations, supply cables between sub-stations, and may want to include these within the scope of their Asset Management System as appropriate.

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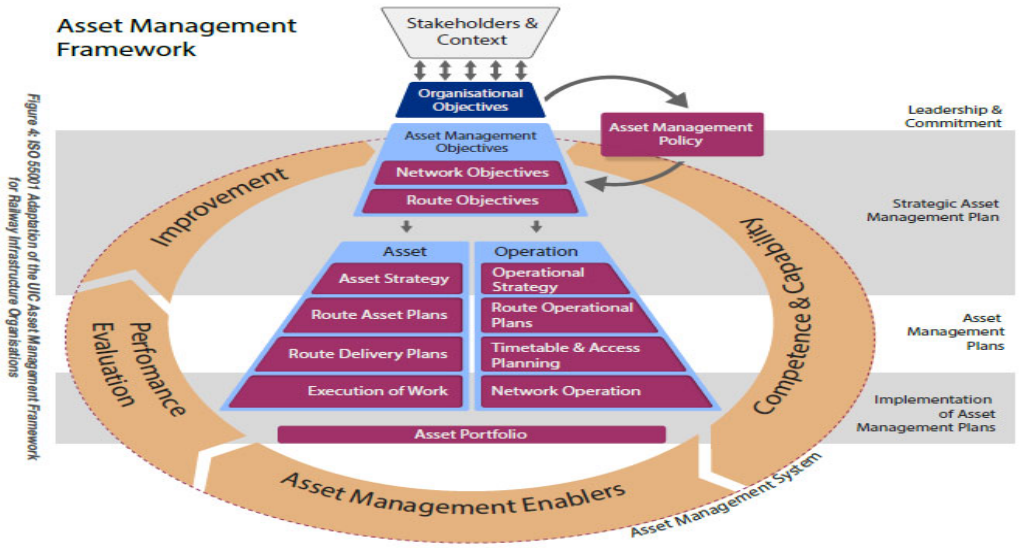
UIC Railway application guide for ISO 55001



Asset Management Frameworks

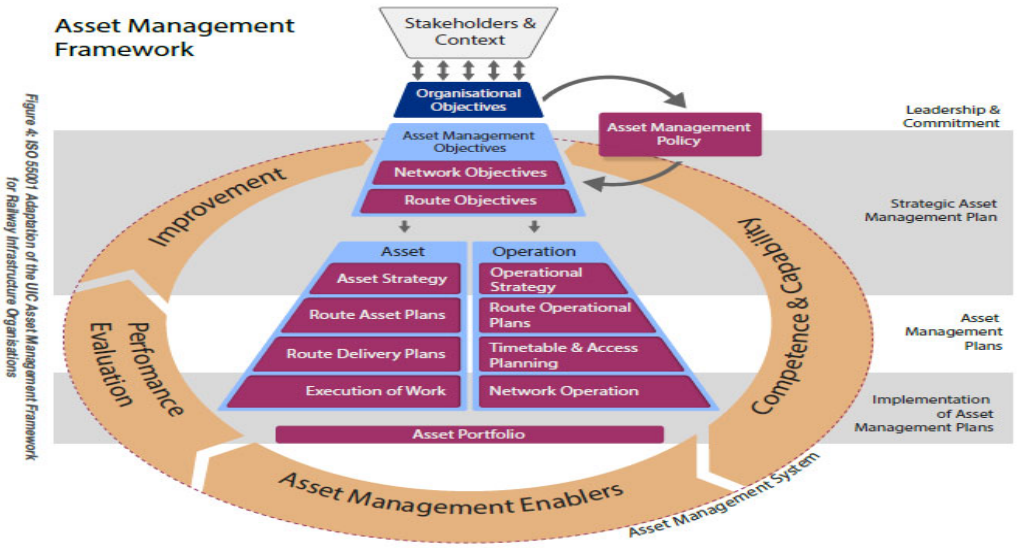
An **Asset Management System** defines the processes, timescales, people, information, IT systems and activities that form an overall management system to enable an asset intensive business to achieve its organisational objectives and maximise value from its assets. The structure, scale, format and documentation or an Asset Management System will vary considerably by business and business context.

An **Asset Management Framework** identifies the key components of an Asset Management System, including:

- Core decisions and activities – the decisions, strategies, plans and activities that link organisational objectives to the delivery of asset interventions on the ground, including both work on the infrastructure and operation of the network
- Competence and capability mechanisms – the management of current and future Asset Management competences and capabilities to assure the effective and efficient implementation and continual improvement of the Asset Management System
- Asset Management and enabler mechanisms – the effectiveness of the core decisions and activities are dependent on many support mechanisms, such as asset information, life-cycle costing tools and business processes
- Performance and evaluation mechanisms – reviewing mechanisms are required to monitor and improve the effectiveness of the Asset Management System in delivering operational objectives, value and sustainable infrastructure outputs for the level of committed funds, effectively providing the feedback loop for continual improvement of the Asset Management System.

Asset Management Frameworks provide a common basis for the development of appropriate Asset Management Systems for any organisation within a relevant industry and context that has a comparable asset base.

UIC Railway application guide for ISO 55001



UIC Asset Management Framework for Railway Organisations

The UIC Railway Application Guide introduces an Asset Management Framework for Railway Infrastructure Organisations which outlines the scope of the Strategic Asset Management Plan (SAMP) within the Asset Management System.

This framework is based on the one established by UIC in 2010 Guidelines for the application of asset management in railway organisations and subsequent adaptation to align with the requirements of ISO 55001.

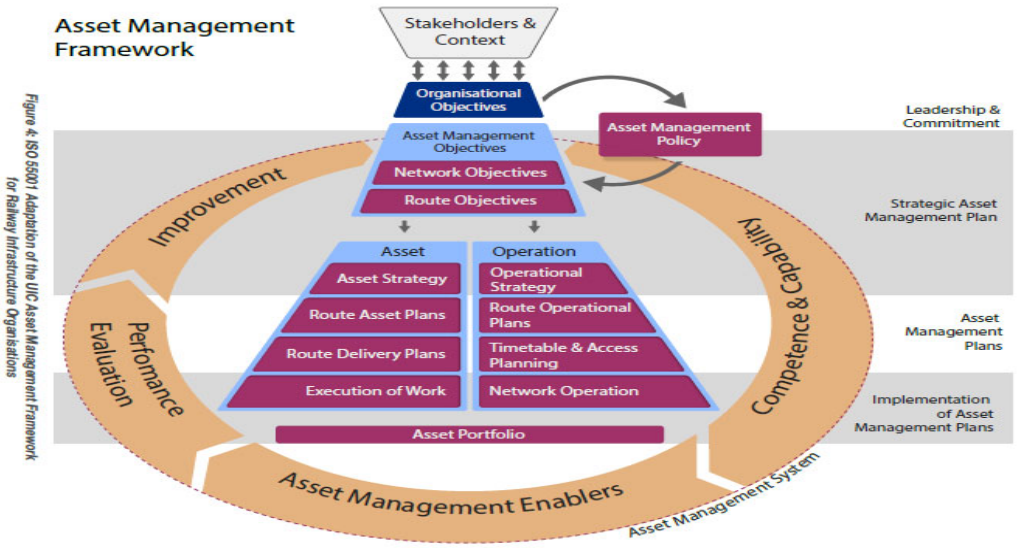
The grey boxes, with titles to the right of the main framework diagram, show the alignment to key components of ISO 55001, including:

- The establishing of a Strategic Asset Management Plan (SAMP) and Asset Management objectives, informed by the Asset Management Policy, to assure alignment with the organisational context and objectives
- The development and implementation of Asset Management Plan(s) to achieve these objectives and derive value.

The purple boxes in the top of the diagram represent the core decisions and activities. The orange elements of the diagram incorporate the further generic requirements of ISO 55001, namely:

- Competence and capability mechanisms
- Asset Management enabler mechanisms
- Performance evaluation mechanisms
- Improvement mechanisms

UIC Railway application guide for ISO 55001



It is key to note the closed-loop feedback process, from the performance evaluation and improvement mechanisms on the left, back into to the top level of the core decisions and activities. The primary requirements of ISO 22001 to demonstrate continual monitoring, review and improvement cannot be overstated.

The purple boxes at the centre of the diagram represent the flow of decisions from strategic to tactical, through to asset interventions, including operations, on the ground. These have been developed by the UIC Asset Management Working Group (AMWG) as a generic framework for use by railway infrastructure organisations.

This Asset Management Framework considers the full range of a railway organisation's Asset Management activities within the scope of the Asset Management System. This includes operational planning, asset operations and work execution. However, there are numerous business models established for railway infrastructure organisations worldwide. These may include all or just some of the activities shown within the scope of a particular organisation. For example, some railway infrastructure organisations may outsource all of their maintenance and project delivery to contractors or may not be responsible for the operation of the infrastructure.

Consideration of all possible models is not feasible, but this framework is intended to provide a comprehensive starting point for railway infrastructure organisations to align with ISO 55001. The boundaries of the specific Asset Management System can, and should, be redrawn to reflect the actual scope of the specific organisation's Asset Management activities. However, the requirements of ISO 55001 are not lessened. Any organisation seeking compliance with ISO 55001 would still have to demonstrably satisfy each requirement of the standard.

For example:

- Full specification, control and review and assurance of the execution of work by contractors, or
- Full specification, control and review and assurance of the interfaces and management mechanisms between the organisation and the rail operations organisation(s) to demonstrate appropriate and continually improving management of access and risks.

UIC Railway application guide for ISO 55001

Implementation tips

- Demonstrate the benefits
- Take the leadership team on the journey
- Establish the governance arrangement for the Asset Management system
- Define the scope base on what makes sense to the organisation
- Integrate with other management systems where possible
- Understand the document hierarchy
- Consider an Asset Information Strategy
- Invest in people
- Make a start!

Implementation Tips

Some implementation tips were defined during the development of the guide. A number of tips directly relate to the predominant nonconformities identified in the pilot test compliance assessment process.

- Demonstrate the benefits. The cost of implement ISO 55001 is a small fraction of a rail infrastructure organisation's capital and operating expenditure. The driver should be business improvement and Asset Management maturity.
- Take the leadership team on the journey. Ensure that the leadership team is committed to implementation of ISO 55001. Awareness and understanding by leadership of the benefits and value that an Asset Management system can bring is an important precursor to this commitment, as wall as identifying the expected resource requirements.
- Establish the governance arrangement for the Asset Management system. Line management arrangement are commonly in place for most asset lifecycle processes. Review the committee arrangements to determine what governance arrangements best meet the needs of the organisation with respect to decision-making, awareness, communication and management review of the Asset Management system.
- Define the scope base on what makes sense to the organisation. Develop a good initial definition and description of the Asset Management System (AMS) specifically in terms of its scope, boundaries, functions and processes, and interfaces with other management systems and external service providers and stakeholders.
- Integrate with other management systems where possible. This should reduce time and effort in creation of the Asset Management system and improving cross-functional coordination.
- Understand the document hierarchy. Establish key document relationships and make sure the Asset Management framework fits the purpose and the intended audience for each of them.
- Consider an Asset Information Strategy. The strategy should include documented information management processes, a consistent and clear hierarchy and structure for asset-related information, and the appropriate alignment of financial and non-financial information.
- Invest in people. Competency and capability of people are the means to deliver Asset Management outcomes. Awareness training puts Asset Management in context, and executive briefings can help to gain buy-in from leadership.
- Make a start! Even if you are not aiming for certification, there will be aspects of ISO 55001 that will provide immediate benefits and improve your business. Make a start on these and work to continually improve.

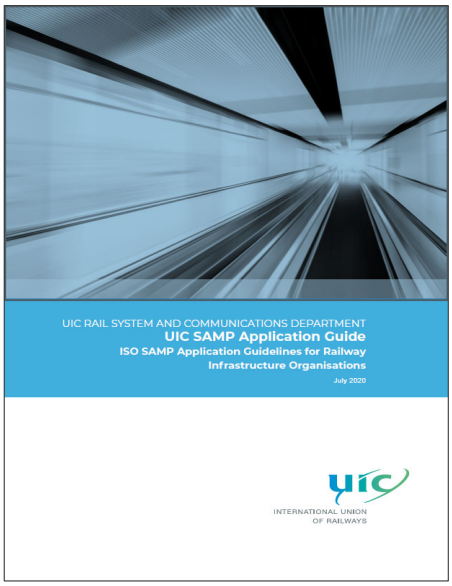
SAMP
Application guide for railway infrastructure organisations

Railway application guide for SAMP

The SAMP is one of the key requirements of ISO 55001 but many organisations (rail and non-rail) have faced difficulties with the implementation. This project was undertaken to provide a railway infra managers with a clear definition of the requirements and structure of the SAMP

DEFINITION
PURPOSE
SAMP STRUCTURE
WHO uses a SAMP?

https://www.shop-etf.com/en/uic-samp-application-guide-iso-samp-application-guidelines-for-railway-infrastructure-organisations



Members seeking ISO 55001 were encountering problems in interpreting Strategic Asset Management Plan (SAMP) requirement. They need railway specific guidance. AMWG decided to produce a railway application guide which was published in July 2020. One of the most useful outputs from this work was an agreed Value Framework for railway Infrastructure Managers.

UIC SAMP Application Guidelines for Railway Infrastructure Organisations
https://www.shop-etf.com/en/uic-samp-application-guide-iso-samp-application-guidelines-for-railway-infrastructure-organisations

Definition
The SAMP is defined as documented information that includes the Asset Management Objectives, the approach for developing Asset Management Plans and the role of the Asset Management System in supporting achievement of the Asset Management Objectives.
The SAMP includes both: how the infrastructure has to perform in order to deliver the Asset Management contribution to achieving the vision of the railway and how the Asset Management System will be implemented to deliver the Asset Management capabilities.

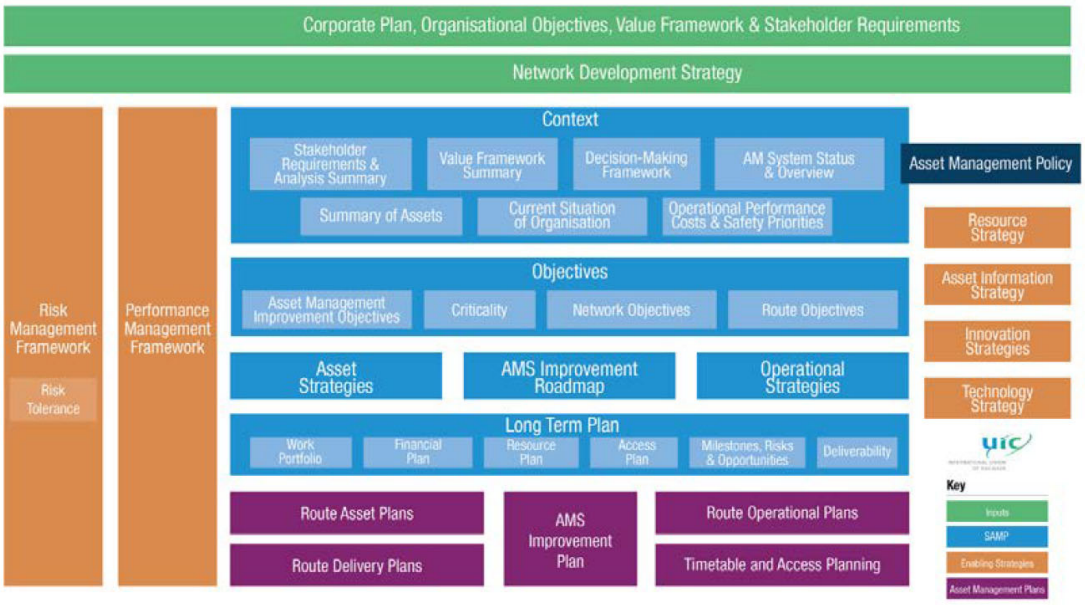
Purpose
ISO 55002 describes the purpose of the SAMP as: “the SAMP details the asset management objectives, explains their relationship to the organisational objectives and the framework required to achieve the asset management objectives”.

Structure
The SAMP can take different structures, dependent upon the size, maturity and preference of the Organisation. It could be one document, or more typically, a set of related documents from a top-level summary to detailed asset and operational strategies. It may also include asset information, risk management, competence, operations and other enabling strategies and plans. The SAMP should be integrated and should reference the long-term work volume and financial plans of the Organisation to enable the balance of any short ot medium term financial constraints with longer-term plans for investment and asset interventions.

