

# CATALOGUE OF SOLUTIONS

2022 Edition



  
Europe's Rail



## CATALOGUE OF SOLUTIONS 2022

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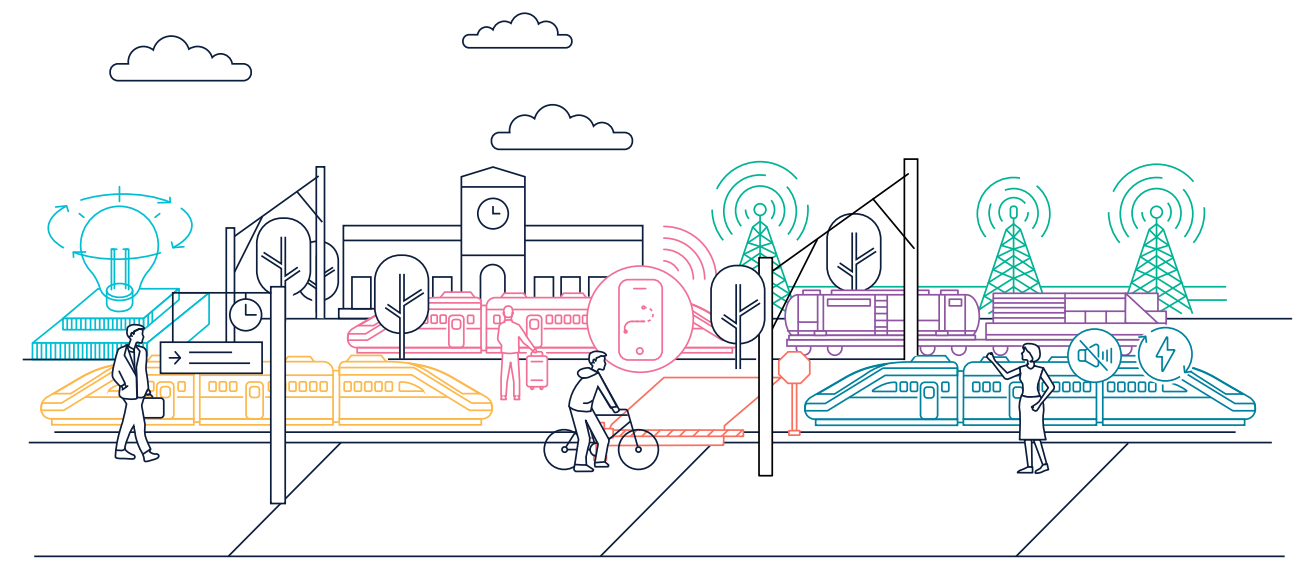
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# Foreword



Leafing through this impressive Catalogue of Solutions reinforces my sense of optimism about the future of rail in Europe. It is inspiring to see so many innovative solutions, on the cusp of being market-ready. Together, they offer lower life-cycle, energy and project-engineering costs, alongside greater comfort, safety and accessibility – and much more besides.

Shift2Rail achieved great things. Now Europe's Rail, together with its members, is building on those results to deliver a European railway network that is resilient, reliable and integrated; that is flexible, sustainable and greater in capacity. Once we eliminate barriers to interoperability, both European citizens and our value chain will see a difference. Rail will take its rightful place in our mobility mix.

The catalogue of solutions strengthens my belief in the value of innovation. It also demonstrates what can be achieved when we pool ideas, knowledge and funding.

As I extend my thanks and congratulations to everyone who has contributed to these solutions, I invite you to read this catalogue with the attention it deserves.

**Adina Vălean,**  
European Commissioner for Transport

# Rail Research and Innovation to Make Rail the Everyday Mobility



*"This second edition of the Catalogue of Solutions shows the progress achieved by the former S2R Research and Innovation Programme, delivering impactful innovative solutions that are shaping the evolution of the rail system. These results set the baseline and pave the way to the new Europe's Rail Programme, which will deliver a systemic transformation of rail. Also, the new Deployment Group will have the opportunity to model the consistent and coordinated European implementation, where necessary, of "ready to go" solutions presented in this Catalogue."*

**Carlo M Borghini,**  
Executive Director,  
Europe's Rail Joint Undertaking

This 2022 edition of the Europe's Rail Catalogue of Solutions illustrates successful R&I results in the form of possible products and solutions, while highlighting the benefits for final users, operators, infrastructure managers and/or suppliers. This publication also outlines the advantages of integrating demonstrators into market solutions so that they can deliver the rail innovation Capabilities of the future.

Through its presence at InnoTrans 2022, Europe's Rail is showcasing the link between the programme and its predecessor, Shift2Rail. This is achieved by presenting the results coming from the Shift2Rail Programme and linking them to the key flagship areas of the new Europe's Rail. At the heart of this Catalogue innovative solutions and game-changing demonstrators are showcased, all of which answer the evolving needs of rail stakeholders.

Europe's Rail Joint Undertaking is the European partnership on rail research and innovation established under the Horizon Europe programme and the universal successor of Shift2Rail. In cooperation with its Members, Europe's Rail builds upon the results of Shift2Rail and aims to deliver, via an integrated system approach, a high capacity, flexible, multi-modal, sustainable, resilient and reliable integrated European railway network by eliminating barriers to interoperability and providing solutions for full integration, for European citizens and supply value chain.

Shift2Rail has achieved great features. It is now Europe's Rail's turn to take over and continue the work, bringing more systemic and ambitious solutions, and making rail the everyday mobility in Europe.





# Shift2Rail and its Innovation Programme

The Shift2Rail Joint Undertaking (S2R JU)<sup>1</sup> was a public-private partnership under the Horizon 2020 Framework Programme established to manage and coordinate rail Research and Innovation (R&I).

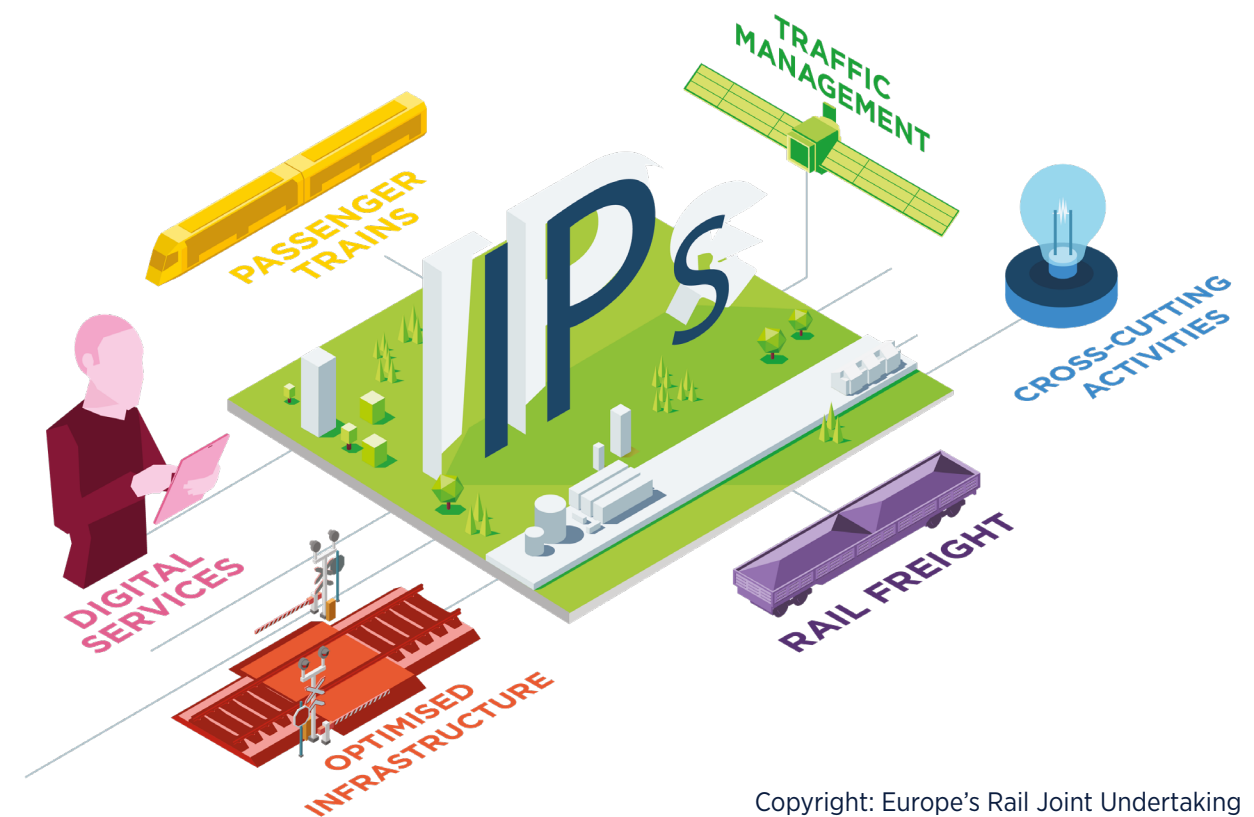
Shift2Rail's vision was to deliver the most sustainable, cost-efficient, high-performing, time-driven, digital and competitive customer-centred transport mode for Europe.

The S2R Programme was based on an integrated set of R&I activities, structured around five asset-specific Innovation Programmes (IPs), covering key structural (technical) and functional (process) subsystems of the rail systems: passenger trains, traffic

management systems, infrastructure, IT services and freight trains. Additionally, cross-cutting activities (CCA), such as research on long-term economic and societal trends in customer needs and human capital and skills, offered information on the market to the different IPs, making sure that R&I activities were up to date and served the needs of the European citizens.

Within each IP and the CCA, researchers developed 70 innovative technologies and solutions, which are illustrated in this catalogue.

<sup>1</sup> The S2R JU was officially established on 7 July 2014, following the adoption of Council Regulation (EU) No 642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking (S2R Regulation).



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# The New Europe's Rail Programme

Europe's Rail Joint Undertaking (EU-Rail)<sup>1</sup> is a public-private partnership under the Horizon Europe Framework Programme established to manage and coordinate mission-oriented research and Innovation (R&I) activities for a major systemic transformation of European rail. Building on the achievements of Shift2Rail, the partnership aims to accelerate research and development in innovative technologies and operational solutions to make rail Europe's everyday mobility.

EU-Rail's ambition is to provide technological and operational solutions to lead the transformation of the rail sector, working towards the twin green and digital transition of Europe. This will be realised through a systemic approach to research and innovation, developing cutting-edge innovative solutions to create railway systems for the future for passengers and freight. 26 Founding Members and all other stakeholders that joined the Programme activities will gather forces to make this ambitious objective a reality. The global vision of this partnership is to ensure a fast transition to more attractive, user-friendly, competitive, affordable, easy to maintain, efficient, resilient and sustainable European rail system, integrated into the wider mobility system. Europe's Rail will support the development of a strong and globally competitive European rail industry while contributing towards the achievement of the Single European Railway Area (SERA).