WHO uses a SAMP?
SAMP is an executive-level document which presents a narrative on why and what the organisation plans to do in managing its asset portfolio and developing its asset management capability.
Aligned with this, an Organisation’s SAMP is a communication tool that enables Top Management to:

- Communicate and justify its plans to external stakeholders and funders such as regulators, government bodies, local authorities, and train and freight operation companies; and
- Provide direction to internal functions and departments in the development of plans and the execution of activities.

Railway application guide for SAMP



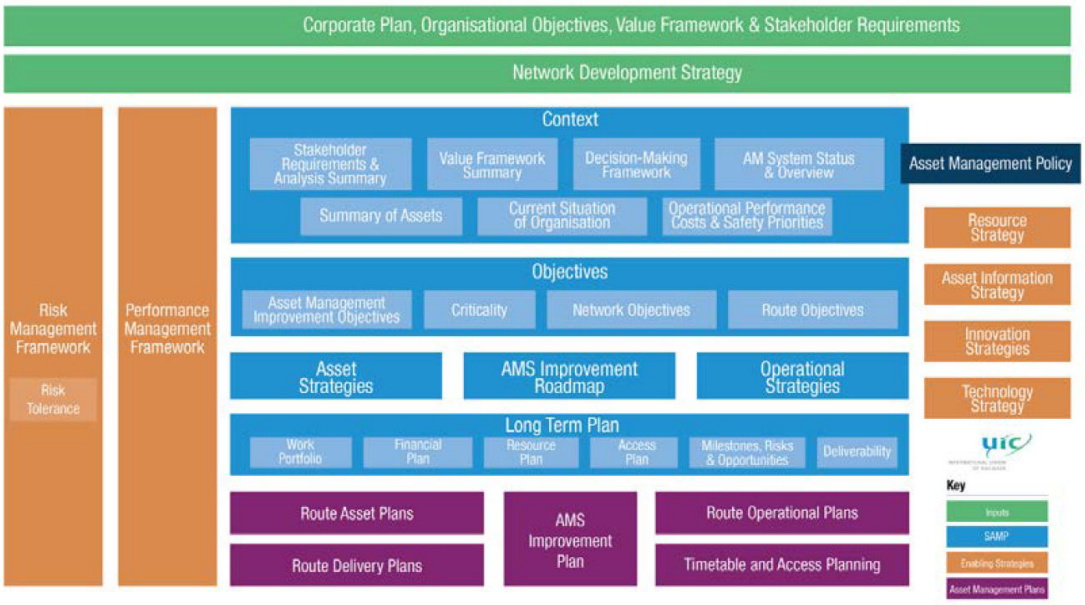
The Strategic Asset Management Plan (SAMP) is one of the key documents within an organisation's **Asset Management System**. **It translates the Organisation's objectives into Asset Management Objectives and a strategic plan to deliver these**, and so provides the framework within which more detailed Asset Management Plans can be implemented and measured. It provides alignment between the strategic direction of an organisation and the activities that occur on the ground or within the organisation itself, resulting in an improved output and service to stakeholders and customers. Furthermore, a good SAMP is a crucial communications tool, providing senior stakeholders and senior management with confidence in the long-tern future of the organisation.

The SAMP expresses the outcomes of many complex, interrelated decisions. These decisions need to be consistently prioritised and optimised to develop and deliver Asset Management Plans which will deliver the organisational objectives. An Organisation's Value Framework provides the Organisation with transparency and consistency in decision-making and provides Top Management assurance that investment and operation projects and activities are being prioritised correctly.

In response to this challenge and recognising the similarities across the Organisations, UIC has developed a guide to provide sector specific guidance on producing a SAMP. It is underpinned by good practice and the requirements ot ISO 55001, however it has been tailored to the rail sector and draws upon the experience of Organisations which have already begun their Asset Management Journey and have developed Asset Management Systems and Strategies.

The guidance provides a structure and recommended approach for creating the SAMP and will benefit the users by providing a degree of standardisation across the sector enabling benchmarking as well as a baseline from which to continuously learn and improve. This will improve the Asset Management maturity of the organisation, resulting in improved reliability and availability across their network, and a better customer experience.

Railway application guide for SAMP



SAMP Content

The diagram shows more detail about the SAMP's content (shown in blue). The diagram also shows how it sits above the AMPs (shown in purple), how it is supported by other frameworks and strategies (shown in orange) and how it aligns to stakeholders' needs and requirements (shown in green).

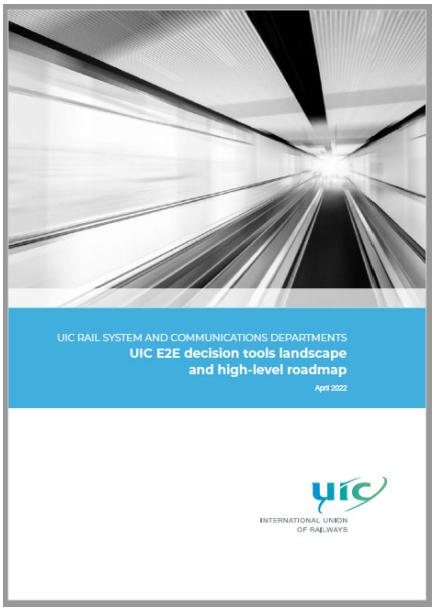
The blue SAMP content is split into four main interdependent elements:

- Context summarises the context of the Organisation: the political and commercial environment in which it is operating, its key stakeholders and their needs and requirements, the future demand for the Organisation's services its Value Framework and an overview of the Organisation's decision-making framework. It contains a description of the Asset Management Framework and the current status of the Organisation's assets, their ability to meet demand, and the immediate operational performance and safety priorities.
- Asset Management Objectives are defined at three levels: overall Network Objectives, aligned Route Objectives for each individual route on the system, and Asset Management Improvement Objectives related to the Asset Management System. This element also contains the most significant risks to achieving the criticality of its assets and routes.
- Asset Management System Improvements and Operational Strategies describes how assets, operational activity and improvements in organisational capabilities will contribute to delivery of Asset Management Objectives.
- Long-Term Plan describes the key elements and milestones of the long-term (or strategic) plan to deliver the Asset Management Objectives. It includes the forecast revenue, costs, resource and access requirements, and also presents a view on the risks associated with the long-term plan and the overall deliverability from an internal and supply chain perspective.


E2E

E2E decision tools landscape and high-level roadmap

https://www.shop-etf.com/en/uic-e2e-decision-tools-landscape-and-high-level-roadmap



UIC AMWG published in April 2022 the document “UIC E2E decision tools landscape and high-level roadmap”

https://www.shop-etf.com/en/uic-e2e-decision-tools-landscape-and-high-level-roadmap

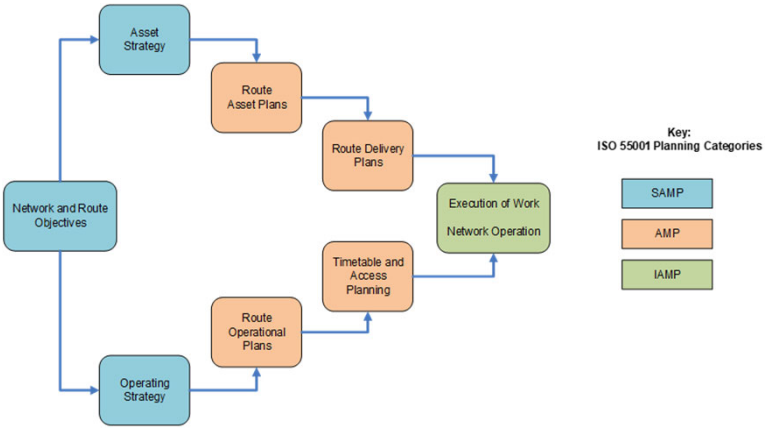
E2E decision tools landscape and high-level roadmap

Motivation for the E2E project

"Ultimately, a company's value is no more (and no less) than the sum of the decisions it makes and executes.

Its assets, capabilities, and structure are useless unless executives and managers throughout the organization make the essential decisions and get those decisions right more often than not."

Harvard Business Review June 2010



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A State of the Art

Undoubtfully, now is the moment for most networks to get benefit of recent advances in Information Technologies (IT). Advances come not only from an excellent and improving price to computational power ratio, but from algorithmics (Artificial Intelligence) and our capacity to make sense from huge amounts of data (Big Data technics). Experience shows, however, that IT introduction does not necessary lead to better productivity. To counter the Parkinson's law (*work expands so as to fill the time available for its completion*), IT implementation needs to be associated with the right changes in organisational structure and processes.

Several key learnings could be established using the UIC Framework to analyse current practice of several railway networks. Learnings cover Network and Route Objectives, Asset and Operational Strategy and Plans, Route Delivery and Timetable and Access Planning, and Execution of Works and Network Operation.

Related to the **network and route objectives**:

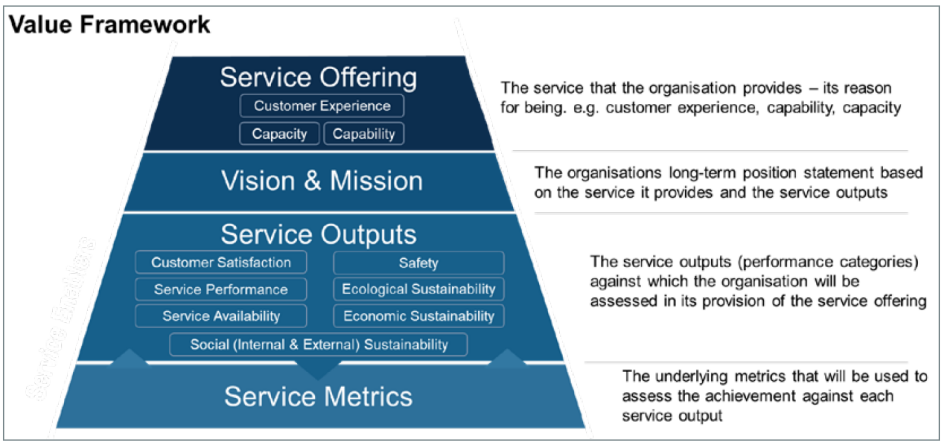
- Coordination of high level objectives to endure synergy with other large public networks (energy, health, …) goes far beyond the power of the lone railway managers. Though the latter could (and should) be associated to this effort, the leading role in this is out of their sole capabilities.
- In setting network objectives, railway management may consider pursuing a proactive approach. Railways' structural advantages can be highlighted in regard to the anticipated evolution of national policies under climate changes concerns.
- Setting high level objectives can sometimes be supported by IT tools. However, the multiplicity of stakeholders and the need to design acceptable trade-offs confine the IT tools into a limited, supportive role at this stage.
- Network management should explicitly recognise for which market segments there is need to adopt a demand driven approach, and for which segments it is wise to resort to a service driven one. Route objectives depend on this choice.

E2E decision tools landscape and high-level roadmap

Network and route objectives:

- Processes and decisions
- Tools
- Characteristics

Comments



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Network Objectives

They reflect what the final customers and the governmental agencies expect from railways in terms of overall performance (traffic growth, safety, punctuality, etc.). They should set the global envelope intended to finance the expected level of performance, on the long term; that funding depending on the public authorities' willingness to pay.

Typical processes and decisions:

- Clarifying and stabilising the vision of all stakeholders.
- Through an iterative process, if needed, trying to make realistic the expectations of some stakeholders.
- Trough an iterative process, combining stakeholders' visions.
- Identifying gaps between network current objectives and stakeholders' expectations.
- Socio-economic analyses to identify alternatives for future developments of the network that reflect the stakeholders' visions.
- Socio-economic evaluation studies to opt for the most suitable alternative(s).
- Final round of multiple processes aimed to settle a development plan for the network and the rail services, defining **the network objectives and strategy**.

Typical tools:

- Demographic and economic forecast studies.
- Demand analysis and forecasting packages.
- Multicriteria analyses methods and tools.
- Aid to negotiation tools.

Depending on the country, there may be codified processes and requirements, and typical values to take into account while using those tools.

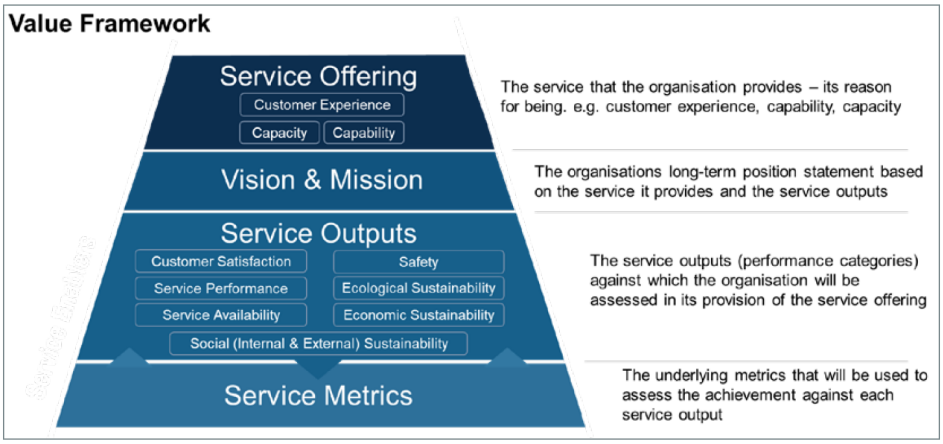
Global characteristics of digital tools:
The methodological and scientific practices implemented in this planning horizon vary significantly from country to country. Overall, the political processes and planning cultures of stakeholders play a more important role than the implementation of innovative digital tools, particularly dedicated to these activities.
The generation of options and the choice of solutions rely on specific, potentially complex tools used by territorial planning bodies (in the broadest sense of the term), usually located outside the IM organisation. Therefore, collaboration with territorial planners is crucial, at this stage.

E2E decision tools landscape and high-level roadmap

Network and route objectives:

- Processes and decisions
- Tools
- Characteristics

Comments



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Route objectives

They disaggregate network objectives into route level objectives, considering their (socio-economic) importance. Route objectives specify performance targets and associated requirements for the infrastructure (both in terms of assets and operations). Route objectives should also define budget targets. Taking into account appropriately stakeholders' interests and point of view is a critical task in setting the route objectives, by applying the UIC Value Framework approach.

Typical processes and decisions:

- Analyse the history of performances by route (or by subnetwork), analyse datasets, histories, related to assets technical and economic performances (failure rates, availability, monitoring and maintenance costs, …) as well as to operation technical and economic performance (safety, achieved traffic, punctuality, operational costs, …).
- Identify any weakness in rail performance, as defined by the value framework.
- Identify the system components (assets and operation, as well) that are the root cause of the identified weaknesses.
- Identify technical and operational solutions that may address known fragilities and estimate their potential contributions.
- Identify and assess the risks of exogeneous origin.
- Set up a high-level roadmap able to lead towards achieving the network objectives, including the implementation options.

Typical tools:

- Statistical analyses and Business Intelligence packages.
- Network and route capacity analysis packages to identify and assess bottlenecks.
- Contribution matrix as defined in [3], Appendix D.
- Cost analysis and modelling methods and tools.
- Risk analysis methods and tools
- Multicriteria analyses methods and tools.

E2E decision tools landscape and high-level roadmap

Network and route objectives:

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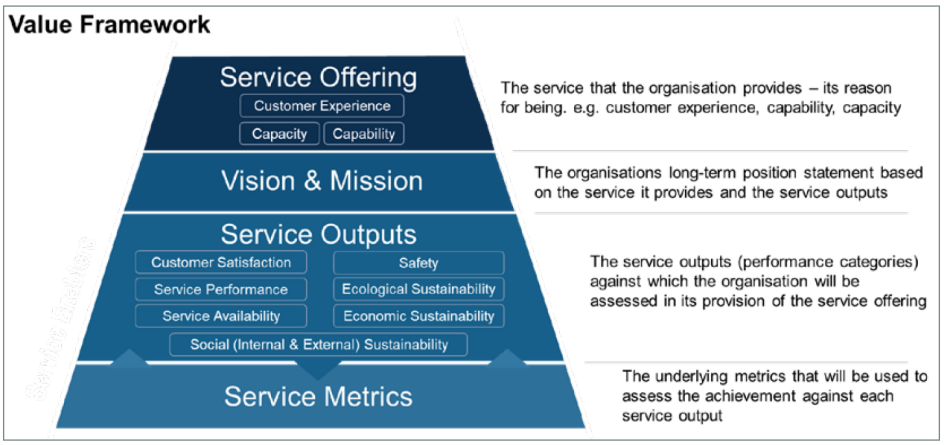

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Global characteristics of digital tools:

Decision-making processes involving stakeholders play a key role. However, understanding the performance of the railway infrastructure system is central to setting appropriate performance targets. This is where the playground for digitalisation of the planning chain really begins.

In this respect, two components are essential:
- systems for structuring and processing feedback data,
- (statistical) tools capable of extracting information related to systems performance (root cause analysis, cause trees analysis, etc.) and feeding life cycle models.

The identity and type of master data management tools vary from one manager to another; the data, if available, are rarely integrated into a single source. This is equally important for financial data.
In terms of data processing, the tools used generally belong to the usual statistical and Business Intelligence suites.
The analysis of data related to railway operations is likely to require specifically designed tools.
The ISO 55 focusses on the link between financial & technical data.

Comments related to the network and route objectives:

- Coordination of high level objectives to endure synergy with other large public networks (energy, health, …) goes far beyond the power of the lone railway managers. Though the latter could (and should) be associated to this effort, the leading role in this is out of their sole capabilities.
- In setting network objectives, railway management may consider pursuing a proactive approach. Railways' structural advantages can be highlighted in regard to the anticipated evolution of national policies under climate changes concerns.
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- Network management should explicitly recognise for which market segments there is need to adopt a demand driven approach, and for which segments it is wise to resort to a service driven one. Route objectives depend on this choice.

E2E decision tools landscape and high-level roadmap

Main conclusions related to:

- Asset and operational strategy level
- Route asset and operational plans level
- Route delivery, and timetable and access planning
- Execution of works and network operation

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Main conclusions

Related to the **asset and operational strategy** level:

- In this matter, there is not (and cannot be) a common practice across networks. The institutional context varies widely from a network to another.
- Railway services are the "*raison d'être*" of the network. Objectives and strategies (*investment/CAPEX strategies*) should always be subordinated to the future vision of operations: the ultimate promise to the end customer. This future vision of operations, expressed through timetables and transport plans, should shape the strategy making, being the common language between stakeholders at the institutional level (IMs, RUs and Authorities), and between stakeholders at the industrial level (asset management and operations).
- Regarding to asset strategies, it is important to use statistical tools in order to understand the fundamental relations, and to manage the assets life cycles in order to correctly forecast.
- To set sound and realistic asset and operational strategies, one needs a fair understanding on how current and past performance of the network is related to the asset strategies. This cannot be done without joined-up robust, complete, reliable, and up-to-date data. Data should be sufficient in coverage and granularity regarding the statistical tools used to analyse them.

Related to the **route asset and operational plans** level:

- The products (railway services) define the needs for a production facility (the network). Asset plans and operational plans should be designed jointly. IT tools should allow this joint design process; if not common, they should make possible a seamless sharing of data and results.
- Mesoscopic scale is vital for this step. While some detail is necessary, too much detail will detract from the clarity of the overall picture.
- Moreover, design of operational plans cannot be done without the involvement of the train operators. To support this inescapable collaboration, there is need for common or intercommunicating IT toolboxes.
- Timetables should include major track possessions defined in the track possession scheme planned by the asset manager. Train paths and track possessions are both capacity demanding elements that should be designed simultaneously at this stage. Tools to implement this functionality are critical for the negotiations not only between the IM's asset division and its operational one, but also between the IM and its customers (train operators or public authorities).

Related to the **route delivery, and timetable and access planning** stage:

- Integration of tools for asset management and operations is necessary to ensure a product based approach. This is seldom, if ever, achieved today.
- On the asset management side, the importance of predictive maintenance is increasing, thanks to advances in remote data collection (IoT).
- Track possessions planning should become more systematic / industrialised, compared to the current practices, at least for routes with medium- to high-density usage.

Finally, regarding to the **execution of works and network operation**, one may notice that there is a fair supply of IT tools. Their efficiency and sophistication are constantly improving, and their use is steadily increasing through the networks.

BIG DATA

Maximising the benefits of big data for Asset Management

https://www.shop-etf.com/en/maximising-the-benefits-of-big-data-for-asset-management

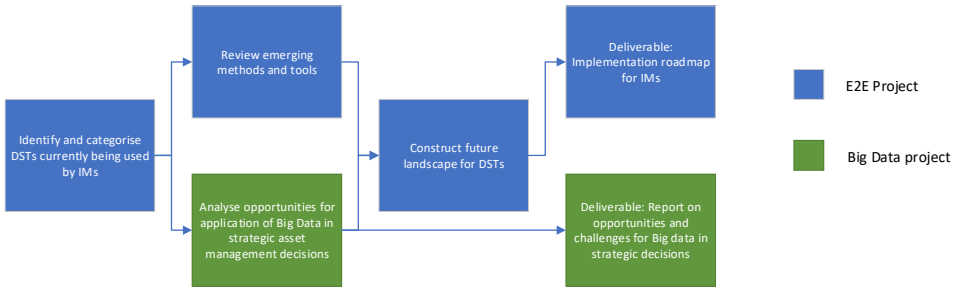
UIC AMWG published in March 2022 the document “Maximising the benefits of big data for Asset Management. Recommendations on the adoption of big data to support strategic asset management decisions in railway infrastructure management organisations”.

This report focuses on **Big data opportunities** in railways for AM strategic decision-making processes to grant the balancing of costs, risks, and performances over the whole asset life cycle.

This report provides an overview of the main results obtained from the analysis and a list of recommendations to be used as a roadmap for adopting Big data to support strategic Asset Management decisions by railway Infrastructure Management organisations.

https://www.shop-etf.com/en/maximising-the-benefits-of-big-data-for-asset-management

Maximising the benefits of big data for Asset Management



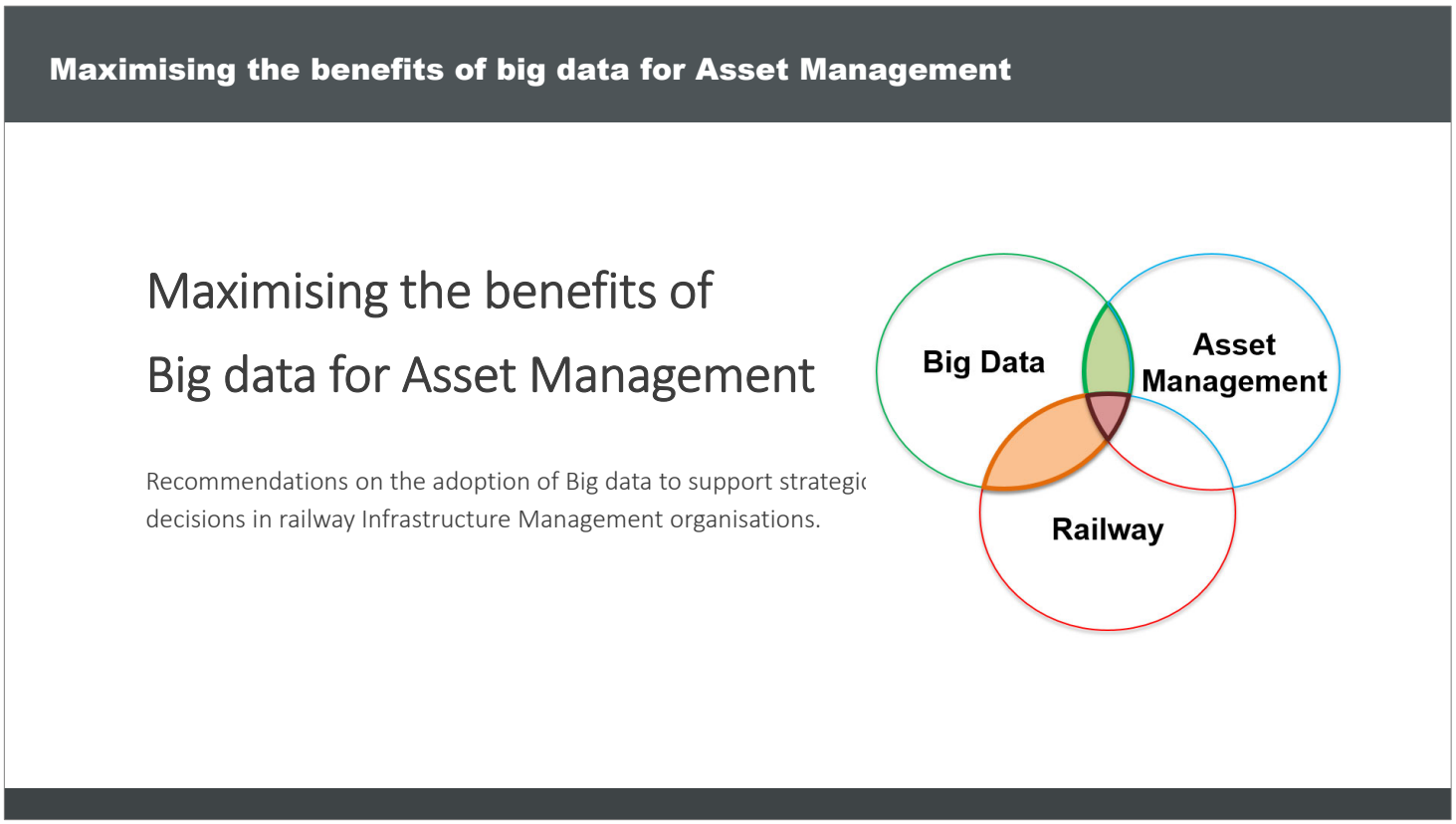
- Study selected to complement the E2E project, with a focus on strategic asset management decisions
- This area has been given less attention to date - the focus has been on shorter-term maintenance interventions to deliver efficiency and reliability benefits.
- However, it is becoming clearer to many organisations that there are potentially strong benefits associated with improved strategic decision making where there is a greater opportunity to influence costs and performance over the whole asset life cycle.

2018 European Work Program - April 26th, 2017

Motivation for the Big Data project

- Study selected to complement the E2E **decision tools landscape** project, with a focus on strategic asset management decisions
- This area has been given less attention to date - the focus has been on shorter-term maintenance interventions to deliver efficiency and reliability benefits.
- However, it is becoming clearer to many organisations that there are potentially strong benefits associated with improved strategic decision making where there is a greater opportunity to influence costs and performance over the whole asset life cycle.

Maximising the benefits of big data for Asset Management



Strategic Asset Management and Big data in Railway Infrastructure Management organisations

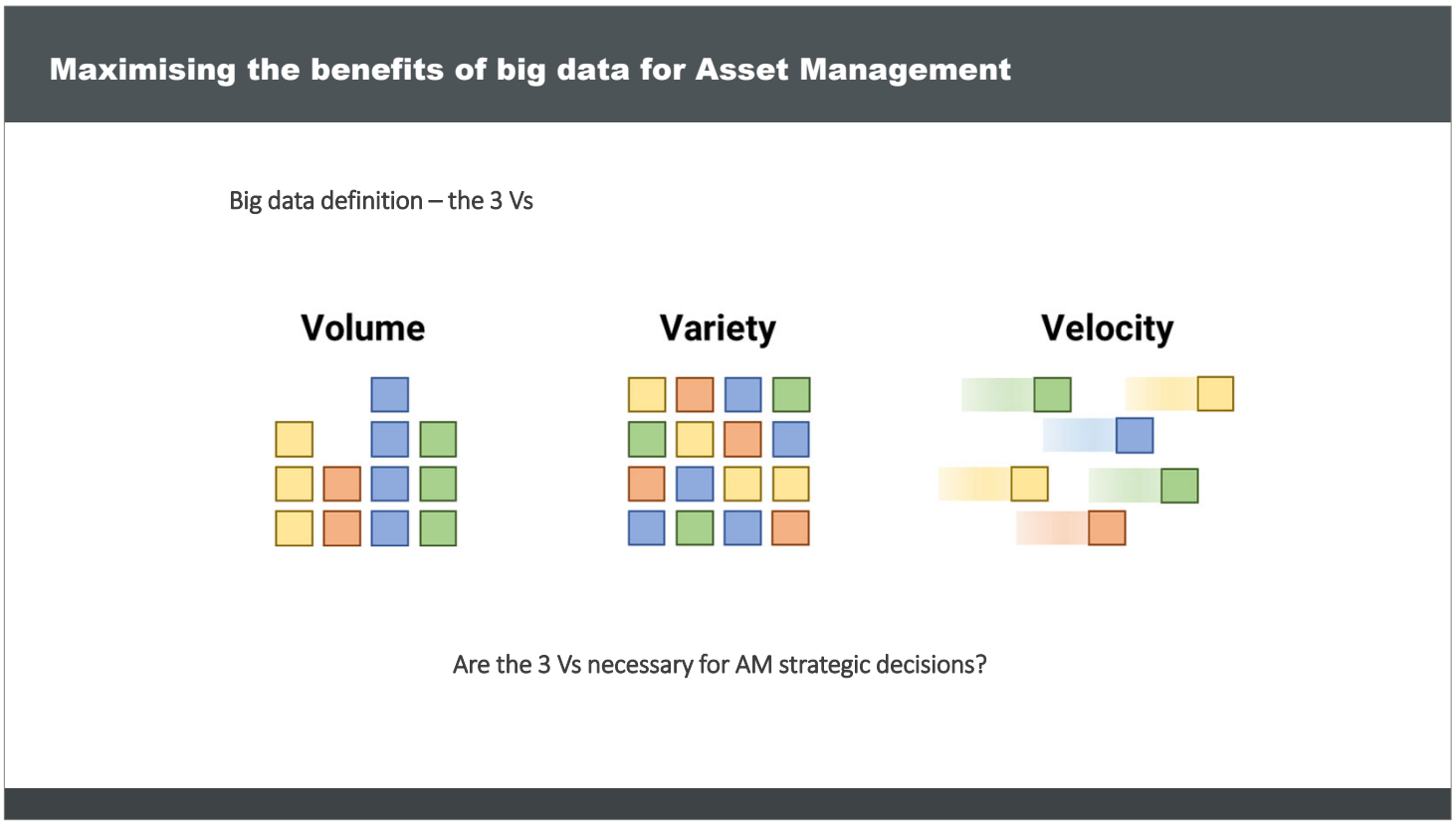
Big data is the new frontier for collecting and analysing data and for turning it into **usable information**. Big data is driven by the evolution of data analytics techniques, the increased computational power, the dramatic reduction of the price of storage devices and the increased potential for collecting data due to technological progress. In several industrial sectors, companies are moving towards the analysis and exploitation of Big data to extract meaningful insights on the phenomena of interest to support the decision-making processes. Additionally, the green transition is challenging industrial companies to be more responsive to social and environmental needs. Big data could play the lion's share in this. Being able to anticipate societal behaviour evaluation and understanding the long-term effects of climate change are within the grasp of Big data.

In the infrastructure sector, asset-intensive businesses involve **significant capital investment**, and the **effective management of the assets** is essential for achieving business goals. In railways, infrastructure managers (IMs) have been given much attention to Asset Management (AM) in the last years. Indeed, for IM organisations, physical assets are core for providing service that can be measured through various outputs like customer satisfaction, safety, sustainability (economical, environmental, and societal) and availability. Asset Management allows IM organisations orchestrating the railway network distributed among different geographically dispersed regions. Moreover, AM allows satisfying consistently multiple stakeholders requirements and expectations.

The **formulation of strategies and objectives for asset portfolio management** is challenging for railway infrastructure management organisations. In fact, there are different expectations among the various stakeholders and, consequently, different perceptions of asset value and the benefits that asset life cycle management can achieve. Moreover, the **decision-making at the strategic level** is inherently characterised by high uncertainty given the long-term reference horizon; on the other hand, **strategic and long-term decisions** are those characterised by the highest CAPEX (Capital Expenditure) with high impact on the organisations' economic sustainability.

To address these challenges, establishing **accurate information and data management strategy** is relevant for improving multiple aspects of AM. Proper management of information/data allows for amending service metrics measurements and testing multiple alternative scenarios for strategic decisions. The relevance of the asset information is remarked in the ISO 55001 to improve service offering performance by coping with uncertainty.

In this context, **advanced data analytics and modelling are required**. It is advisable that Big data could be used to unveil hidden patterns and links between key decisions and service outputs (Thaduri et al., 2015; RSSB, 2014). Thus, the value delivered to the customers and stakeholders could be assessed through a **data-driven approach** and the strategy of the organisation could better cope with changes in needs and expectations.



Big data definition – the 3 Vs

Generally, Big data are characterised by three Vs (Laney, 2001), used to distinguish between Big data and traditional data sets. The 3 Vs are volume, velocity and variety (Intezari et al., 2017):

- **Volume** refers to the size (magnitude) of Big data, which scales easily up to terabyte and petabyte; tools for storage and analysis must cope with this volume.
- **Variety** underlines that Big data is characterised by a "structural heterogeneity", that is, it does not include pre-defined formats a priori, and structured, semi-structured and unstructured data are collected, and analyses should account for this.
- **Velocity** highlights that Big data are generated at very high speed and, consequently, they should be analysed at (almost) the same rate, too.