In order to deliver its objectives and strategy, EU-Rail is set-up around one single Research and Innovation Programme based on a system view. The Programme will be delivered through two integrated pillars and complemented by a Deployment Group, all together covering the full life cycle of R&I from blue sky to pre-deployment and pre-industrialisation processes.

**System Pillar:** Brings all rail sector representatives under a single coordination body. Provides the governance and resources to support the sector in converging on the evolution of the rail system and lays out the operational concept and system architecture to achieve it.

**Innovation Pillar:** Coordinates innovative technological and operational solutions for services of the future, through flagship projects, large-scale demonstrations and exploratory and fundamental research and innovation.

**Deployment Group:** Ensures that future solutions are deployed in a coordinated and consistent way at European level, considering alternative rollout scenarios, behavioural and organisational changes, and synergies with other modes of transport.

## Europe's Rail Impact:

-  Meeting evolving customer requirements
-  Improved performance and capacity
-  Reduced lifecycle costs
-  More sustainable and resilient transport
-  Harmonised approach to evolution and greater adaptability
-  Rail as the backbone of European transport and mobility
-  Improved EU rail supply industry competitiveness

## EU-Rail Multi-Annual Work Programme

### Network management planning and control & Mobility Management in a multimodal environment

Network management planning and control (new processes and automation for decision support) & rail management in a multimodal environment (real-time demand-driven operations, including demand from other transport modes)

### Digital Enablers

Provide Digital Twins Design toolbox for design as well as for validation, verification and test + a Federated dataspace where all digital elements of the system can play together in a coherent and interoperable way

### Digital & Automated up to Autonomous Train Operations

Digital "Automated & Autonomous" Train Operations building upon the next gen Automatic Train Control based on ERTMS + enhancements on TCMS for integration at the on-board level

### Intelligent & Integrated asset management

Knowledge from the digital transformation will feed back into the design, construction, manufacturing as well as into operation and maintenance processes.

### A sustainable and green rail system

Innovative solutions and services based on leading edge technologies to minimize the overall energy consumption and environmental impact of the railway system

### Innovation on new approaches for guided transport modes

Explore non-traditional and emerging flexible and/or high-speed guided transport systems, as well as to create opportunities for innovators to bring forward ideas for shaping those future systems

### Regional rail services / Innovative rail services to revitalise capillary lines

Decreasing cost while offering a high quality of service and operational safety + increase customer satisfaction and attractiveness

### Sustainable Competitive Digital Green Rail Freight Services

Digitalization and automation of operational functions (e.g. DAC) and processes as well as increasing the efficiency of the immaterial (information/data) layer of transport in logistic

<sup>1</sup> Council Regulation published in the Official Journal <https://eur-lex.europa.eu/eli/reg/2021/2085>





# Purpose of the Catalogue of Solutions

This catalogue illustrates the value of R&I investments, generating innovative solutions for market uptake. The purpose is to:

- Describe successful results in terms of possible products and solutions with a clear timetable
- Show Benefits for “customers”: final users, operators, infrastructure managers and/or suppliers
- Highlight the advantages of integrating the demonstrators into market solutions
- Illustrate how the solutions will contribute to delivering the Innovation Capabilities of the future railways

This catalogue includes 70 solutions in relation to the whole rail system. Each solution includes a description and specifies a targeted market, market outlook and estimated date for market uptake. In addition, potential benefits and market impact are indicated for all solutions.



# IP1



## Passenger trains:

Cost-efficient and reliable trains, including high-capacity trains and high-speed trains

### TRACTION SYSTEMS

**Solution 1:** Master Silicon Carbide (SiC) Semiconductors

**Solution 2:** High Speed Motor on Wheel

### TCMS

**Solution 3:** Next Generation TCMS - New Vehicle Control Unit

### TRAIN COMMUNICATIONS

**Solution 4:** Standardised Train-To-Ground Communication System

### LIGHT STRUCTURES

**Solution 5:** Light Carbodies

**Solution 6:** Door Leaves

**Solution 7:** Composite Door Leaves

**Solution 8:** New Door Functions Towards Autonomous Doors

**Solution 9:** Boarding Aid

**Solution 10:** Lightweight Antenna Supporting Element

### LIGHT RUNNING GEAR

**Solution 11:** Lightweight Axle

**Solution 12:** Austempered Ductile Iron (ADI) spoke wheel

**Solution 13:** Light Running Gear Frame

### CONDITION BASED MAINTENANCE

**Solution 14:** HMS for CBM

### BRAKING SYSTEM

**Solution 15:** Electromechanical Brake System (EMB)

**Solution 16:** Adhesion Management Solutions

**Solution 17:** Adhesion Management Enhanced Solutions

**Solution 18:** High-SIL Brake Control

**Solution 19:** Innovative Friction Pair

### INTERIORS

**Solution 20:** Passengers' Room Adapted to Their Needs

**Solution 21:** Driver's Cabin

### ECO-FRIENDLY HVAC

**Solution 22:** Eco-Friendly Air Conditioning with Natural Refrigerant

## TRACTION SYSTEMS

### Solution 1: Master Silicon Carbide (SiC) Semiconductors

- Applied to rail traction systems (tramway, metro, sub-urban, regional)
- Complemented by methodologies, tools, standards & norms developed on noise, reliability, smart maintenance, virtual validation and certification

#### Targeted market:

Tramway, Metro, Sub-Urban, Regional, HST, VHST

#### EU-Rail Solution available for industrialisation:

Solution ready for prototype testing

#### Market outlook:

Good perspectives for all trains segments



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## TRACTION SYSTEMS

### Solution 2: High Speed Motor on Wheel

- Distributed traction on independent wheel bogie to increase traction capabilities
- Permanent magnet motor with high power and torque density (in terms of weight and volume)
- Inclusion of permanent magnet motor to increase traction capabilities

#### Targeted market:

High Speed Trains and Very High-Speed Train markets

#### EU-Rail Solution available for industrialisation:

Solution ready for prototype testing

#### Market outlook:

Applicable for all trains segments



Copyright: Talgo

## TRACTION SYSTEMS

### BENEFITS

#### Potential benefits and market impact:

- Reduced life cycle cost thanks to lower maintenance (up to -15%) and energy costs (up to -20%) and capital cost reduction via virtual validation & certification
- High reliability, predictive maintenance components included for higher availability & punctuality of trains
- Lower noise traction components thanks to specific design optimisation and natural cooling

#### Customer benefiting from the solutions:

Operator and Supplier

TCMS

Solution 3:  
Next Generation TCMS - New Vehicle  
Control Unit

TCMS Next GeN

- New SIL4 functions, while removing safety lines
- Wireless inter-consist & intra-consist
- Train-to-ground communications

Functional Distributed Framework defined in the New Vehicle Control Units for TCMS

Targeted market:

Mainly for the whole rail transport market and possibly even further TCMS Next GeN

EU-Rail Solution available for industrialisation:

Before 2025 for SIL2

Beyond 2025 for SIL4

Market outlook:

Good perspectives for urban and regional transport



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TCMS

BENEFITS

Potential benefits and market  
impact:

- 50% reduction of trains unavailability due to better functioning of train control and monitoring
- 50% cost reduction in project engineering, integration and certification phases
- Safety increase thanks to enabling the implementation of SIL4 functions in the TCMS
- 25% weight reduction of cabling and space used by electronics hardware

Customer benefiting from the  
solutions:

Operator and Supplier

TRAIN COMMUNICATIONS

Solution 4:  
Standardised Train-To-Ground  
Communication System

New standardised train-to-ground communication system for interoperable Mobile Communications Gateways by suppliers New SIL4 functions, while removing safety lines.

Targeted market:

Mainly for rail vehicle market and technology enablers

EU-Rail Solution available for industrialisation:

Solution ready for prototype testing

Market outlook:

Good perspectives for urban and regional transport



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TRAIN COMMUNICATIONS

BENEFITS

Potential benefits and market impact:

- 50% of trains' availability increase related to the functioning of train control and monitoring
- 50% cost reduction in project engineering, integration and certification phases
- Cost reduction and cost-efficient management of fleets

Customer benefiting from the solutions:

Operator, Infrastructure Manager and Supplier



## LIGHT STRUCTURES

### Solution 5: Light Carbodies

- New materials, processes, and technologies in the current carbody concepts scalable for manufacturing
- Hybrid solutions with metallic/composites components due to optimal combination of properties and requirements for high- speed trains
- Substitution of welded extruded aluminium profiles by pultruded Carbon Fibre Reinforced Plastics (CFRP) and/or one-shot infusion panels of sandwich and CFRP
- Hybrid concept for validation metallic and composites components (manufactured with different technologies) due to optimal combination of properties and requirements

#### Targeted market:

Mainly rail vehicle manufacturer market and technology enablers

#### EU-Rail Solution available for industrialisation:

Solution ready for prototype testing

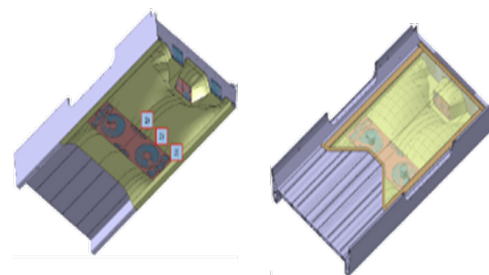
#### Market outlook:

Good perspectives for High Speed transport



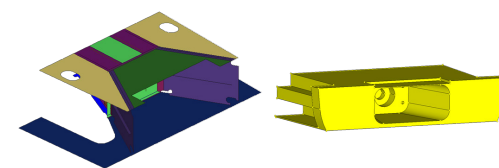
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Headstock Metro Carbody



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Coupler end HST Carbody



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## LIGHT STRUCTURES

### Solution 6: Door Leaves

New concept design of metallic door leaves based on metallic architecture introducing plastic/composite parts, innovative filling materials and sealing solutions for thermal insulation, acoustic attenuation, and weight optimisation. It will improve passenger comfort thanks to improved thermal and acoustic insulation, and reduce weight for less impact on the infrastructure or train weight constraints with the introduction of an optimised metal solution or a plastic or composite solution.