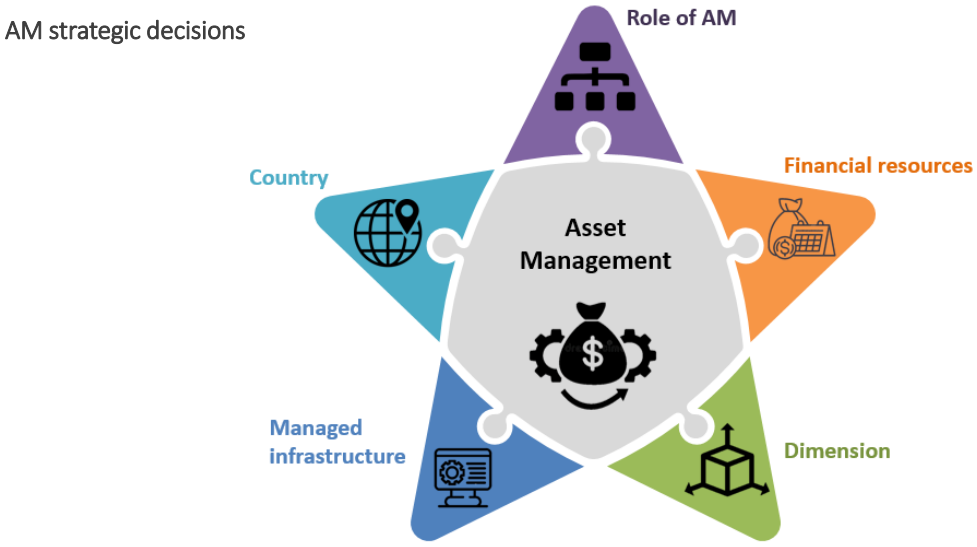
Are the 3 Vs necessary for AM strategic decisions?
Despite the current trend in using Big data to improve decision-making processes at various levels (operational, tactical, and strategic) and across industries, the discussion on whether the 3 Vs together are needed for supporting AM strategic decision-making is still open. Considering the opinions of the asset managers of the different countries in Europe involved in the study, the following evidence emerged.

Regarding **volume**, there is a widespread agreement on the need to rely on a wide set of data to describe more facets of the asset to support the business decision of interest. In particular, this is valid mainly when talking about asset-related data used to understand asset degradation, failures, impacts, effectiveness of interventions, cost of interventions, etc. Being capable of collecting data efficiently and storing them for further analysis enables strategic decisions.

Regarding **variety**, there is common agreement that strategic decisions should include several aspects, both asset-related and external, impacting the business. This is particularly true today where sustainability is stepping up the game by introducing economic, environmental and societal aspects in the decision-making. Different datasets are joined together and aligned with route sections with the aim to maximise the value to passengers and freight customers for the lowest long-term cost.

Regarding **velocity**, no common agreement has been reached yet. On the one hand, offering an up-to-date service to improve customer experience is paramount to providing value to customers and society. This requires real-time and updated data and information to adjust the service offering. For this reason, velocity is considered a requirement for the data used for refining strategic decisions, ensuring better communication and more accurate relationships for better customer experience and satisfaction. On the other hand, an open debate exists on whether strategic decisions should rely on real-time data generated at high velocity. In fact, this is mainly seen as a requirement for operational decisions to manage asset performance ('predict and prevent') by collecting and analysing edge data, or more generally, high-velocity data from remote monitoring. While, when it comes to triggering business processes, it does not necessarily be in real-time.

Maximising the benefits of big data for Asset Management



AM strategic decisions

Making effective strategic decisions is one of the critical abilities that managers are required to have and develop to lead their organisations in the increasingly volatile and competitive business world. Strategic decisions impact the long-term, address ambiguous and complex issues, engage various departments, and involve a high level of organisational resources. Because of the extensive uncertainty, ambiguity and risk associated with strategic decisions (McKenzie et al., 2011), gathering, analysing and considering reliable data and information are critically important in strategic decision-making.

Considering AM strategic decisions of railways IMs organisations, two main categories can be distinguished:

- **Lifecycle delivery strategic decisions**: strategic decisions directly linked to the lifecycle of the assets, composed of three main stages: Beginning of Life (BoL), Middle of Life (MoL) and End of Life (EoL) decisions.
- **AM support strategic decisions**: decisions indirectly related to the lifecycle of the assets. They act as transversal decisions, helpful in ensuring an efficient and effective AM service.

The **decisions and sub-decisions** associated with these two categories are shown in the figure. They result from the analysis of technical and scientific documents (El-Akruti K. & Dwight R., 2013; Roda I. & Garetti M., 2014; Roda I., Macchi M. & Albanese S., 2019; UIC_SAMP Application Guide_2020; UIC_Practical Implementation of AM through ISO 55001_2016; Asset Management – an anatomy, 2015, IAM) and the integration of the evidence collected through the interviews. It must be noted that the strategic decisions taken by an IM organisation depend on a series of contextual factors:

- **Role of AM** within the organisation.
- **Dimension** and available **financial resources** of the organisation.
- **Managed infrastructure** (single or multi-infrastructure).
- **Country** where the IM organisation operates**.**

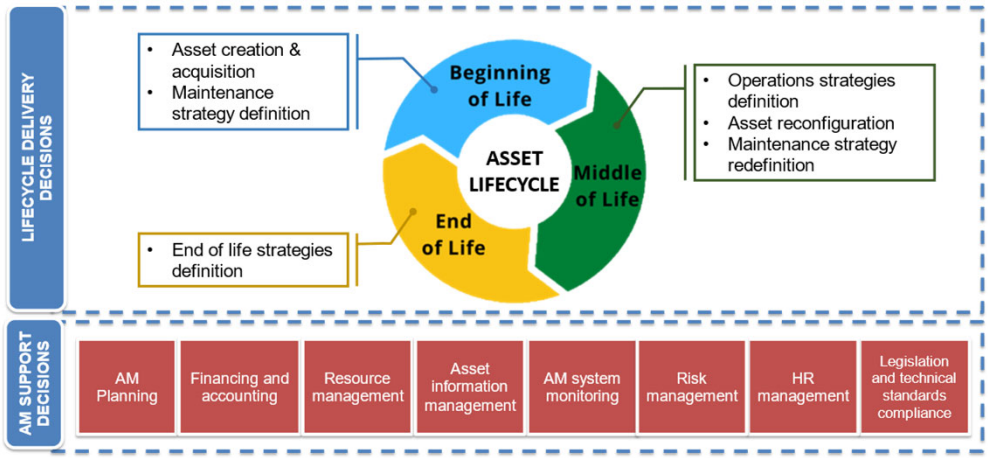
AM is considered as a **core business** in railway infrastructure management organisations and all business functions must contribute to its processes. Looking at the organizational architecture, two main different **organisational solutions** can be identified:

- AM is a department, generally staff business unit of the CEO, that supports the AM processes by ensuring coordination among different business functions.
- AM is not formalized as a department in the organization, but all business functions contribute to AM processes.

Moreover, depending on the contextual factors, not all AM strategic decisions may be taken by all IMs organisations as other actors could cover them.

Big data

AM strategic decisions for IMs organisations in Railways



AM strategic decisions for IMs organisations in Railways

The most important Strategic Decisions studied are:

- **Asset creation and acquisition.** Description of new asset development based on requirements, needs and functionalities that it must have or comply with.
- **Maintenance strategy definition.** Definition of the best inspections and maintenance policy mix.
- **Operations strategies definition.** Implementation of the programs, services, policies, or systems, and related procedures.
- **Asset reconfiguration.** Evaluation of the deviations of the technical-economic parameters.
- **Maintenance policy redefinition.** The redesign of the maintenance strategy thar must take into account performance, risk and costs
- **End-of-life strategies definition.** Definition of timing and type or EoL strategy

Maximising the benefits of big data for Asset Management

Benefits of Big data adoption for AM strategic decisions

- Asset performance:
  - *higher reliability;*
  - *higher capacity.*
- AM performance:
  - *better resource planning;*
  - *better system design;*
  - *higher effectiveness;*
  - *cost reduction.*
- Service offering:
  - *delay reduction;*
  - *higher flexibility;*
  - *improved sustainability;*
  - *higher safety.*

Which AM decisions may benefit most from Big data?

Benefits of Big data adoption for AM strategic decisions

Several are the expected benefits by IMs organisations coming from the exploitation of Big data for improving asset and AM performance and contributing to value generation by improving the service offering, and they are:

- **Asset performance:**
  - higher reliability
  - higher capacity
- **AM performance**:
  - better resource planning
  - better system design
  - higher effectiveness
  - cost reduction
- **Service offering**:
  - delay reduction
  - higher flexibility
  - improved sustainability
  - higher safety

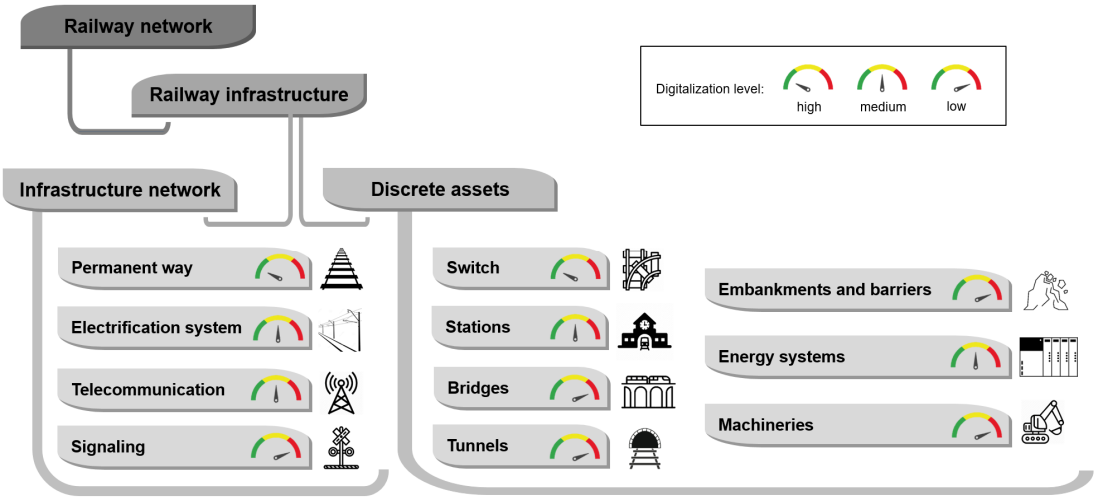
In general, it is possible to say that Big data are expected to improve value generation from assets, hence improving the business performances of IM organisations.

Which AM decisions may benefit most from Big data?

Big data could be disruptive in terms of how the decision-making processes are carried on. Some strategic decisions may benefit more than others from exploiting Big data. Specifically, the decisions to be taken at the **Beginning of Life of the lifecycle of assets** are the ones considered as mostly benefitted from using Big data. This is coherent with the long-term and high-risk characteristics of this kind of decisions. Also, **Middle of Life-related decisions** will benefit from Big data, especially concerning **maintenance strategy redefinition**. Moreover, **AM support decisions** are expected to be positively impacted if Big data are introduced. In fact, the data-driven decision-making process that Big data promotes may favour more objective planning or financing, habilitating lifecycle delivery decisions to provide value.

Maximising the benefits of big data for Asset Management

Asset-centric decision-making processes. Asset portfolio and asset digitalisation level



Asset-centric decision-making processes. Asset portfolio and asset digitalisation level

Asset-centric strategic decision-making means **leveraging upon asset performance and characteristics to judge the best decisions**. Hence, the description of the railway network is necessary, and the asset portfolio should be taxonomically ordered as well. In fact, a topological description of the railway network together with the asset register forms the reference system for all data.

The figure proposes a **taxonomy of assets** composing the railway infrastructure (categorised into infrastructure network and discrete assets). The taxonomy reports assets at different aggregation levels, from systems of assets to single assets.

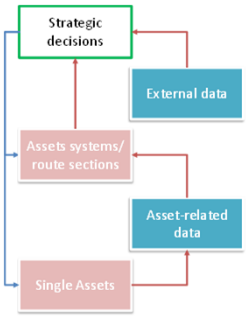
An indication of the "**digitalisation level**" for each asset type is also reported in the figure, evaluated by relying on information gathered from experts as a general opinion of the current state of art. In fact, it must be considered that to implement an effective and efficient asset-centric and data-driven decision-making process, the level of digitalisation of railway assets is an important enabler. Indeed, digitalisation means retrieving data from assets that are usually geographically dispersed and collecting them into databases ready for further elaboration. As a result of our analysis, assets like the permanent way and switches are the most digitised so far and many related data are already available to IM organisations (monitoring data, maintenance interventions, historical data, etc.). On the other hand, assets like bridges, tunnels, embankments, and machineries are likely to have a lower level of digitalisation.

The higher the data availability, the better the uncertainty is included in the related analysis, and strategic decisions are better tuned. Consequently, assets characterised by a higher level of digitalisation bring higher opportunities for a data-driven strategic decision-making process using Big data. For assets characterised by low digitalisation level, a short-to-medium-term strategy must be put in place to enlarge the available data on which judging decisions.

Maximising the benefits of big data for Asset Management

Scope of AM strategic decision-making process

Top-down and bottom-up approaches for systemic and asset-centric, data-driven decision-making.



AM strategic decisions refer to all levels of the asset hierarchical breakdown and rely on a systemic and asset-centric data-driven approach.

Scope of AM strategic decision-making process

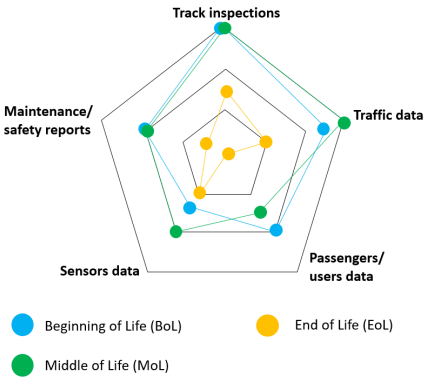
Considering the asset-centric and data-driven AM strategic decision-making process, bottom-up and top-down approaches should be put in place jointly. Decisions must consider **asset-related data** coming from single assets (bottom-up). As such, they guarantee a thorough knowledge of the assets that promote informed decision-making at different aggregation levels by relying on systemic analysis.

Moreover, when dealing with strategic decisions, not only asset-related data are needed, but **external data** either from other organisation department/s and from external stakeholders are recommended to be integrated as well.

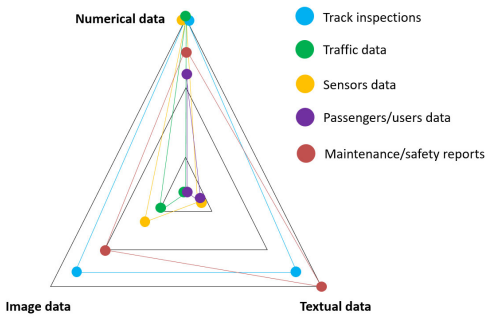
From a top-down perspective, based on the analysis carried out, strategic decisions can then address both the top level of the asset breakdown structure (systems/ systems of systems) and every single asset, guided by the systemic analysis of data (criticality analysis), allowing to prioritise assets and systems for budget allocation.

Maximising the benefits of big data for Asset Management

Data types, methods and sources. Data families and data types



Relation between data families and asset lifecycle stages



Relation between data types and data families

Data types, methods and sources. Data families and data types

Asset-related data and other external data should be used to support AM strategic decision-making by exploiting Big data. Considering asset-related data, the most relevant ones to be included in the analysis supporting the decisions are:

- **Lifecycle data** refer to technical characteristics of the assets in the asset register (installation date, technical parameters and functionalities)
- **Track inspections data** relate to data availability and information on inspections done following regulatory prescriptions or maintenance policy.
- **Traffic data** refer to the load, including passengers and goods, to which the network is subjected per track and per intermodal point.
- **Sensors data** include data from installed sensors on the network's assets to monitor the asset health conditions.
- **Maintenance/safety reports** relate to information and data included in the work order reports and activities performed on assets according to maintenance policies.
- **Passengers/users data** target the specific information on the user of the railway infrastructure.

External data are worth to be included so to enlarge the results that could be obtained through data analytics. A non-exhaustive list of external data is provided hereafter:

- Socio-economic data;
- Environmental data;
- Capacity data;
- Energy consumption data;
- Government data;
- Stakeholder expectations data;
- Financial data.