#### Targeted market:

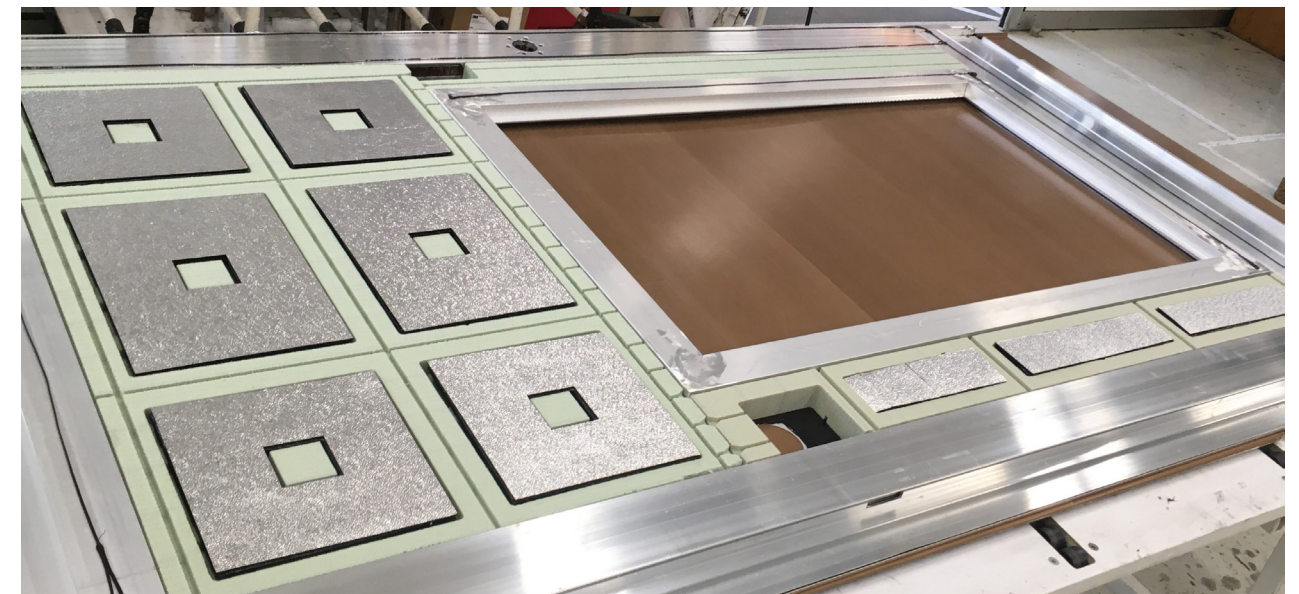
Mainly regional and commuter rolling stock markets worldwide; extended to tramways, and metros

#### EU-Rail Solution available for industrialisation:

Discrete solution ready for prototype testing, and integrated solution available in 2023

#### Market outlook:

Good perspectives for all trains segments



Copyright: Faiveley Transport Tours



## LIGHT STRUCTURES

### Solution 7: Composite Door Leaves

New door leaves designed for thermal insulation, weight reduction and cost by selecting the best composite materials, manufacturing process and architecture.

#### Targeted market:

Mainly regional and commuter rolling stock market worldwide and extended to tramways, metros and up to very high-speed trains market

#### EU-Rail Solution available for industrialisation:

Solution ready

#### Market outlook:

Good perspectives for all trains segments



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## LIGHT STRUCTURES

### Solution 8: New Door Functions Towards Autonomous Doors

The solution of adding new door functions will result in easing, helping passenger access and increasing safety while reducing other passenger and neighbourhood disturbances.

#### Targeted market:

Rolling stock market worldwide

#### EU-Rail Solution available for industrialisation:

Discrete solution ready for prototype testing, and integrated solution available in 2023

#### Market outlook:

Good perspectives for all types of trains except partially metros



Copyright: Faiveley



## LIGHT STRUCTURES

### Solution 9: Boarding Aid

This new accessibility solution will consist of a new generic bridging plate useable for all types of doors and could be integrated in an improved door sill in the case of sliding doors, delivering safer and easier passenger boarding and alighting by reducing accessibility barriers.

#### Targeted market:

Mainly European regional/commuter trains market

#### EU-Rail Solution available for industrialisation:

Solution ready for prototype testing in 2023

#### Market outlook:

Good perspectives for all types of trains



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## LIGHT STRUCTURES

### Solution 10: Lightweight Antenna Supporting Element

A new lightweight antenna supporting element will result in weight reduction of the bogie component while making assembly and maintenance work easier.

#### Targeted market:

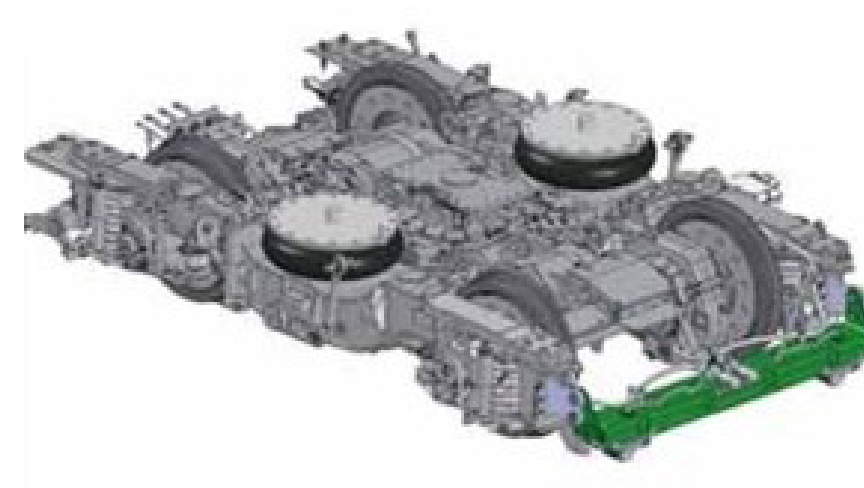
Mainly rail components manufacturer market

#### EU-Rail Solution available for industrialisation:

After 2023

#### Market outlook:

Good perspectives for metro and regional transport



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### BENEFITS

#### Potential benefits and market impact:

- Up to 12% energy savings due to weight reduction
- 10% capacity increase for the coaches in new layout configurations
- Cost efficiency due to simplification of manufacturing / assembly
- New services and solutions for rolling stock
- Significant increase of thermal insulation and acoustic attenuation
- Low specific weight and higher structural strength
- High corrosion and ageing resistance
- Ease of installation on working rolling stock

#### Customer benefiting from the solutions:

Operator, Infrastructure Manager and Supplier

### Solution 11: Lightweight Axle

A new lightweight axle which significantly reduces weight, unsuspended mass, time for wheelset maintenance, production cost while at the same time increases safety against cracks and break down.

#### Targeted market:

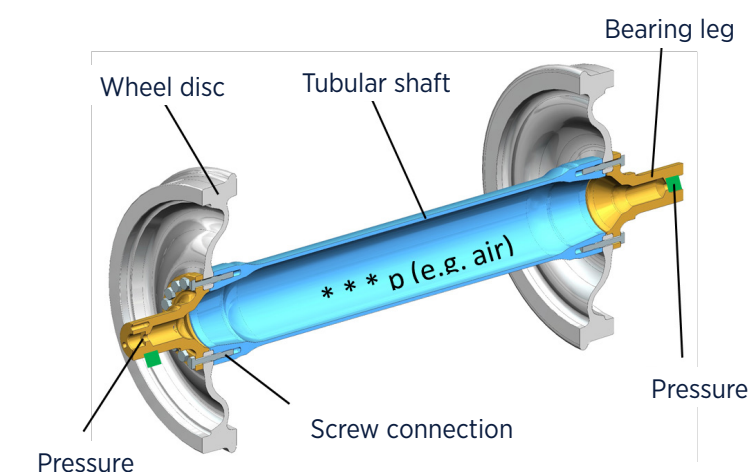
Freight market in test period and subsequently metro application Mainly rail components manufacturer market

#### EU-Rail Solution available for industrialisation:

Freight market in test period and subsequently metro application, available after 2023

#### Market outlook:

Good perspectives for all types of trains



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## LIGHT RUNNING GEAR

### Solution 12: Austempered Ductile Iron (ADI) spoke wheel

A new spoke wheel made of Austempered Ductile Iron that will contribute to the potential reduction of maintenance needs of railway vehicles and reduce wheel and infrastructure wear.

**Targeted market:**

Mainly metro wheelset with monoblock wheels market

**EU-Rail Solution available for industrialisation:**

Solution ready for prototype testing

**Market outlook:**

Good perspectives for metro and regional transport



Copyright: Siemens

## LIGHT RUNNING GEAR

### Solution 13: Light Running Gear Frame

New materials, processes and technologies in the current running gear frames, substituting welded steel plates and profiles by monocoque CFRP structures and machined high end alloys reaching up to 50% reduction in weight compared to conventional solutions.

**Targeted market:**

Mainly high-speed rail

**EU-Rail Solution available for industrialisation:**

Solution ready for prototype testing

**Market outlook:**

Good perspectives for high-speed transport



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## BENEFITS

### Potential benefits and market impact:

- Reduction of bogie maintenance by reduction of wheel and polygonization
- Reduction of infrastructure maintenance cost by reduction of unsuspended masses
- Possibility for load increase by reducing hardware masses
- Reduction of energy consumption and noise emission levels
- New costs efficient maintenance and inspection concepts
- Simplified modular assembly

### Customer benefiting from the solutions:

Operator, Infrastructure Manager and Supplier

## Solution 14: HMS for CBM

Development of Health Monitoring Systems to substitute preventive maintenance for Condition Based Maintenance (CBM) focused on both vehicle dynamic and track characteristics making use of hardware and software specifically developed for CBM applications.

#### Targeted market:

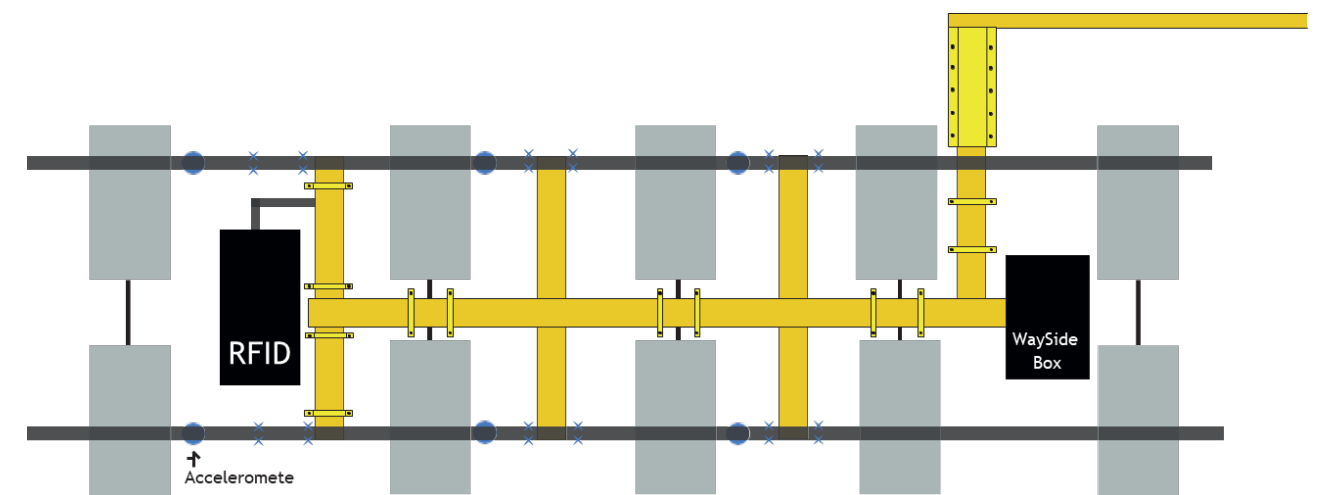
Various markets: mainly metro, also mainline applications

#### EU-Rail Solution available for industrialisation:

Solution ready for prototype testing

#### Market outlook:

Good perspectives for metro transport and others



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## CONDITION BASED MAINTENANCE

### BENEFITS

#### Potential benefits and market impact:

- 70 % to 90 % reduction of bogie maintenance cost with preventive maintenance
- Optimization of track maintenance procedures
- Reduction of unavailability derived from bogie failure
- Safety increase due to a continuous monitoring of critical elements (suspension, track, ...)
- Foster the generation of new services and solutions for vehicle maintenance

#### Customer benefiting from the solutions:

Operator and Infrastructure Manager

## BRAKING SYSTEM

### Solution 15: Electromechanical Brake System (EMB)

New generation of Electro Mechanic Brake devices that enables the transition towards the air-less trains, simplifying the train's architecture (brake-by-wire) and supports the removal/reduction of air compressor (weight and energy reduction).

#### Targeted market:

Passenger main line traffic using multiple units

#### EU-Rail Solution available for industrialisation:

First test campaign successfully completed early 2021. Expected to be ready for serial production in 2026

#### Market outlook:

Good perspectives for all types of passenger trains, linked with effective migration to air-less solution of other sub-systems (e.g. suspension, pantograph, MTB)



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BRAKING SYSTEM

Solution 16:  
Adhesion Management Solutions

New adhesion management solutions intended to solve low adhesion issues between wheel and rail and improve rail operation under severe conditions.

Targeted market:

Mainly rail vehicle manufacturer and system supplier market

EU-Rail Solution available for industrialisation:

Solution ready end of 2022

Market outlook:

Good perspective, especially combined with ATO under ETCS protection



Copyright: Knorr-Bremse

BRAKING SYSTEM

Solution 17:  
Adhesion Management Enhanced Solutions

The adaptive wheel slide protection and smart sander, ensures safety and performances in degraded condition and reduces LCC by eliminating wheel lock occurrences. New adhesion management solutions intended to solve low adhesion issues between wheel and rail and improve rail operation under severe conditions.

Targeted market:

All railway market segments, passenger and freight

EU-Rail Solution available for industrialisation:

Solution ready end 2022

Market outlook:

Good perspectives for metro and regional train transport



Wabtec demonstrator PIVOT2

Copyright: Faiveley



## BRAKING SYSTEM

### Solution 18: High-SIL Brake Control

The HSIL braking system conceived has implemented a full engineering process and demonstrations have been successfully run. It provides a safety qualification with a robust and reliable design and ready for a train installation.

#### Targeted market:

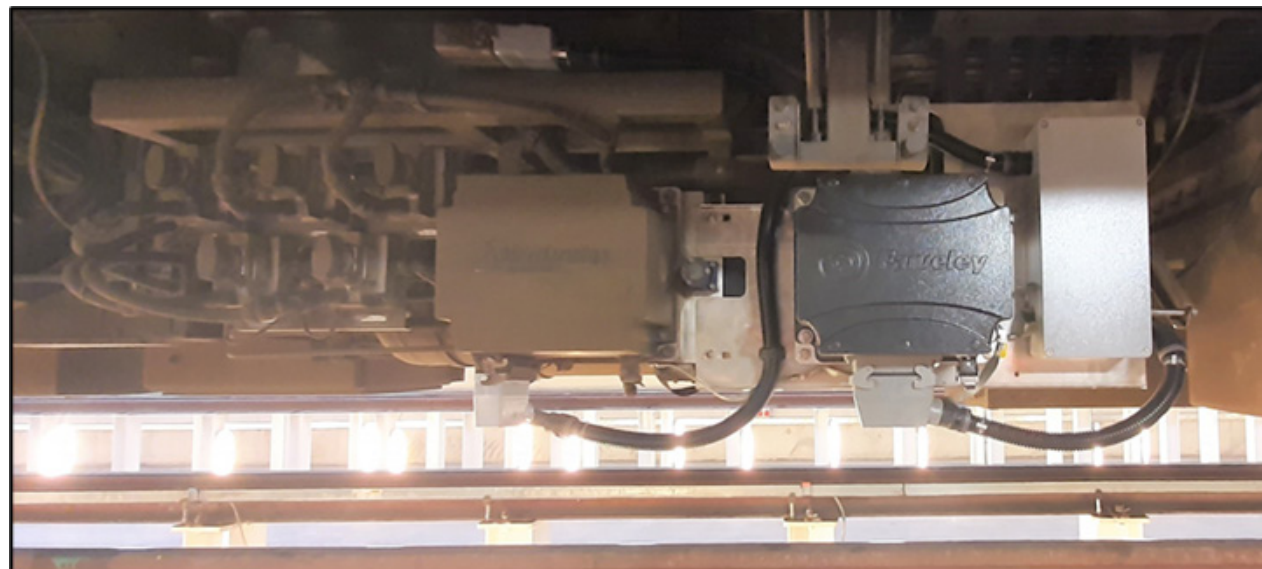
All railway market segments for passenger

#### EU-Rail Solution available for industrialisation:

Solution ready

#### Market outlook:

Good perspectives for both metro and regional services



Copyright: Faiveley

## BRAKING SYSTEM

### Solution 19: Innovative Friction Pair

The innovative friction pair has been conceived and developed with a strong focus on the environment. This new, eco-friendly system of brake disc and brake pad is able to significantly reduce brake emissions (dust reduction of up to 75% for PM10 and 2.1% LAeq in dB(A) for noise).

#### Targeted market:

Mainly rail vehicle manufacturer

#### EU-Rail Solution available for industrialisation:

Solution under prototype testing and expected to be ready in 2023

#### Market outlook:

Good perspectives for metro and regional train transport



Copyright: Faiveley



BRAKING SYSTEM

BENEFITS

Potential benefits and market impact:

- 25% brake performance increase and safety due to adaptive algorithm for accurate low adhesion situations and increased number of virtual tests
- Noise levels significantly reduced
- Life-Cycle Cost Reduction, due to:
  - reduction of capital cost of the adhesion system
  - abandoning air supply components
  - energy savings of up to 15% due to the virtual validation
  - use of ethernet
  - reduced number of on-track certification tests
- Capacity increase due to the improvement of the braking distance for future rail traffic

Customer benefiting from the solutions:

Operator, Infrastructure Manager and Supplier

INTERIORS

Solution 20:  
Passengers’ Room Adapted to Their Needs

Solutions for interiors intending to increase attractiveness to passengers and flexibility to operators by introducing new evolving interiors design making use of direct access of the fixing points and optimized shapes with the goal to reduce time and cost.

Targeted market:

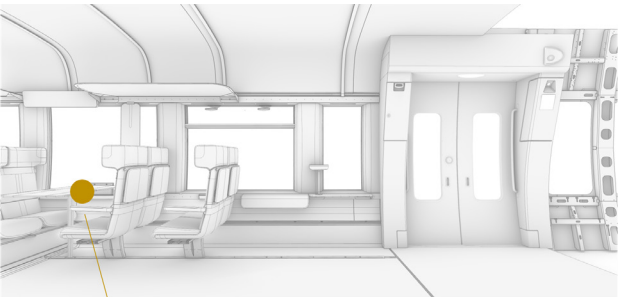
Rolling stock market worldwide including refurbishment

EU-Rail Solution available for industrialisation:

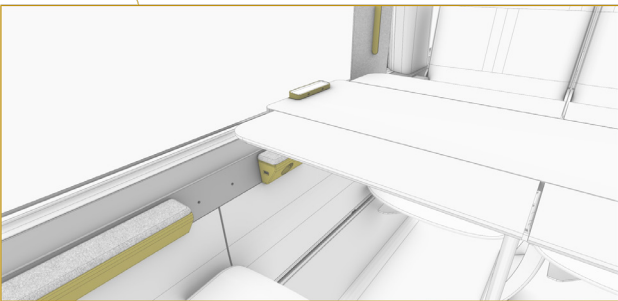
After 2022 for a complete interiors’ design

Market outlook:

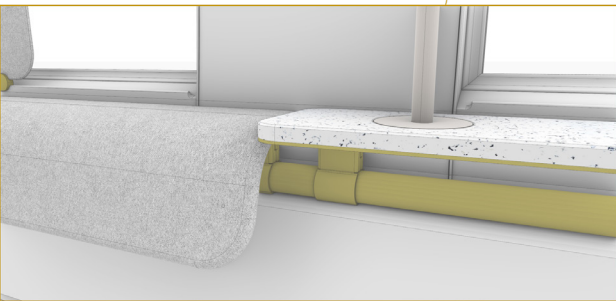
Good perspectives for urban, regional and high-speed trains for the interiors design or part of a vehicle



CONCEPT 1



CONCEPT 2



Copyright: SNCF Voyageurs

INTERIORS

Solution 21:  
Driver’s Cabin

The concepts will enable including new technologies and uses of the driver’s cabin to allow the design of Cabin & Driving 2030 which is considering partially autonomous trains in combination with interiors’ design and also include new Human Machine Interfaces.

Targeted market:

Rolling stock market worldwide and system suppliers

EU-Rail Solution available for industrialisation:

After 2025

Market outlook:

Long-term perspectives for new architecture of driver’s cabin



Copyright: SNCF Voyageurs

INTERIORS

BENEFITS

Potential benefits and market impact:

- Cost efficiency and Life-Cycle Cost decrease due to:
  - 50% time and cost consuming to renew the passengers room
  - digitalisation of driver’s desk, commands and refurbishment capability
  - new fixation systems for interiors’ changing set up
- Safety increased thanks to new technologies to assist the driver
- Attractiveness due to new HMI, services and capability to evolve the interiors
- Time to create a new interior design decreases due to the reduction of assembly time, quick assembly and disassembly
- Increase in the flexibility of operation due to the new capacity offer to test and deploy new configurations for commercial operation in an easier way

Customer benefiting from the solutions:

Final user, operator and supplier

## ECO-FRIENDLY HVAC

### Solution 22: Eco-Friendly Air Conditioning with Natural Refrigerant

Ecologically friendly air conditioning system with natural refrigerant (CO<sub>2</sub>) for new rolling stock or refurbishing of existing trains with a reduced energy consumption due to implementation of a heat pump.