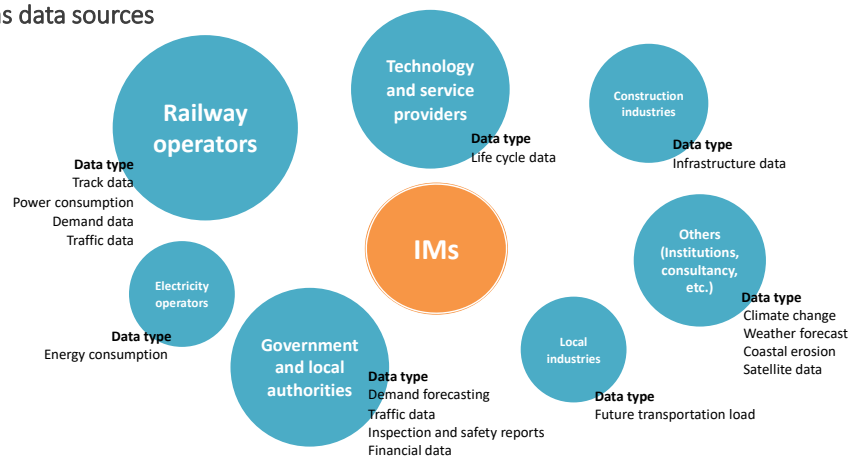
It is important to underline that almost all external data are linked to internal dynamics of the organisation and therefore some types of data may come from within the organisation. Depending on the IM organisation, some data may be already internal and elaborated through data analytics.

The figure on the left represents the most commonly used data nowadays per asset lifecycle stage. It is highlighted that so far, mostly asset-related data are collected and analysed rather than external data. Most data are adopted for Beginning of Life and Middle of Life strategic decisions, rather than for End of Life decisions.

Regarding the data types, mostly numerical data are used together with image data and textual data coming from track inspections and safety/maintenance reports as shown in the figure of the right.

Maximising the benefits of big data for Asset Management

The role of stakeholders as data sources



Opportunities and challenges of the adoption of BD for AM strategic decisions

Technical and organisational challenges

The role of stakeholders as data sources

When referring to valuable data for AM strategic decisions, whether they are asset-related data or external data, it must be considered that they may be owned by the IM organisation itself or they may be collected from external stakeholders. In particular, the relevant stakeholders who can provide additional data to the railway AM organisations are reported in Figure 12. Among them, there are, first of all, railway operators. They own crucial data (data on track, power consumption, demand forecasting and traffic data) essential for efficient and effective asset management. Other stakeholders identified as particularly significant are:

- government and local authorities;
- technologies and services providers.

The figure provides an overview of the main stakeholders and relevant data types they may bring in to support IMs decision-making processes

Opportunities

The opportunities related to the use of Big data for AM in the railway sector that can be foreseen are several. On the one hand, Big data is recognised as a contributor for better planning of AM activities, bringing:

- crossing of multi-type data for improved decision-making;
- transparent and real-time data sharing;
- exploitation of cross-industry data;
- real-time data analysis and visualisation;
- objective decision-making criteria.

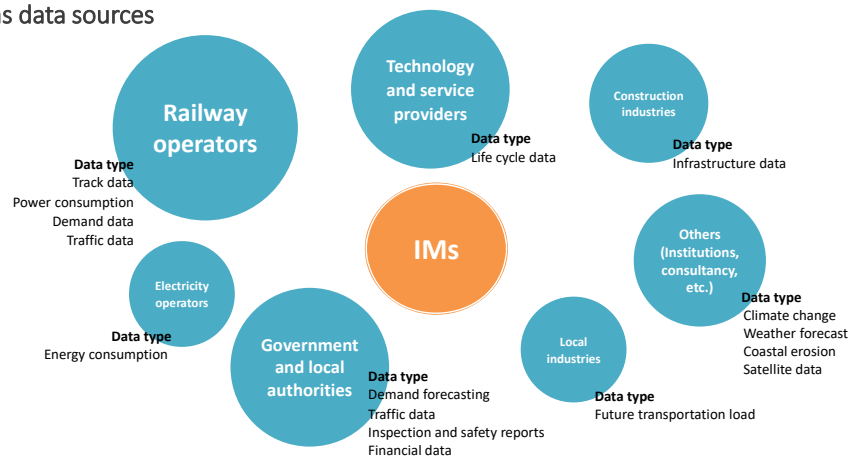
On the other hand, Big data are recognised as an opportunity for:

- support digital transformation – modernisation of railways industry;
- generate synergies among IM organisations.

Some of the opportunities are considered reachable in the shorter-term (less than 5 years), such as: crossing multi-type data, transparent data sharing, real-time data analysis and visualisation and getting to objective decision-making criteria. At the same time, some others are expected to rise in the longer-term (up to 15 years).

Maximising the benefits of big data for Asset Management

The role of stakeholders as data sources



Opportunities and challenges of the adoption of BD for AM strategic decisions

Technical and organisational challenges

Technical and organisational challenges

The main technical challenge for Big data exploitation of AM strategic decisions is the *information systems interoperability*. The need to connect the different information systems is considered a critical task to achieve, given the large number of systems used by the organisations and their specific characteristics. Regarding other technical challenges, it is relevant to highlight the following ones:

- high variety of data to be managed;
- cybersecurity;
- data governance.

On the other hand, many are the organisational challenges for successful exploitation of Big data in AM, such as:

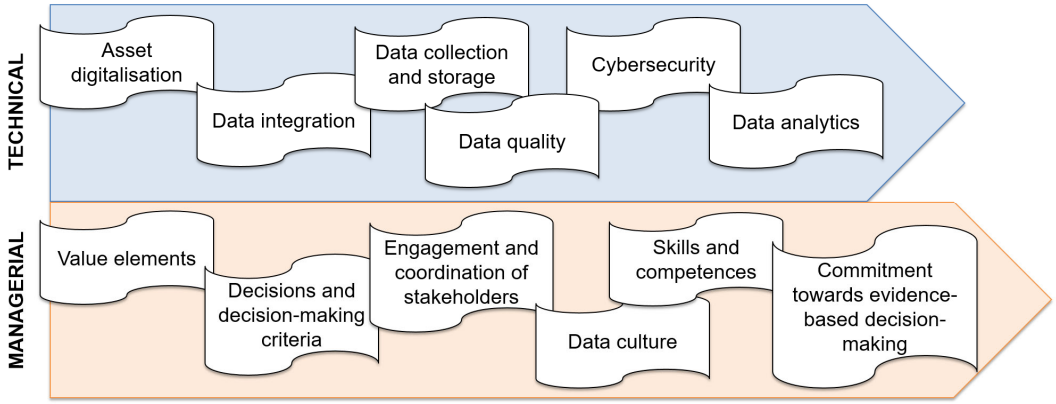
- organisational commitment to evidence-based decisions making;
- data culture;
- data transmission with external stakeholders and within the organisation;
- skills and competencies on Big data;
- quantifying benefits vs costs.

The organisational challenges are deemed the most critical ones. In particular, “quantifying benefits vs costs”, “organisational commitment to evidence-based decision-making” and “data culture” are critical challenges to be addressed, given that they are related among each other. In fact, being able to quantify benefits and costs on the adoption of Big data technologies is not trivial and identifying performance metrics for that is a hard task (like ROI-Return On Investment or PBT-Pay Back Time). In turn, this may not convince the management to invest in Big data technologies; without the commitment of the top managers, there is no data culture spreading throughout the organisational levels, bringing to a stack in the digital transformation.

Among the technical challenges, “data availability” remains a critical one in railway. Depending on the contextual factors, the IMs may be in charge of managing both the railway infrastructure and operating trains. In this case, high integration of systems ensures the availability of several types of data. However, this is not a common scenario, and the train operator is a stakeholder that could be critical for data availability. In that case, data transmission with external stakeholders is critical and adequate information systems integration is required, together with formal contracts and agreements definition and management.

Maximising the benefits of big data for Asset Management

The roadmap towards Big data-based AM strategic decision-making for Ims. Critical factors for Big data adoption



Main factors for implementing Big data for AM strategic decisions in railway IM organisations.

The roadmap towards Big data-based AM strategic decision-making for Ims. Critical factors for Big data adoption

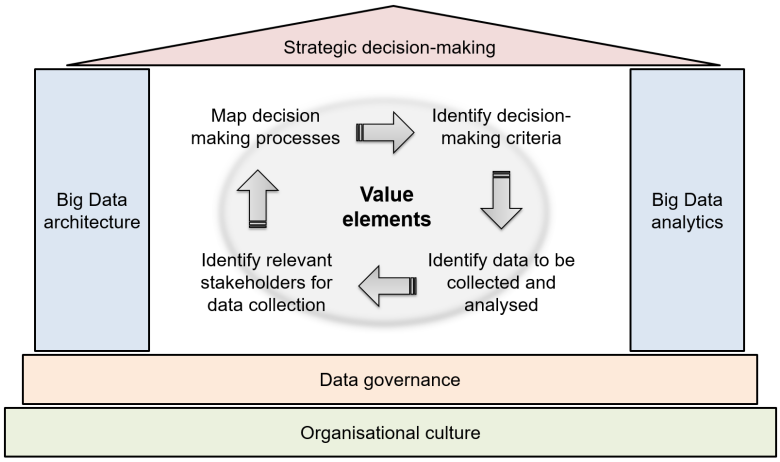
Being aware of both opportunities and challenges related to the adoption of Big data is essential to trace down the evolution path towards Big data-based AM strategic decision-making. In Figure 13, a representation of the main factors to consider are reported, divided into technical and managerial issues.

On the **technical side**, the cornerstone is asset digitalisation: guaranteeing that each asset is “smart” and that it is able to provide the necessary data and information is fundamental to create the dataset/s for further analysis. Indeed, the available datasets must be integrated and stored to guarantee that the Big data algorithms could be exploited at scale by considering the entire asset portfolio, letting relevant relationships emerge. At the same time, input data should be carefully managed; in fact, data quality is one of the major challenges in the current application of Big data analytics. Cybersecurity is also a relevant aspect to be addressed for successfully implementing Big data.

On the **managerial side**, the decisions are not only to be taken upon proper data elaboration but should address the ultimate objective of AM, which is value generation. Hence there is the need to be consistent with the value framework of the organisation. The value elements must set the course of any strategic decision to comply with company strategy and vision. Clear mapping of the AM decision-making processes in the organisation is also necessary for setting up proper decision criteria to guarantee consistency with the value framework. Stakeholders must be more and more engaged in the decision-making process, being the source of relevant data. Internal company functions must be engaged, and imprinting data culture in the organisation is crucial. Training must be set up to let people in the organisation have the right skills and competencies to understand the outputs of Big data analytics correctly as well as properly criticise the given inputs. In this evolution, evidence-based decision-making is a major change that must be pursued starting from the top corporate management.

Maximising the benefits of big data for Asset Management

Vision for implementing Big data for AM strategic decisions in railway IM organisations



The vision for implementing Big data for AM strategic decisions

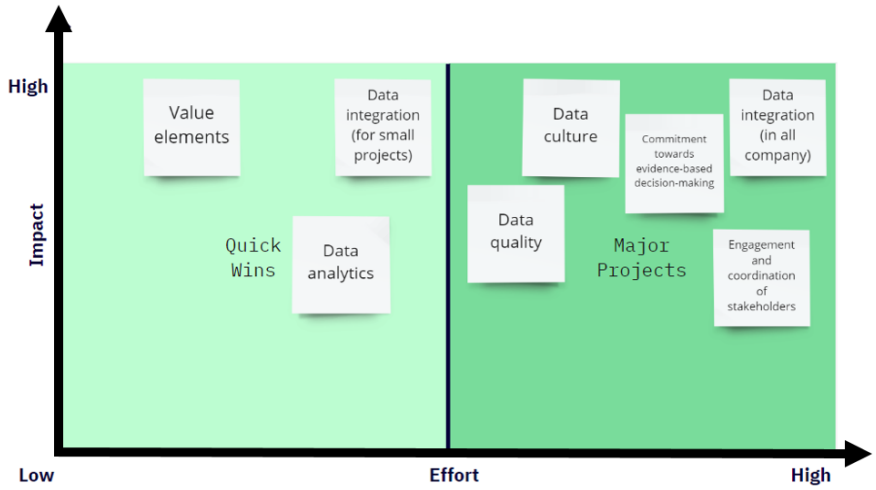
At the very centre of the vision towards Big data adoption for AM strategic decision-making is the value framework. Given the mapping of the decision-making processes, related decision criteria must be defined consistently with the value elements to ensure value generation from AM. Once this is done, it is possible to identify which are the required data to be collected and analysed and which are the relevant stakeholders to be involved.

The two technical pillars for enabling the vision are Big data architecture and Big data analytics. Moreover, the overall vision can stand only if it is based on strong data governance and data-oriented culture. Data governance means clear data accountability to define who is responsible and ensure ownership; it includes also data lineage to understand where data comes from and to describe it, data quality to ensure data is clean and consistent so to manage data risks proactively, data privacy & security to protect asset data and ensure sensitive information are safeguarded.

Regarding the organisational culture, strong commitment from the top management and adequate skills and competencies are the main issues to be integrated.

Maximising the benefits of big data for Asset Management

Roadmap and recommendations



Roadmap and recommendations

Overall, the **main actions** to be followed towards adopting Big Data for AM strategic decision making in IM organizations are:

1. Define a list of prioritised value elements and the decisions that impact on them.
2. Identify for each decision, the set of already available useful data as well as a data wish list including those data that may improve the judgement of such decisions.
3. Set up a set of PoC (Proof of Concepts) where data integration is pursued at first and where small-sized, fit-for-purpose data analytics are developed.
4. Once the PoC are concluded, scale up the analytics towards the use of Big data in terms of volume and variety.

On the **cultural side**, several are the actions that should be planned:

1. Commit from the top to promote data-driven decision-making approaches in the whole organization.
2. Strengthen competences related to data and their analysis, not only for the analytics itself, but also to promote data-driven thinking across organisational levels.
3. Engage employers into small projects and PoC in order not to let them feel overwhelmed by the transformation but be part of it.
4. Promote inter-department collaboration

To provide some recommendations for implementing the depicted vision, high impact projects have been identified that may be either quick wins requiring low effort to be put in place or major projects.

Overall, value elements definition and data analytics solution development are quick wins, requiring low effort to be implemented and having a high impact for Big data adoption for AM strategic decision-making. Data integration is also a relevant task to be implemented. If it is confined within small projects, it is not really challenging but rather a quick win. Instead, vertical and horizontal integration throughout the company is a long-term objective and major project for organisations. Other major projects to be implemented should address data quality, data culture, engagement, and coordination of stakeholders. These are seen as major projects since they involve radical changes in the ongoing processes and in the partnerships with stakeholders. Last but not least, an important transformation that is required is related to the shift from experience-based decision-making to evidence-based decision-making since the future becomes more and more unpredictable and Big data may help shed light on some uncertain future situations or, at least, evaluate their likeliness.

Predicting the maintenance of railway infrastructure with digital technologies (PMDT)

Transtelecom JSC
Kydyrbek Kussainov
October, 2022

PMDT
ASU MAGISTRAL

Aim: Transition of track maintenance from the planned to the actual repair method.