#### Targeted market:

Rolling stock market worldwide (single deck and double deck)

#### EU-Rail Solution available for industrialisation:

Before 2024

#### Market outlook:

Good perspectives, applicable for all passenger train segments



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## ECO-FRIENDLY HVAC

### BENEFITS

#### Potential benefits and market impact:

- Energy savings up to 20% due to integrated heat pump
- Reduction of global warming due to avoidance of synthetic refrigerants like R134a
- Overcome the limitation of synthetic refrigerants

#### Customer benefiting from the solutions:

Final user, operator and supplier



# IP2

## Traffic Management:

### Advanced Traffic Management and Control Systems' Solutions

#### ERTMS NEXT GEN

**Solution 23:** Automatic Train Operation (up to GoA4)

**Solution 24:** Moving Block

**Solution 25:** Fail-Safe Train Positioning

**Solution 26:** Adaptable Communication 22 System

**Solution 27:** Integrated Mobility Management (I2M/TMS)

**Solution 28:** Onboard Train Integrity



#### ERTMS NEXT GEN

### Solution 23: Automatic Train Operation (up to GoA4)

The standard solution that EU-Rail is developing for mainline applications in different Grades of Automation guarantees the interoperability and interchangeability of the subsystems (trackside and on-board) delivered by different suppliers.

#### Targeted market:

Mainly technology providers market worldwide

#### EU-Rail Solution available for industrialisation:

ATO GoA2: solution ready

ATO GoA3/4: ready for prototype testing from 2023

#### Market outlook:

Good perspectives for all types of trains (mainline/high speed, urban/suburban, regional and freight lines)



Copyright: Europe's Rail Joint Undertaking

# Solution 24: Moving Block

The Moving block solution aims to increase the line capacity through decoupling the signalling from physical infrastructure and decreasing the constraints imposed by trackside train detection resulting in the increase of transit of trains.

**Targeted market:**

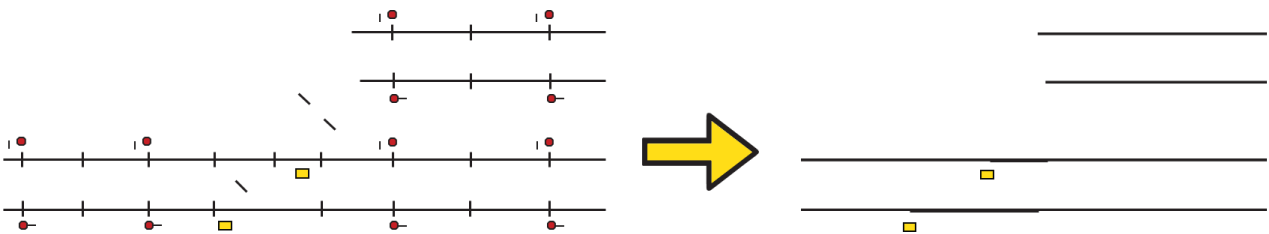
Mainly technology providers market worldwide

**EU-Rail Solution available for industrialisation:**

Solution ready for prototype testing in 2023

**Market outlook:**

Good perspectives for all types of trains (mainline/high speed, urban/suburban, regional and freight lines)



Copyright: Europe's Rail Joint Undertaking

# Solution 25: Fail-Safe Train Positioning

The Fail-Safe Train Positioning (including satellite technology) is aimed to become an absolute positioning system, by applying GNSS technology to the ERTMS/ETCS core and by using new technologies (e.g. inertial measurement units) or other on-board existing sensors (e.g. accelerometers, odometer sensors).

The Fail-Safe Train Positioning aims to boost the quality of train localization and integrity information, while also reducing overall costs, in particular by enabling a significant reduction in track- side conventional train detection systems (e.g. track circuits, axle counters) and physical balises.

**Targeted market:**

Mainly technology providers market worldwide

**EU-Rail Solution available for industrialisation:**

Solution ready for prototype testing in 2023

**Market outlook:**

Good perspectives for all types of trains (mainline/high speed, urban/suburban, regional and freight lines)



Copyright: Europe's Rail Joint Undertaking

Solution 26:  
Adaptable Communication 22 System

This adaptable communication system will be able to decouple the applications from the underlying radio access networks and provide generic communication services based on bearer flexibility with defined Quality of Service (QoS) leveraging multiple access technologies (LTE, 5G, SatCom, WiFi, ...).

Targeted market:

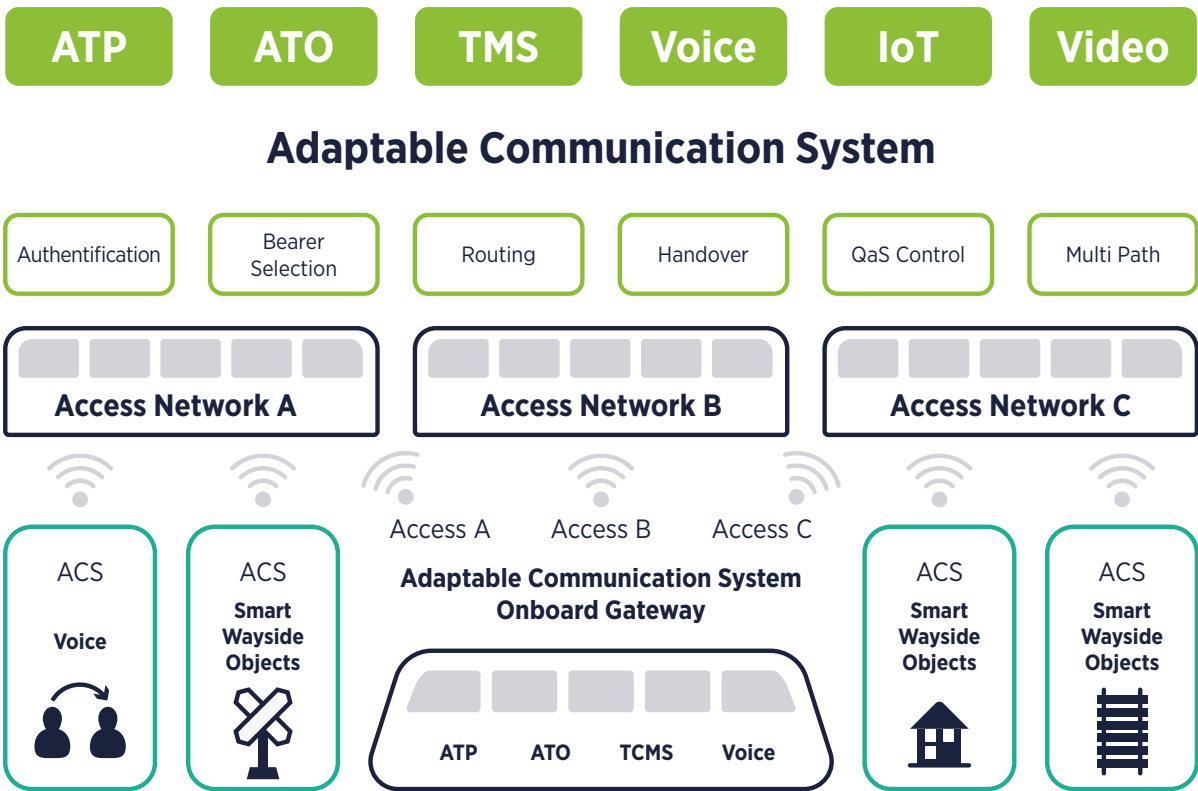
Mainly rolling stock and technology providers market

EU-Rail Solution available for industrialisation:

Solution ready by 2024, paving the way for the introduction of possible future 5G telecoms solutions

Market outlook:

Good perspectives for all types of trains (mainline, urban and freight)



Copyright: Europe's Rail Joint Undertaking

Solution 27:  
Integrated Mobility Management (I2M/TMS)

The Integrated Mobility Management solution combined with the solution arising from Traffic Management work stream aims at integrating the data exchange between all rail business services into one communication platform, the Integration Layer.

Targeted market:

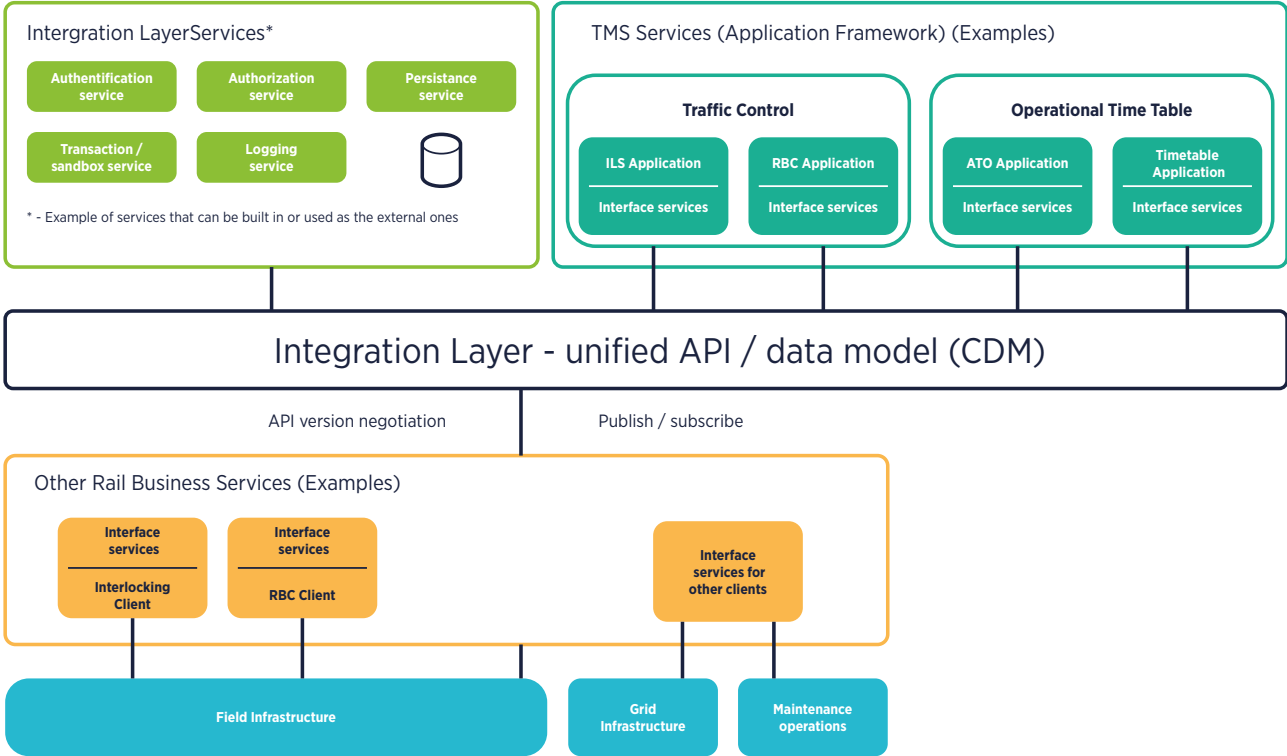
Mainly railway operating companies and technology suppliers' market