Objectives:

- Auditing and re-engineering of business processes for track facilities management
- Introduction of high-precision track diagnostic tools
- Introduction of high-precision positioning systems and digital track model
- Development of a technological solution for an integrated system that automates equipment maintenance and repair processes (EMRP)

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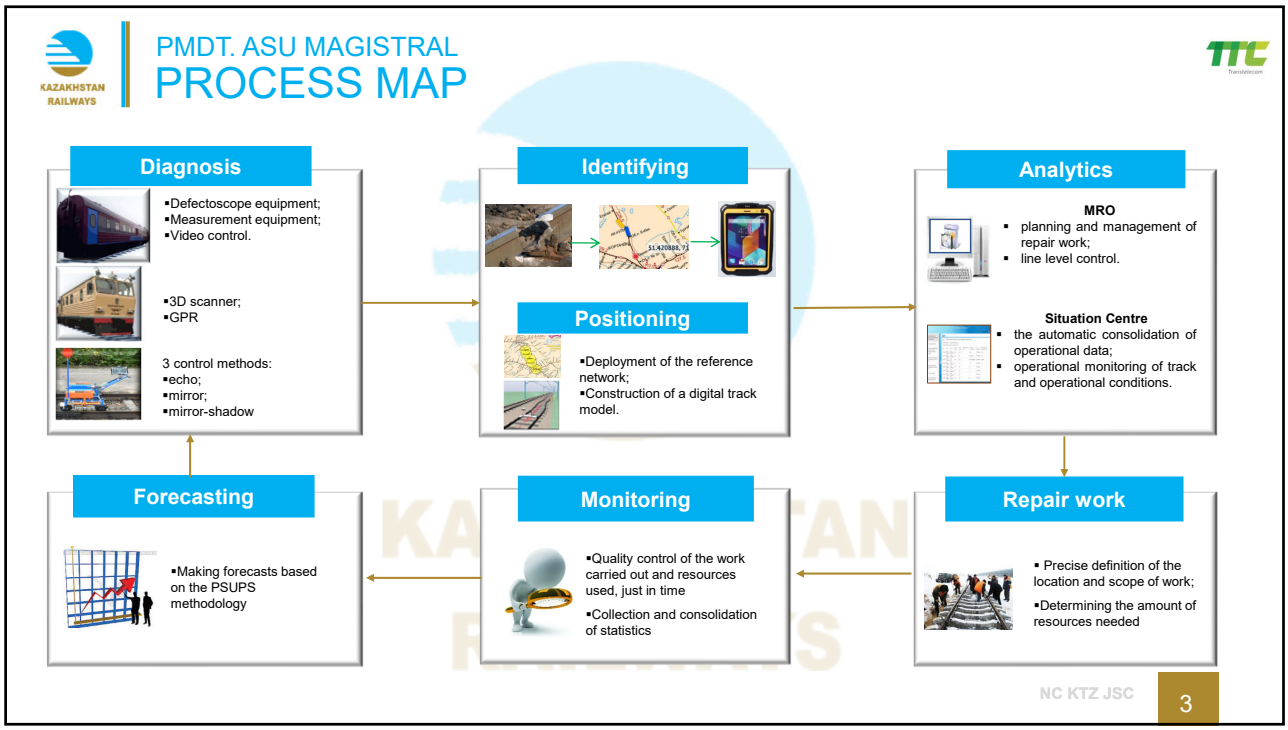
KAZAKHSTAN RAILWAYS
PMDT. ASU MAGISTRAL
PROCESS MAP
Diagnosis
▪Defectoscope equipment;
▪Measurement equipment;
▪Video control.
▪3D scanner;
▪GPR
3 control methods:
▪echo;
▪mirror;
▪mirror-shadow
Identifying
Positioning
▪Deployment of the reference network;
▪Construction of a digital track model.
Analytics
MRO
▪ planning and management of repair work;
▪ line level control.
Situation Centre
▪ the automatic consolidation of operational data;
▪ operational monitoring of track and operational conditions.
Repair work
▪ Precise definition of the location and scope of work;
▪Determining the amount of resources needed
Monitoring
▪Quality control of the work carried out and resources used, just in time
▪Collection and consolidation of statistics
Forecasting
▪Making forecasts based on the PSUPS methodology
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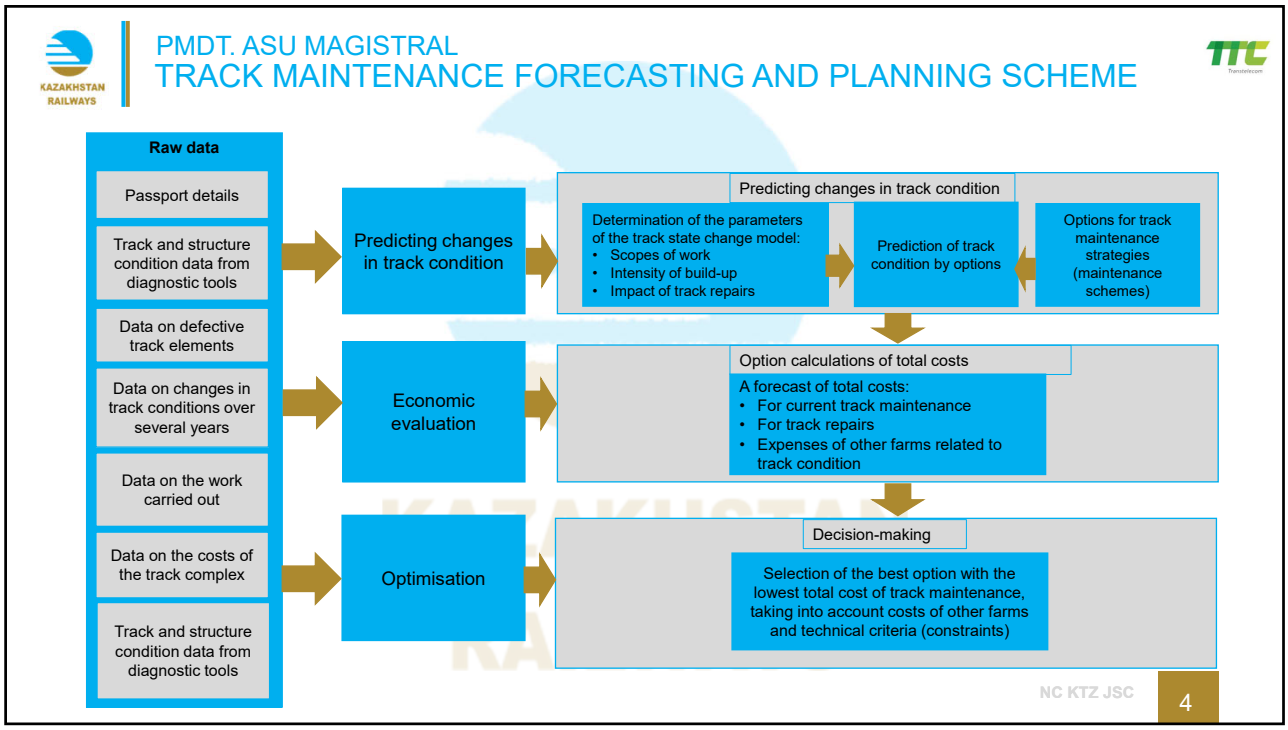
3


KAZAKHSTAN RAILWAYS
PMDT. ASU MAGISTRAL
TRACK MAINTENANCE FORECASTING AND PLANNING SCHEME
Raw data
Passport details
Track and structure condition data from diagnostic tools
Data on defective track elements
Data on changes in track conditions over several years
Data on the work carried out
Data on the costs of the track complex
Track and structure condition data from diagnostic tools
Predicting changes in track condition
Economic evaluation
Optimisation
Predicting changes in track condition
Determination of the parameters of the track state change model:
• Scopes of work
• Intensity of build-up
• Impact of track repairs
Prediction of track condition by options
Options for track maintenance strategies (maintenance schemes)
Option calculations of total costs
A forecast of total costs:
• For current track maintenance
• For track repairs
• Expenses of other farms related to track condition
Decision-making
Selection of the best option with the lowest total cost of track maintenance, taking into account costs of other farms and technical criteria (constraints)
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4

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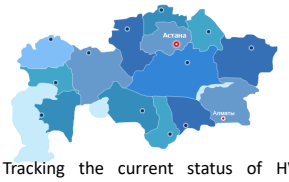
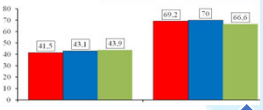
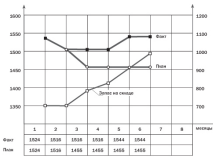
SITUATION CENTRE



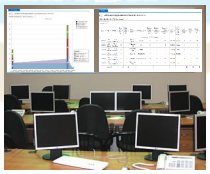
Tracking the current status of HWC facilities - with interactive maps and analytical reports



Assessment of the quality of the work carried out (degree of improvement from the work carried out)

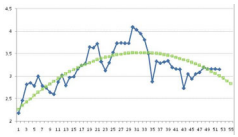


Assessment of the current status of track facilities (operational certificates)

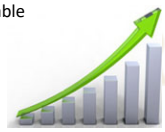


Situation Centre

Prompt notifications on a basic range of issues (current status, current and potential problems) - customisable templates for each recipient



Plan and forecast funding (using multi-factor methodologies)

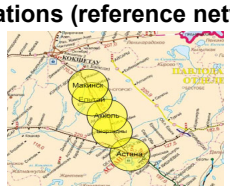


Monitoring the implementation of the development strategy

Evaluate the optimality of work planning

PMDT. ASU MAGISTRAL
POSITIONING

Installation of differential stations (reference network)



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Fieldwork photography

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Data processing

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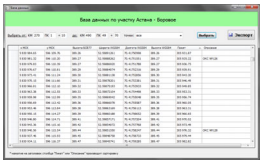
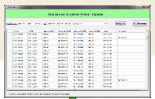
Digital track model (DTM)





The DTM is the link and is used to determine the coordinates of defects, and to create jobs for trackside machines to place the track in its designed position.

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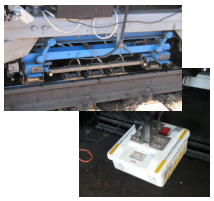
EMRP



DEFINITION DEFECT

ON EMRP

REQUIRED WORKS

ON MRO for tablets

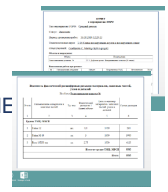
STATISTICS AND REPORTS

PLANNING WORK FOR SECONDARY INSPECTION AND RECTIFICATION OF DEFECTS

- HUMAN RESOURCE MANAGEMENT
- PLANNING TORO ACTIVITIES
- EQUIPMENT INVENTORY

CARRYING OUT SECONDARY INSPECTION AND RECTIFICATION OF DEFECTS

- STANDARDS MANAGEMENT
- TANGIBLE GOODS MANAGEME
- OUTFIT MANAGEMENT



- **INCREASED TRANSPARENCY OF FINANCIAL EXPENDITURE**
- **OPTIMISATION OF HUMAN AND MATERIAL RESOURCES**

NC KTZ JSC 7

PMDT. ASU MAGISTRAL

PROJECT PERFORMANCE INDICATORS

Production indicators:	Economic indicators:
• Increased detectability of defects • Increased data processing speed • Integration of measurement results in a unified database; • An increase in labour productivity of 30%; • Increasing the level of automation of existing technological processes • Transition to maintenance by actual state • Automating the functions of track specialisations • Diagnostics with minimal human influence	• Economic benefits for the company • Extension of the time between repairs • Savings by reducing the cost of major repairs; • On-time repairs (avoiding repairs earlier or later than economically feasible) • Increasing the speed of trains

NC KTZ JSC 8

PMDT. ASU MAGISTRAL

DIAGNOSTIC TOOLS: MOBILE DIAGNOSTIC COMPLEX BASED ON A RAILCAR (MDC)


Ultrasonic flaw detection:
- A 24-channel ultrasonic scheme using four ultrasonic testing methods and patented ultrasonic schemes;
- non-contact (magnetic) alignment of the locating system relative to the longitudinal axis of the rails;


Magnetodynamic flaw detection:
- detection of subsurface head defects at temperatures down to minus 50ºC;
- stable magnetic flux in the rail, higher than that of "U" magnet systems;
- automatic sleeper counting;
- auto-detection of track design elements


Control of gauge geometry:
- non-contact measurement of track geometry (laser sensors);
- real-time output of processing results with determination of deviations from track gauge standards


Control of rail head geometry:
- automatic marking of track sections with unacceptable wear and tear on the head;
- Analysis of rail gradient values to identify rail joint defects;


Video inspection of the condition of rails and fastenings:
- 4 cameras installed on the outer and inner sides of the track;
- energy-efficient backlighting;
- automatic recognition of individual rail elements.

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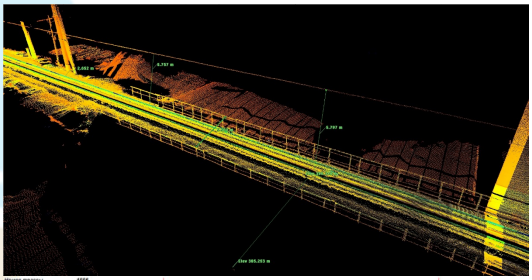
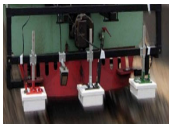
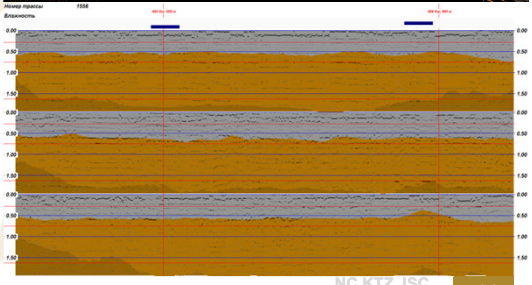
DIAGNOSTIC TOOLS: MOTRISA-BASED COMPLEX

3D scanning system:
- Determine the dimensions of the building approach;
- monitoring of the track superstructure.





A georadiolocation system:
- Graphical and tabular display of ballast layer by depth;
- qualitative assessment of the degree of blockage of ballast material with the provision of graphical and tabular information;
- estimating the moisture content of the ballast material.



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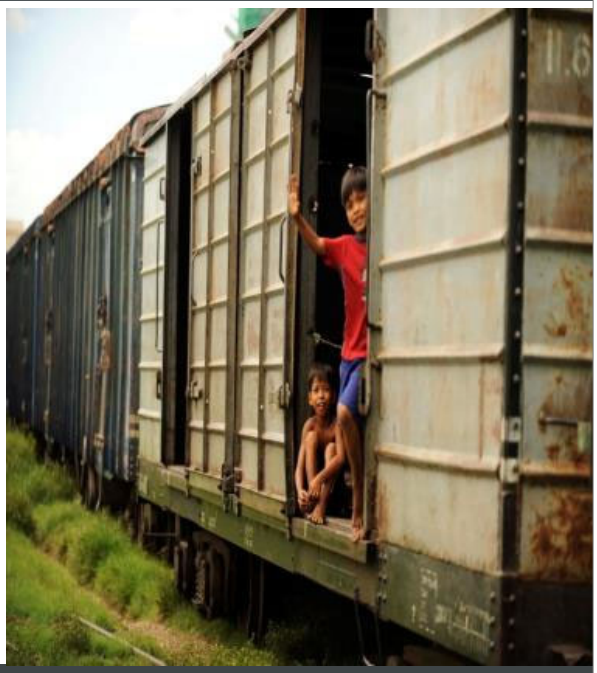
DIGITAL RAIL BORDER CROSSING

Sandeep Raj Jain, UN ESCAP

Railway border crossing processes play a central role in facilitating international railway transport. One weak railway border crossing could undermine the efficiency of the entire railway corridor, lead to increased transit time for railway transport, reduce the reliability, predictability, and punctuality of freight trains, increase logistics costs for firm, and ultimately discourage investments in border crossing facilities.

Digital Rail Border Crossing

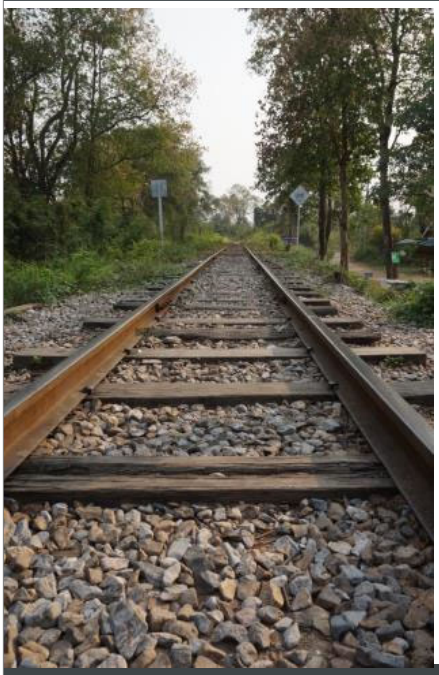
1. Intergovernmental agreement on TARN
2. Importance of digital rail border crossing
3. Complexity of rail border crossing
4. Electronic information exchange between railways and among control agencies
5. Key issues to streamline customs formalities for international railway transport
6. Electronic information exchange can promote streamlined customs formalities



This module has six subsections:

1. Intergovernmental agreement on TARN
2. Importance of digital rail border crossing
3. Complexity of rail border crossing
4. Electronic information exchange between railways and among control agencies
5. Key issues to streamline customs formalities for international railway transport
6. Electronic information exchange can promote streamlined customs formalities

1. Intergovernmental Agreement on Trans-Asian Railway Network



Trans-Asian Railway Network formalized through intergovernmental agreement entered into force in 2009. Has now 21 contracting parties.

Developed by ESCAP members as a coordinated plan to develop a regional railway network to meet the growing needs of intra and interregional trade and transport.