EU-Rail Solution available for industrialisation:

Solution ready for prototype testing in 2023

Market outlook:

Good perspectives for all market segment



Copyright: Europe's Rail Joint Undertaking



# Solution 28: Onboard Train Integrity

- The solution aims at achieving the safe On-board Train Integrity to allow the application of new signalling train separation concepts (e.g. Moving Block or Virtual Block). Systems based on these concepts deliver very significant advantages in terms of capacity, shorter headways; capital and maintenance cost and removal of track infrastructure for block detection etc.
- The solution is composed of an OTI Master module located in front cabin, an OTI Slave module located at train tail and an on-board communication network. It has the following functionality: train composition, head-tail communication, power supply, train tail status and availability of ETCS at train tail.
- Three OTI product classes have been defined with modular approach respect to costs and functionalities. Class 1 addresses trains with a wired communication network; Class 2 is defined for trains with wireless communication network; Class 3 determines also the safe train length and requires OTI module installed in each wagon.

**Targeted market:**

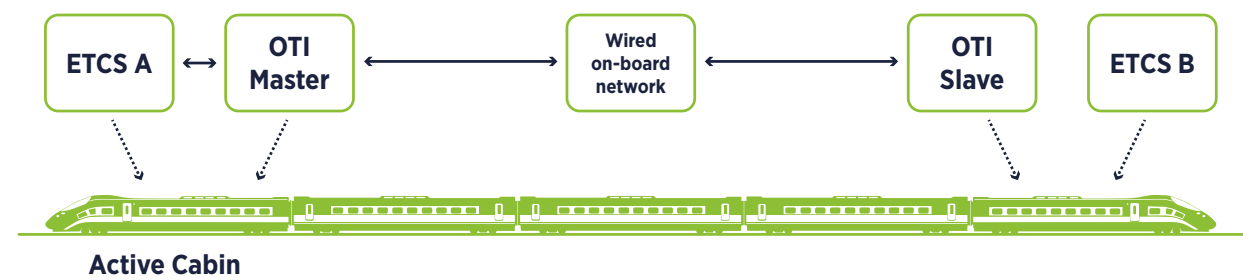
Mainly railway operation companies and technology providers' market

**EU-Rail Solution available for industrialisation:**

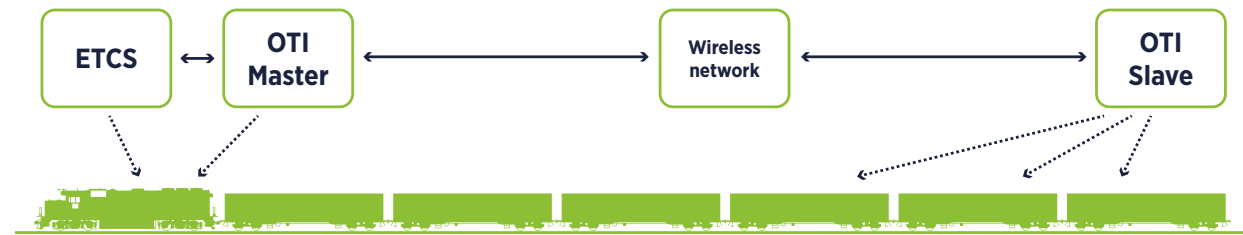
Solution ready for prototype testing in 2023

**Market outlook:**

Good perspective for all application domains (mainline/high speed, urban/suburban, regional and freight lines)



Example for Product Class 1 (Wired on-board communication and OTI devices installed in each cabin)



Example for Product Class 3 (Wireless on-board communication and OTI devices installed in all waggons)

# BENEFITS

## Potential benefits and market impact:

- Accelerated industrialisation thanks to specification already in TSI 2022 for some solutions
- 50% better punctuality and less variability due to ATO in all GoA,
- Increased operations and capacity on existing tracks
- Energy savings of up to 45% through optimised speed profiles
- Enhanced Productivity due to driverless and unattended operations
- New and dynamic control of train management
- Decoupling applications from the radio access networks in order to lower integration costs and avoid making independent upgrades
- Improved coverage as well as enabled cost efficient access alternatives
- New services and solutions for signalling systems
- Increase of operational reliability
- Better forecasting of traffic and reduce delays
- Increase of the efficiency of Passenger and Rail Freight Operations
- New services and solutions for mobility management and smart planning

## Customer benefiting from the solutions:

Final user, operator, infrastructure manager and supplier

# IP3

## Optimised Infrastructure:

### Intelligent Asset Management & High-Capacity Infrastructure

#### LONG PERFORMING STRUCTURES

**Solution 29:** Low-Cost High-Speed Bridges

**Solution 30:** Long Performing Structures

#### TRACK SYSTEM

**Solution 31:** Enhanced Switches and Crossings

**Solution 32:** High Performance Wheel-Rail Interaction

**Solution 33:** Moulded Multi-Modular Block (3MB) System

#### MAINTENANCE

**Solution 34:** Data for Track Circuit Maintenance

**Solution 35:** Data & Positioning: Lean Tamping

**Solution 36:** Automation: Robot platform

**Solution 37:** Integrated Measuring System

**Solution 38:** Decision Making Planning

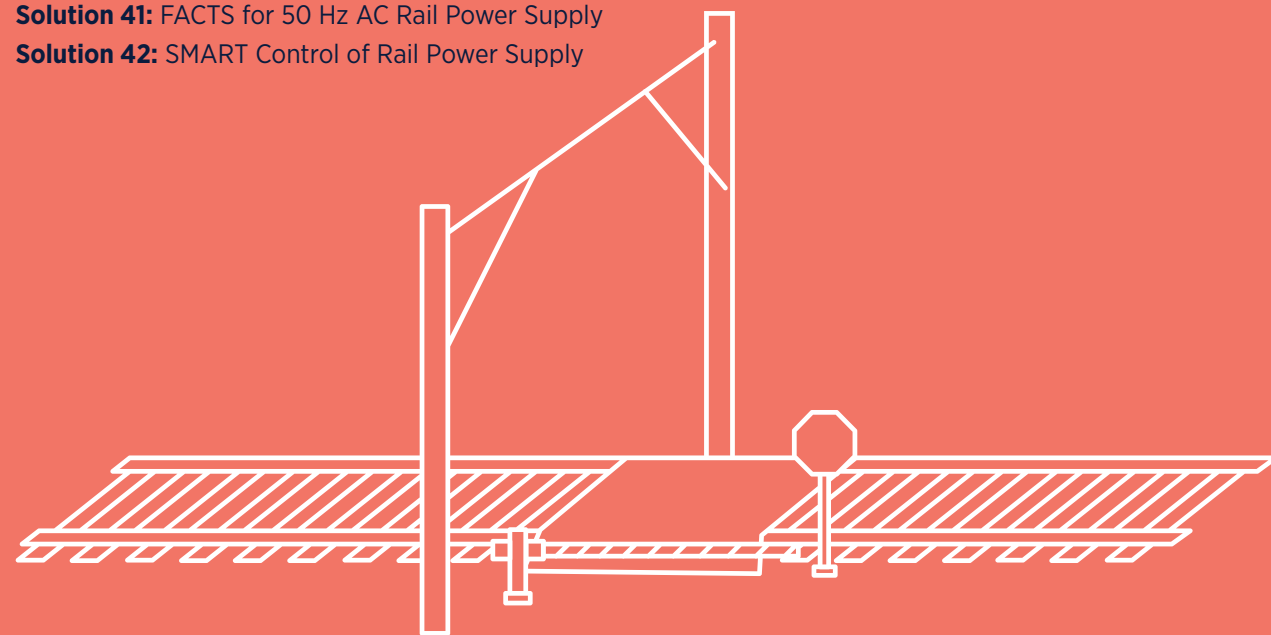
**Solution 39:** Modular Multitasking Powered Exoskeleton (MMPE) for Rail Workers

#### ENERGY

**Solution 40:** Smart Energy Metering

**Solution 41:** FACTS for 50 Hz AC Rail Power Supply

**Solution 42:** SMART Control of Rail Power Supply



#### LONG PERFORMING STRUCTURES

### Solution 29: Low-Cost High-Speed Bridges

Low-cost high-speed bridges solution will improve the understanding of bridge-train dynamic interactions and how damping will allow to reduce unnecessary expensive special solutions for bridges. Bridges will be possible to design and construct with fewer restrictions, allowing for geometries tailored for surroundings, less material usage i.e. more environmental friendly and significantly reduced costs. Solutions will also give a more uniform safety removing uncertainties.

#### Targeted market:

Solution applicable for new lines and upgrade of existing lines. Mainly technology providers market worldwide

#### EU-Rail Solution available for industrialisation:

Solution expected to be ready before 2024

#### Market outlook:

Good perspectives for infrastructure managers that own bridges



Copyright: Trafikverket

## LONG PERFORMING STRUCTURES

### Solution 30: Long Performing Structures

This long-performing structures solution aims at increasing the longevity of infrastructure projects before becoming critical and has effective improvement solutions so that structures can be restored without disturbing traffic through regulating speed and structure availability. Structures time of service is extended leading to cost and environmental savings with ensured safety.

#### Targeted market:

Mainly technology providers market worldwide. Solutions mainly intended for existing structures on existing lines

#### EU-Rail Solution available for industrialisation:

Several parts of the solution are ready

#### Market outlook:

Good perspectives for infrastructure managers that own bridges



Copyright: Trafikverket

## LONG PERFORMING STRUCTURES

### BENEFITS

#### Potential benefits and market impact:

- Capacity increase and reduced structure unavailability leading to higher punctuality
- New bridges to be built making use of this solution may end up lowering the cost up to 25% + Cost efficient solution as replacement of structure is delayed
- Safety increase due to uniform treatment of safety
- Energy savings of up to 25% from bridges energy consumption due to less material usage and of at least 10 % due to prolonged usage of already existing structures

#### Customer benefiting from the solutions:

Infrastructure manager and supplier



TRACK SYSTEM

Solution 31:  
Enhanced Switches and Crossings

- This solution will result in developing an enhanced switches and crossings (S&C) system that will improve the operational performance of existing designs through the delivery of new sub-systems with sensing and monitoring capabilities and self- adjustment.
- Virtual simulation of dynamic behaviour of a S&C and the deterioration of its components resulting from vehicle interaction. It will support the development towards virtual authorisation.