The Working Group under the agreement provides a regional platform for the member countries to discuss persistent and emerging issues in international railway transport along the network. Seven meetings- focus on operational issues.

The Trans-Asian Railway Network is a regional rail network that was formalized through an intergovernmental agreement in 2006 and came into force in 2209. There are currently 21 contracting parties. It was developed by ESCAP members as a coordinated plan to develop a regional railway network to meet the growing needs of intra and interregional trade and transport.

Seven Working Groups were held under the agreement. The Working Group provides a regional platform for the member countries to discuss persistent and emerging issues in international railway transport along the network.

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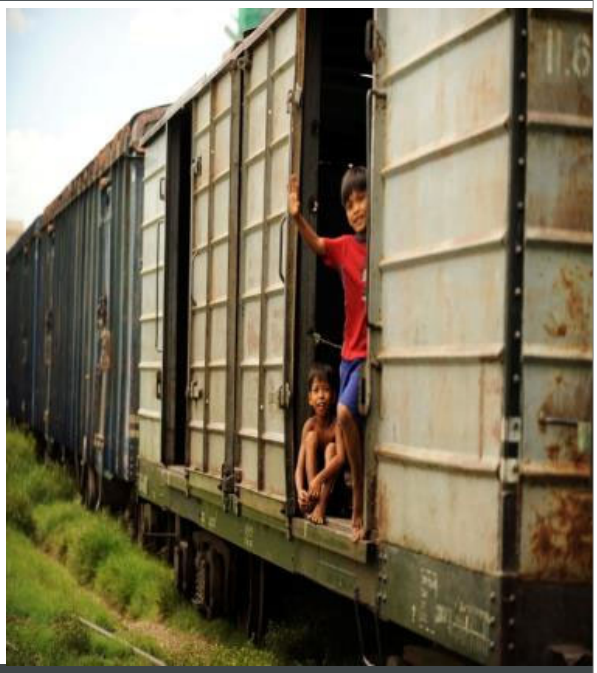
2. Importance of Digital Rail Border Crossing

Emerging trends in international railway transport along Trans-Asian Railway Network:

- New routes for international railway transport
- New rail infrastructure
- New services along the Trans-Asian Railway network
- New alliances to promote international railway freight

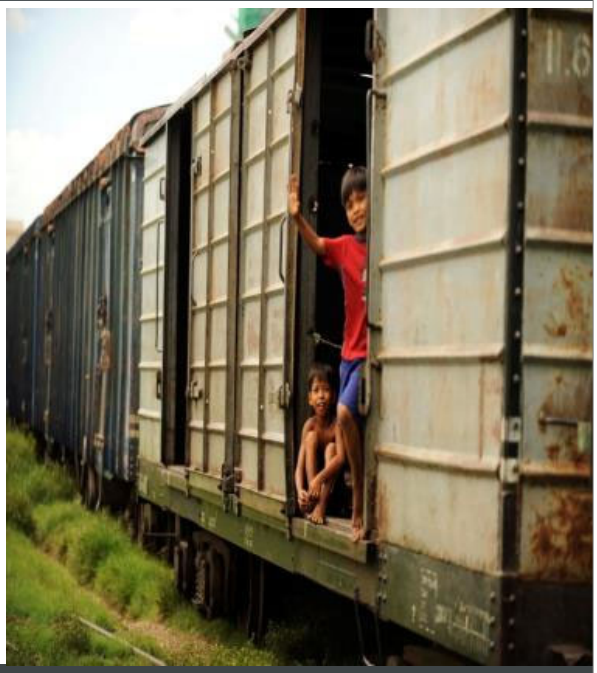


The emerging trend of new routes for international railway transport, new rail infrastructure, new services along the TARN, and new alliances to promote international railway freight indicate the necessity and importance of digital rail border crossings for enhancing rail competitiveness.

Importance of Digital Rail Border Crossing

Pandemic impact on railway transport

- Railways proved to be reliable transport means - as the rail freight flows avoided major restrictions
- Pandemic helped in promoted faster solutions and special
- Pandemic gave further momentum to digitalization of railway transport even in countries with relatively low level of digital services

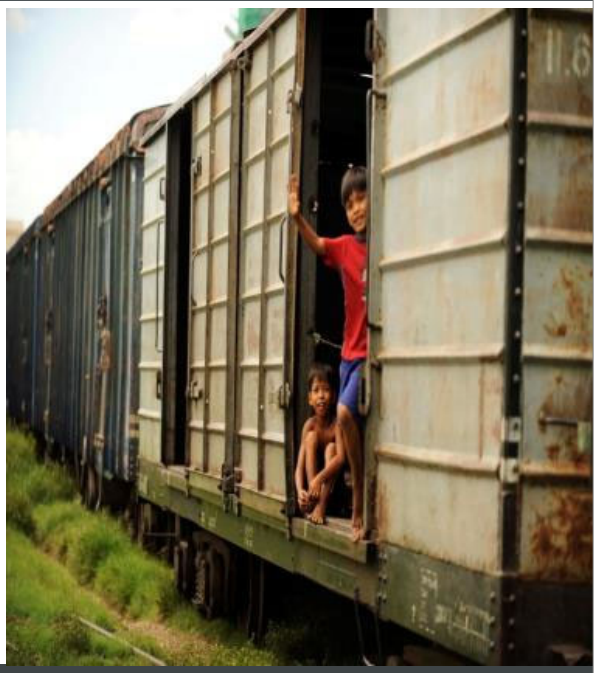


During the COVID-19 Pandemic, railways have proven to be a reliable means of transport. Pandemic also gave a further boost to the digitalization of railway transport, even in countries with relatively low level of digital services.

Importance of Digital Rail Border Crossing

Pandemic impact on railway transport

- New solutions for customers and services, primarily digital, were proposed in many countries
- Most national railway strategies have yet to considers the full impact of COVID-19 pandemic in medium and long term
- No dedicated funded support programme for railways at international

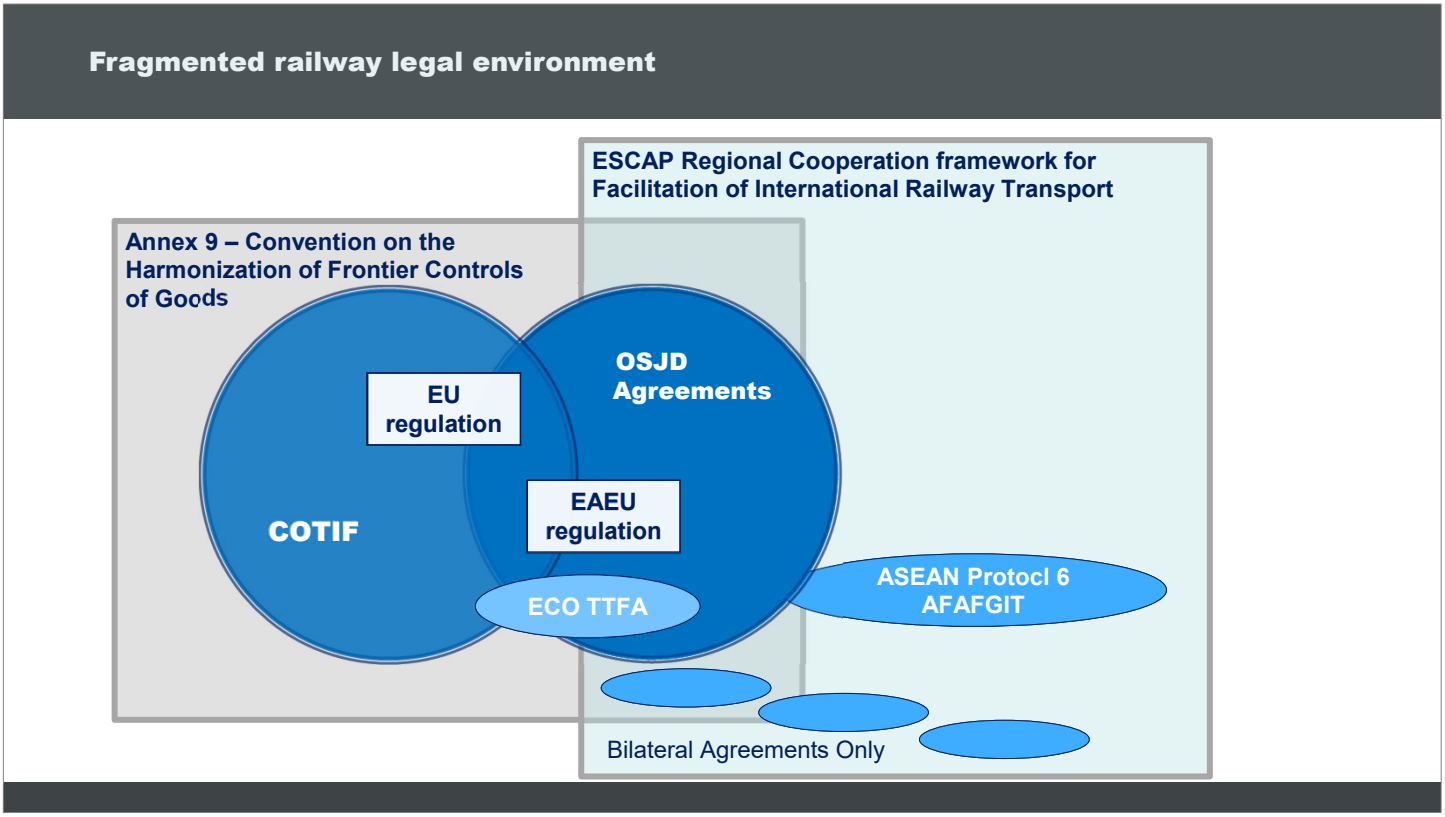


During the pandemic many countries proposed new, mainly digital, solutions for customers and services to cope with the challenges brought about by the Pandemic. However, most national railway strategies have yet to consider the full impact of the pandemic over the medium and long term on freight transport mix including demand and supply.

3. Complex environment of railway border crossing

The environment at railway border crossings is complex because of the involvement of numerous stakeholders, which often have different interests. The interface between regulators and railways at railway border crossings can be complicated, and the requirements for completion of the formalities need substantial streamlining of border formalities among the countries. Customs seals or inspections are not mutually recognized unless there is an arrangement to that effect.

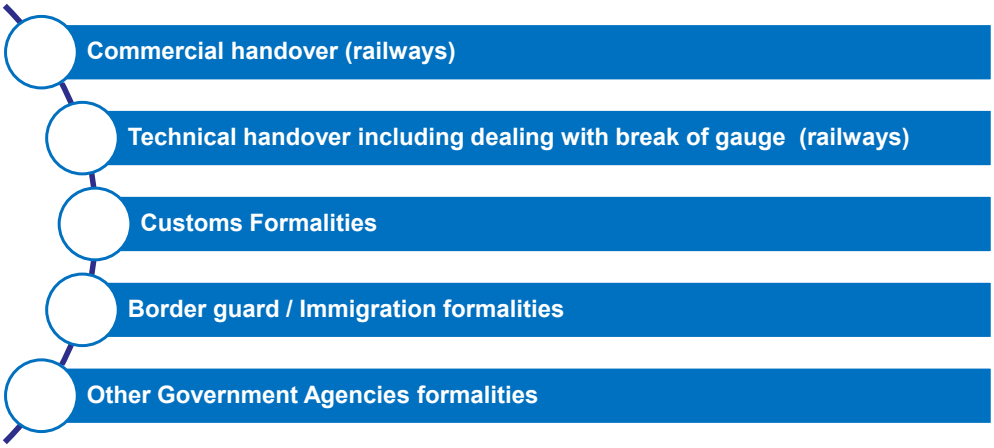
The lack of an appropriate mechanism for sharing information and mutual recognition of inspection results among the regulatory agencies also leads to duplication of many procedures at railway border crossings.



Moreover, the international railway transport is fragmented as it is based on different legal regimes and numerous bilateral arrangements that poses a challenge to achieving seamless international railway transport due to different rules, documents, procedures, and practices. The organization of the railway operations at railway border crossings with different legal regimes is burdened by the requirement for different railway transport documents. Divergence in formalities for railway transit among the countries also compounds and add to the delays at the border crossings.

Main processes at the railway border crossings

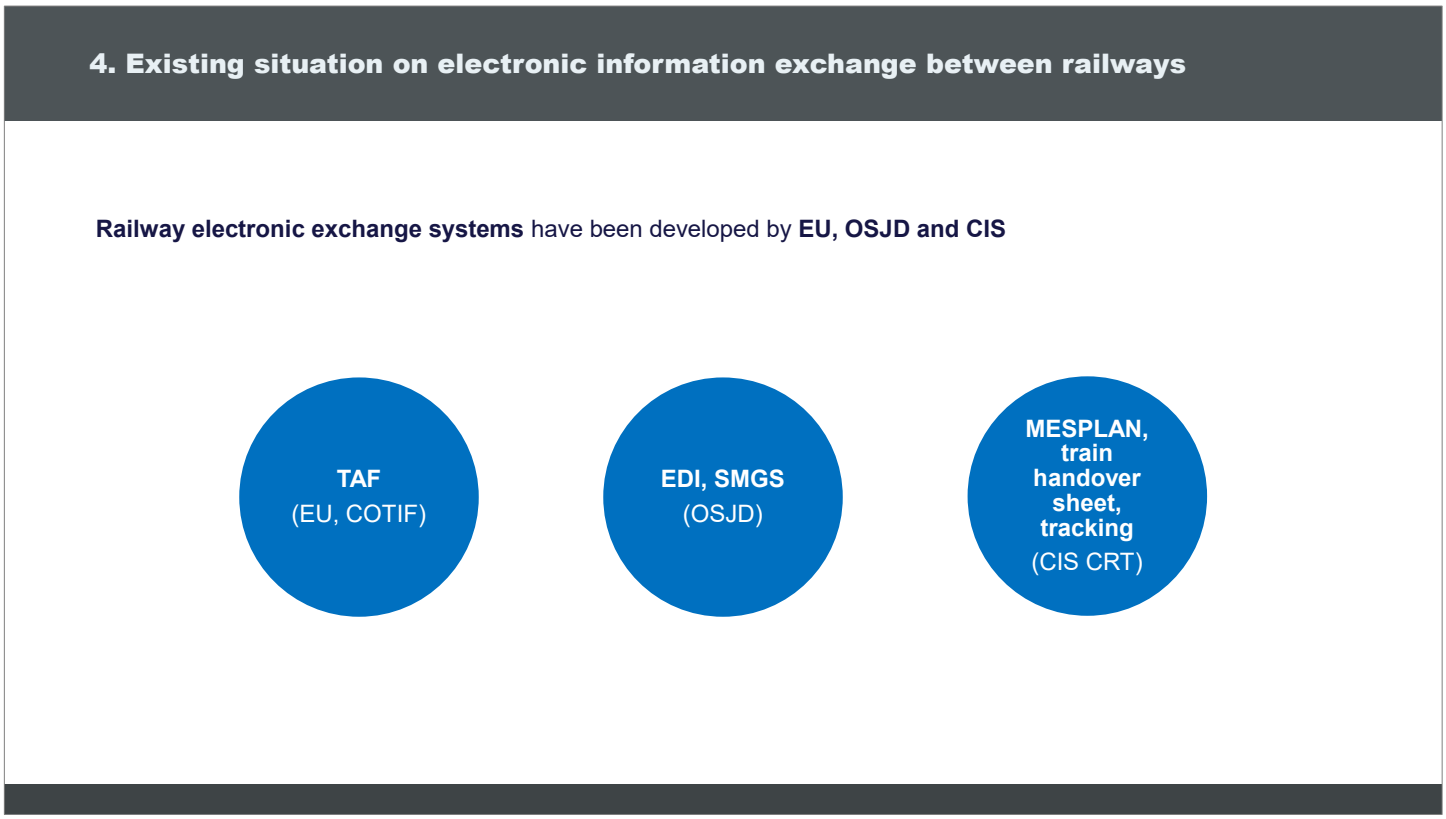
The main processes undertaken at the railway border crossing can be grouped as follows:



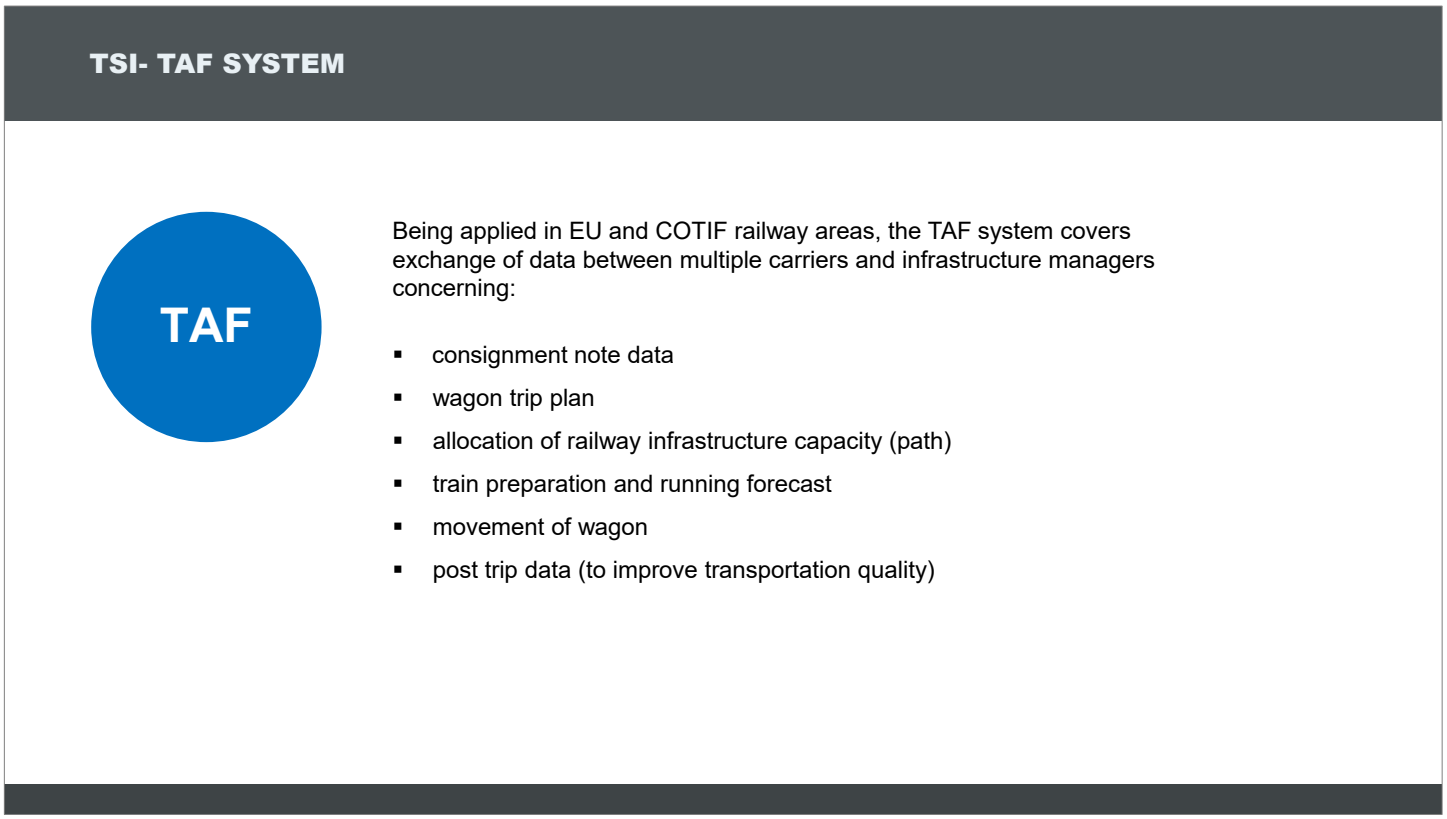
A freight train normally goes through five processes after arriving at a railway border crossing.

Commercial handover from one railway to another; Technical handover; Customs formalities; Border guard and immigration formalities; and other government agencies formalities.

All this need information to complete and therefore the way in which information flows with different stakeholders at the border crossing can make difference and that why electronic exchange is so important.



The electronic exchange of information between railways can greatly enhance the efficiency of processes at the border crossings. Currently, different regions have different railway electronic exchange systems as elaborated in the slide.



The telematics Application for Freight-Technical Specifications for Interoperability (TAF-TSI) is being applied in EU and COTIF railway areas to exchange data between multiple carriers and infrastructure managers concerning consignment note data, wagon trip plan, allocation of railway infrastructure capacity, train preparation and operation forecast, movement of wagon, and post trip data.

OSJD DEVELOPMENTS

OSJD

Apply within the geographic scope of the organization, solutions aimed at facilitation of international rail freight traffic by:

- implementing electronic railway data exchange (EDI)
- developing electronic SMGS consignment note
- contribution to development of the electronic CIM/SMGS consignment note

For countries who are members of OSJD, the Agreement on International Freight Transportation by Rail (SMGS) provides legal background for electronic documents. The agreements support electronic information exchange by implementing electronic railway data exchange, developing electronic SMGS consignment note, and developing CIM/SMGS consignment note.

CIS CRT SOLUTIONS

CIS CRT

Products developed in the context of the CIS CRT are being applied in the territory of the Commonwealth of Independent States and in neighboring railway networks.

They are dedicated to data exchange between railways to facilitate:

- global planning of international rail freight flows (MESPLAN system)
- facilitation of cross-border operations (electronic train handover sheet)
- goods/vehicles tracking (standardized dedicated messages)

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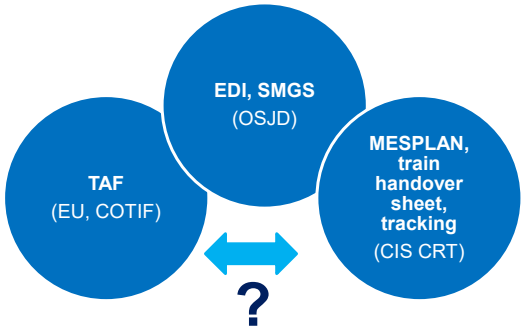
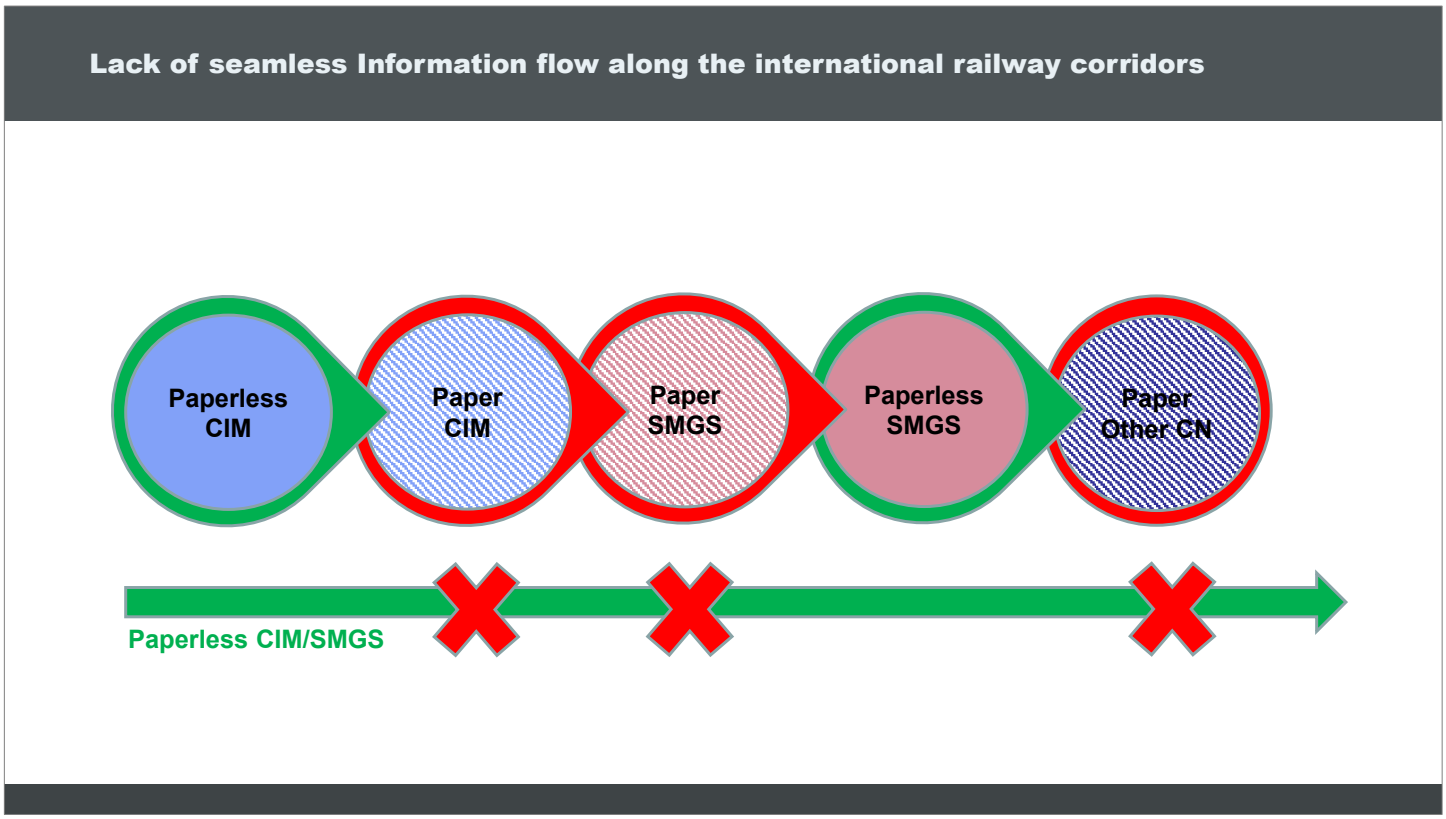
Challenges for international railway transport

- Each of the systems applies in its own (often overlapping) geographical area, **virtually independently developed**, in accordance with its own legal framework and governed by different entities
- **Lack of interface between some systems** imposes use of numerous solutions for information exchange in "transit" railway networks



These three railway electronic exchange systems are applied in its own geographical area, and lack of interfaces between systems poses challenges for international railway transport.



Different electronic information exchange systems can potentially lead to the development of different electronic systems for the same processes and events. Such multiplicity can undermine the seamless flow of information, particularly along the international railway corridors, and therefore the efficiency of transport operations along the corridors.

5. Key issues in streamlining customs formalities for international railway transport

- Information exchange among railways in many countries, remains paper based - lack of electronic information exchange inhibits prior information and advanced risk management for Customs
- Documents and data required by Customs for international rail transit varies among the countries leading to burdensome procedures
- Recognize consignment note as customs transit declaration

Streamlined customs formalities for international railway transport can significantly enhance the efficiency in border crossing. However, many challenges remain to harness their potential along the international railway corridors.

One of the key issues in streamlining customs formalities is the current paper-based information exchange. Customs and other government agencies often require an excessive number of documents. Excessive documentary requirements hamper efforts to streamline clearances at the border crossings and, as experience suggests, such methods are ineffective because the collected documents are usually stored without any substantial control.

In addition, the documents required by customs still needs to be standardized and harmonized to streamline border crossing processes. The use of electronic consignment note plays a major role in railway-to-railway electronic information exchange as consignment note contains the information required by adjacent railways as well as by control agencies and therefore it should be also acceptable as customs document.

Key issues in streamlining customs formalities for international railway transport

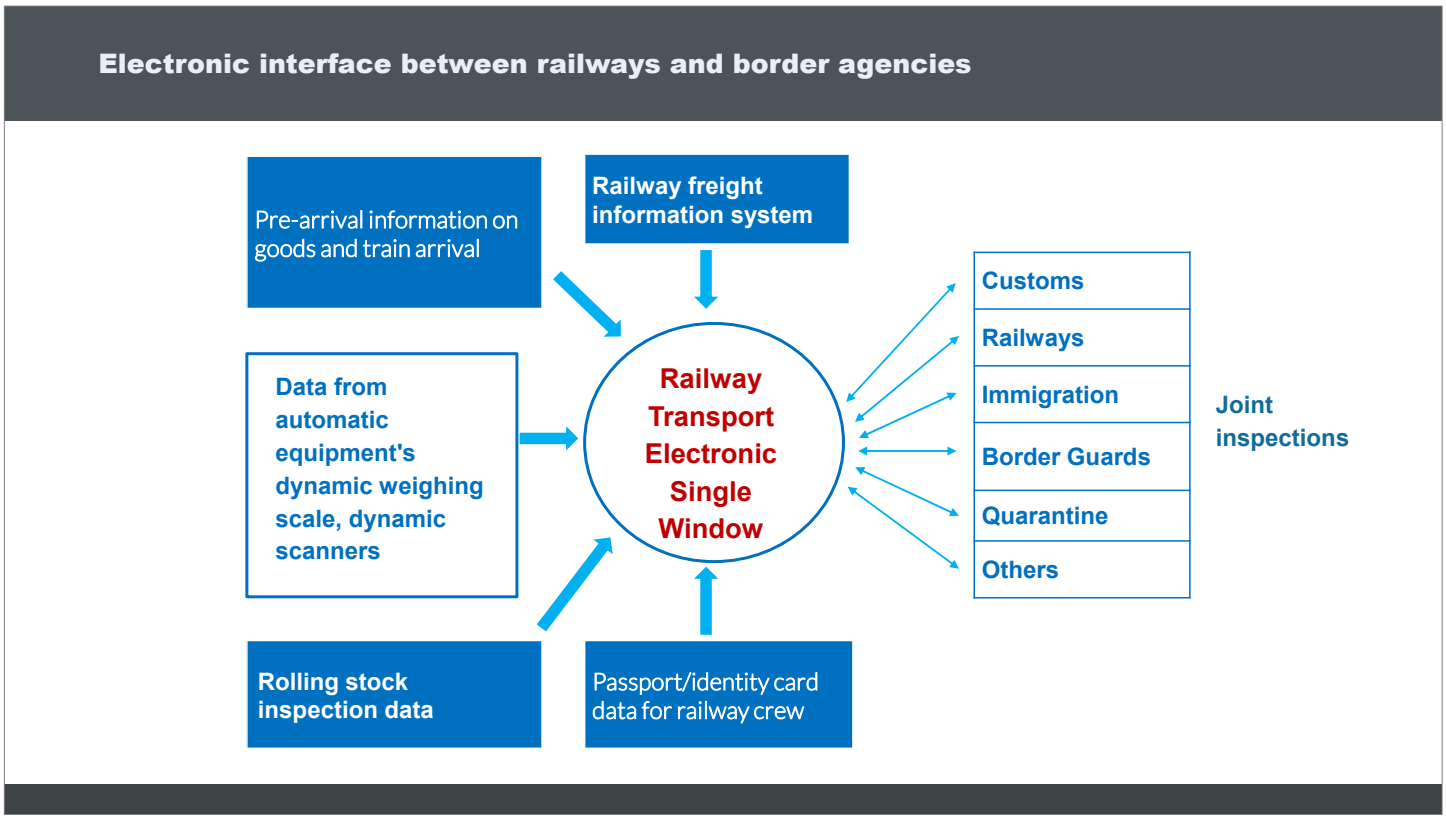
- Lack of interface between railways and Customs information systems hinders efficient exchange of information required for use of new technologies in completion of control measures
- Electronic pre- arrival intimation for advance and integrated risk assessment
- Lack of cooperation (mutual recognition and joint controls) among customs and other government agencies in instituting control measures
- Some customs authorities require guarantees for rail transit increasing time and cost

Other issues include the lack of interface between railways and customs information systems, the lack of electronic pre-arrival intimation for advance risk assessment, which is particularly important for railway border crossings with high traffic flows, the lack of cooperation between customs and other government agencies, and the time and cost increase by requiring guarantees for rail transit.

6. Electronic exchange of information for streamlining customs formalities for rail

- Recognition of railway consignment note as customs transit declaration
- Use of new technologies in collecting information required for regulatory controls and increased cooperation among border agencies behind the border and across the border
- Joint completion of customs and other regulatory controls including mutual recognition of inspection results and integrated risk analysis
- Electronic pre- arrival intimation can facilitate integrated risk assessment

To streamline customs formalities, it is recommended to use consignment note as customs transit declaration, encourage new technologies at rail border crossings, such as dynamic scanners and dynamic scales, X-ray scanners and mobile scanners, implement joint control measure by border agencies. Under that arrangement, the train does not have to stop at both the exit and entry border crossing stations, but only at designated railway border crossing station. Use electronic pre-arrival intimation especially for high traffic flows can facilitate risk assessment by Customs



It is also recommended to implement an electronic single window or electronic interface between railways and border agencies. The data and information from multiple sources, including electronic systems of railways, customs, immigration; automatic control equipment's; and dynamic scanners, could be stored in a neutral platform or the single window for railway transport to improve the efficiency of information exchange, particularly to reduce the need for resubmission of similar information.