Targeted market:

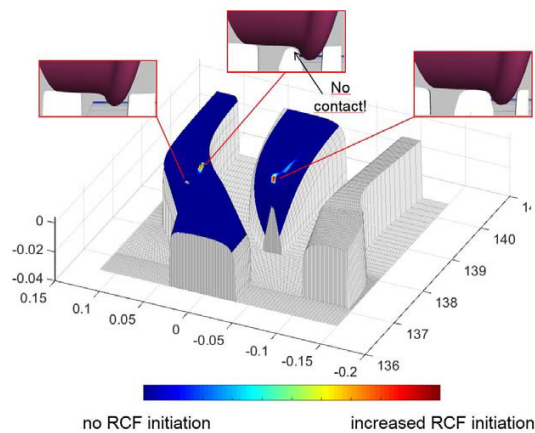
Mainly system suppliers market

EU-Rail Solution available for industrialisation:

Solution expected to be ready before 2024

Market outlook:

Good perspectives for infrastructure managers



Copyright: Europe’s Rail Joint Undertaking



TRACK SYSTEM

Solution 32:  
High Performance Wheel-Rail Interaction

- This solution aims at providing a mechanical/structural improvement of existing rail and wheels interaction performance.
- System simulations aim at providing an innovative way for testing new solutions for track and wheels.

Targeted market:

Mainly wheel set manufacturer and system suppliers market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2025

Market outlook:

Good perspectives for freight and passengers train suppliers, Wheelset manufacturers, and infrastructure managers



Copyright: Adobe Stock

TRACK SYSTEM

Solution 33:  
Moulded Multi-Modular Block (3MB) System

The 3MB system is based on the concept of multiple-level modularity and strives to achieve fast and easy maintainability through the use of easily replaceable, precast components. The solution consists of prefabricated concrete slabs in which, in each of them eight prefabricated blocks are housed that are coupled in a horizontal direction. They are combined with a elastomeric strips provide vibration attenuation and prevent the hammering between base slab and blocks and a steel pin system that restrain the blocks horizontally while allowing the free vertical movement that the elastomeric strip requires for dissipating vibrations.

Targeted market:

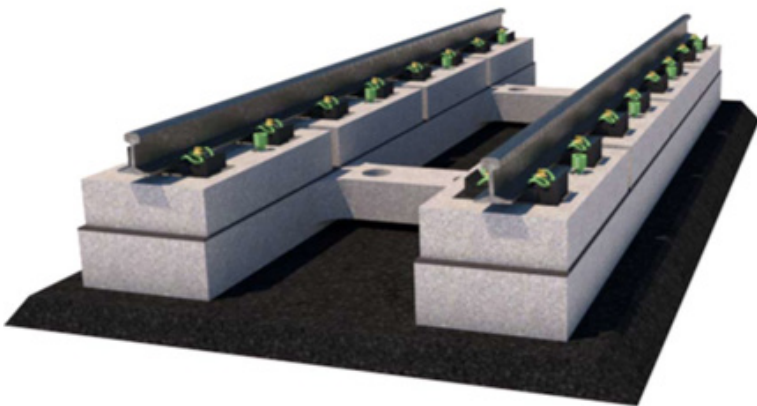
Mainly system suppliers market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2023

Market outlook:

Good perspectives for infrastructure managers



Copyright: ACCIONA

HIGH PERFORMANCE WHEEL-RAIL INTERACTION

BENEFITS

Potential benefits and market impact:

- Enhancement of capacity and punctuality for infrastructure and operations
- Life cycle-costs decrease of the wheel/rail system
- Reduced levels of noise and vibration
- Improvement on the loading capacity for rolling stock
- Better comfort level for passengers
- Maintenance reduction based on condition-based maintenance of railway assets and continuous improvement of components and maintenance schedules
- Improved possibilities for (remote) monitoring of the system and capabilities

Customer benefiting from the solutions:

Operator, infrastructure manager and supplier

MAINTENANCE

Solution 34:  
Data for Track Circuit Maintenance

Innovative solution for Track Circuits maintenance. This market solution consists of a big data platform, which provides the current status, anomaly detection and predictive analysis of the Track Circuits assets. It will lead to better support for maintenance action plans.

Targeted market:

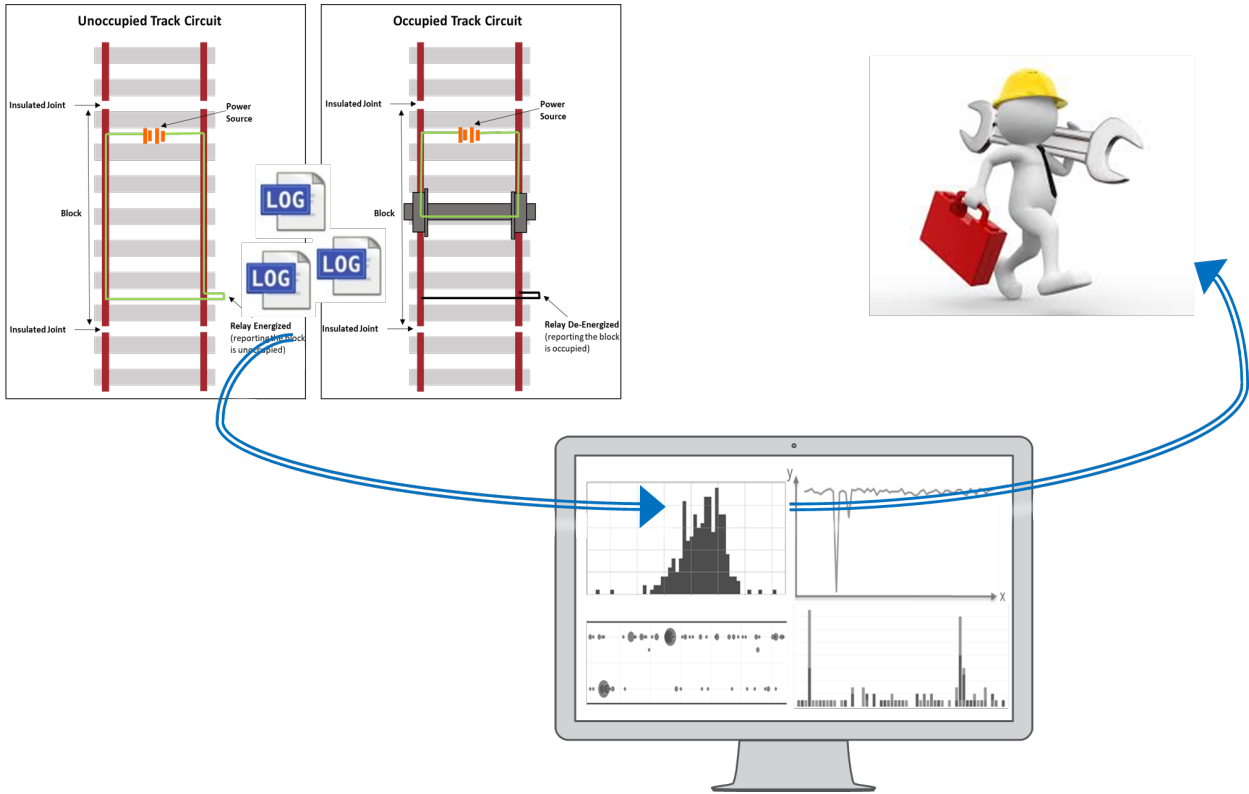
All markets (mainline, urban, regional) infrastructure

EU-Rail Solution available for industrialisation:

Solution expected to be ready before 2024

Market outlook:

Infrastructure managers, and entities in charge of maintenance



Coyright: Hitachi Rail STS

MAINTENANCE

Solution 35:  
Data & Positioning: Lean Tamping

The lean tamping process eliminates the step of pre-measurements between the track measurement and the tamping.

Targeted market:

Mainly system suppliers market

EU-Rail Solution available for industrialisation:

Solution ready

Market outlook:

Good perspectives for infrastructure managers, industrial heavy haul network operators



Copyright: Deutsche Bahn & Siemens



MAINTENANCE

Solution 36:  
Automation: Robot platform

This solution in combination of the ones presented for lean tamping and decision-making planning. It will result in automatised operations for maintenance tasks and will significantly reduce manual and arduous work on-site.

Targeted market:

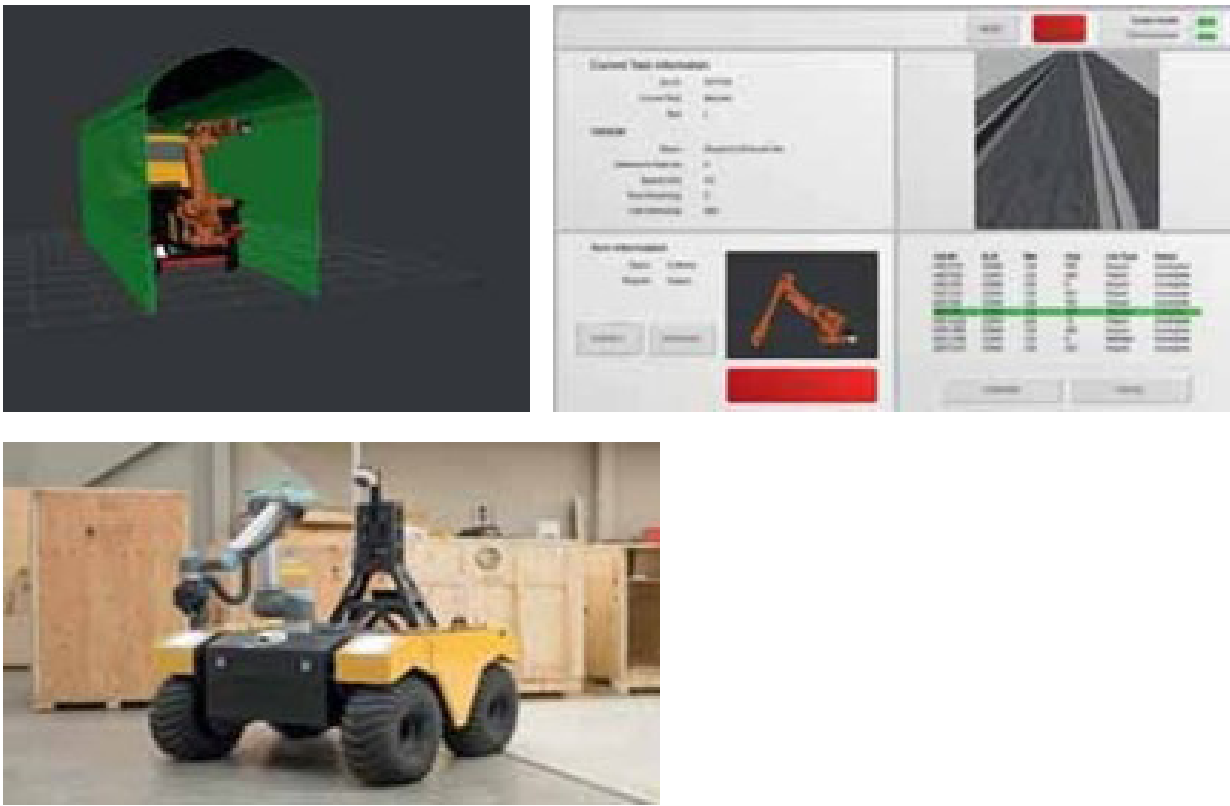
Mainly system and technology suppliers market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2024

Market outlook:

Good perspectives for system and technology suppliers, infrastructure managers, and entities in charge of maintenance



Copyright: Network Rail

MAINTENANCE

Solution 37:  
Integrated Measuring System

The integrated measuring system will contribute to decreased service disruptions and lower maintenance costs through continuous non-intrusive monitoring of rail thermal stress by incorporating this system on in-service trains. Data can be used to minimize risks/failures induced by thermal stress.

Targeted market:

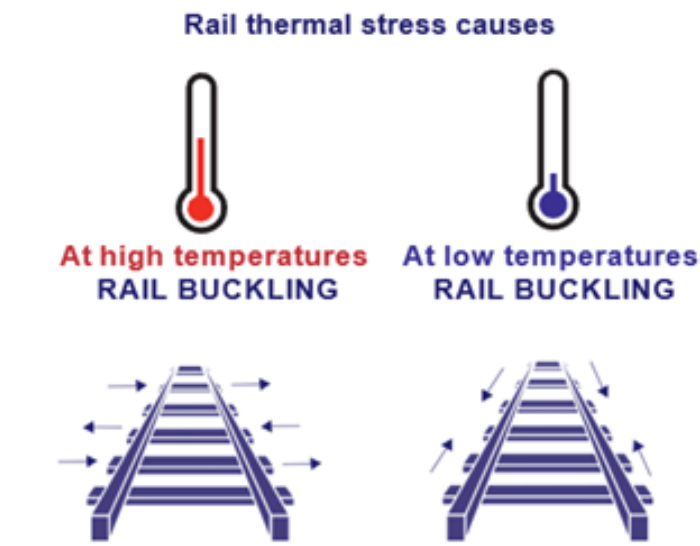
Mainly system and technology suppliers market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2026

Market outlook:

Good perspectives for infrastructure managers



Copyright: Europe's Rail Joint Undertaking

MAINTENANCE

Solution 38:  
Decision Making Planning

The decision-making process proposed has been improved by developing a general framework that structures the planning process at all levels of planning. This framework has been successfully applied to model and implement specific planning tools that cover all planning levels. These allow, for example, a more efficient utilization of resources, a reduction of working time and repetitive work, and the estimation of long-term impacts of investments.

Targeted market:

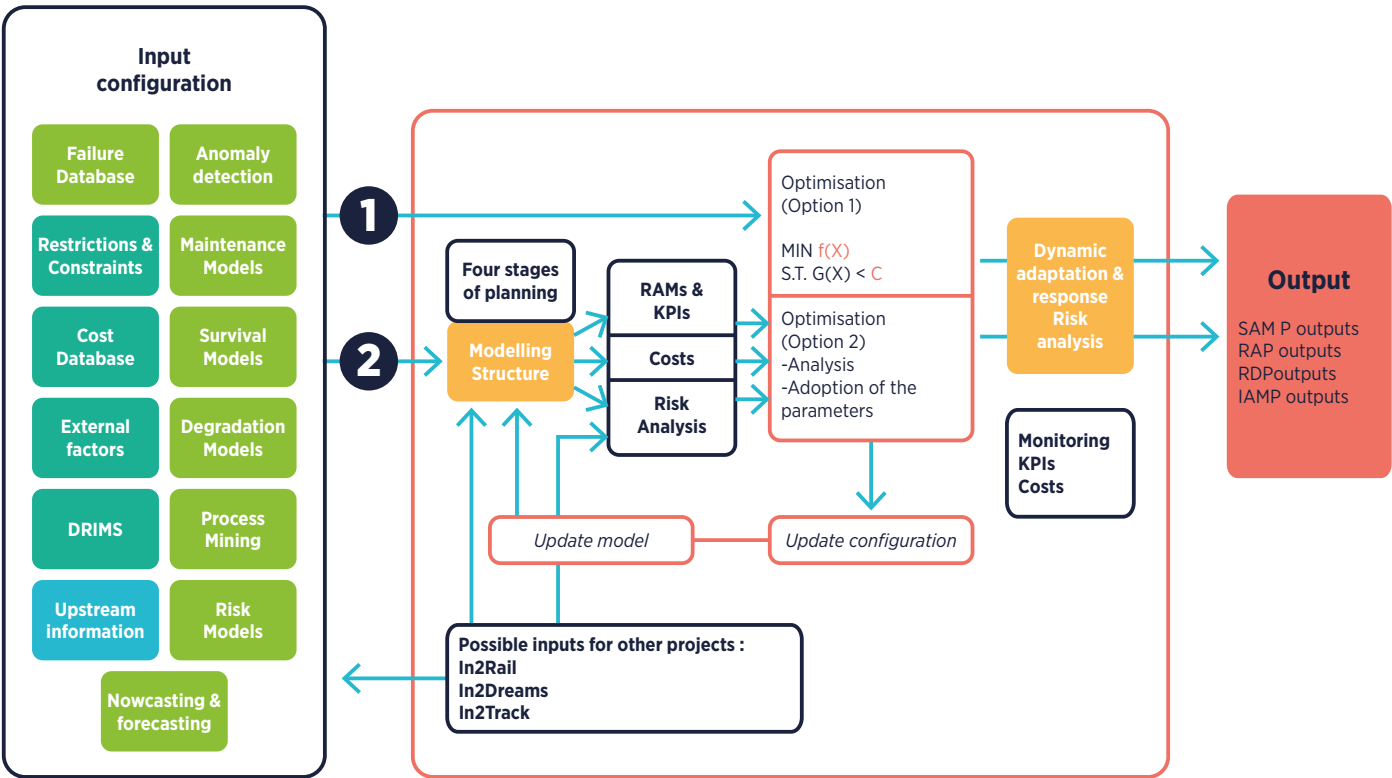
Mainly technology suppliers market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2026

Market outlook:

Railway undertakings, infrastructure managers and service providers



Copyright: Europe's Rail Joint Undertaking

MAINTENANCE

Solution 39:  
Modular Multitasking Powered Exoskeleton (MMPE) for Rail Workers

The exoskeleton will be able to assist in multiple different tasks and operations by detecting the user activity in real-time and helping workers reduce the experienced load. The MMPE will reduce musculoskeletal loading by up to 50% during manual handling tasks (e.g. holding, lifting, pulling, pushing, and carrying). The device will be usable in unstructured working environments and with unstructured methodologies.

Targeted market:

Mainly entities in charge of maintenance and infrastructure managers

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2023

Market outlook:

Good perspectives for infrastructure managers



Copyright: Stream Project

MAINTENANCE

BENEFITS

Potential benefits and market impact:

- Foster the generation of new services and solutions for an Intelligent Asset Management System
- Reduction of manual and arduous work to a minimum by also decreasing the ergonomic risk
- Fosters a culture of safety enhancement, preventing propagation of more physical severe causes
- Enhancement of sustainable employability and reduction of work-related physical barriers
- Accuracy of data and better traceability of works carried out
- Eases asset management tasks and planning
- Increases safety and reduces cost (up to 35%) by also improving quality
- Minimum service disruptions (reduction by 50 to 70%)
- Life cycle costs reduction based on condition-based maintenance of railway assets and continuous improvement of components/ maintenance schedules.
- Increase of punctuality based on targeted maintenance interventions and fewer interventions due to sudden failures
- Higher availability of track and lower maintenance costs up to 20% in the long run

Customer benefiting from the solutions:

Final user, operator, infrastructure manager and supplier

ENERGY

Solution 40:  
Smart Energy Metering

This innovative solution for railway system energy measurements both on-board trains and on the electrical infrastructure will support in decision-making process and lead to energy consumption reduction and other cost-efficient actions.

Targeted market:

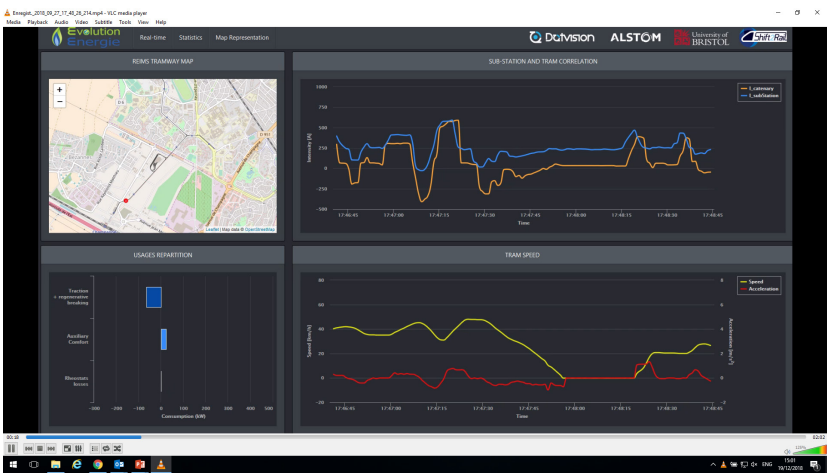
Mainly system and technology suppliers market

EU-Rail Solution available for industrialisation:

Solution ready

Market outlook:

Railway undertakings, infrastructure managers and transport authorities



Copyright: Europe's Rail Joint Undertaking



ENERGY

Solution 41:  
Automation: Robot platform

Modern power electronic assets (FACTS) enable innovative feeding concepts for 50 Hz railway power supply systems. Installed at the connection between the public power supply grid and the electrical traction system as well as operating along the track. This innovative solution for railway system energy measurements both on-board trains and on the electrical infrastructure will support in decision-making process and lead to energy consumption reduction and other cost-efficient actions.

Targeted market:

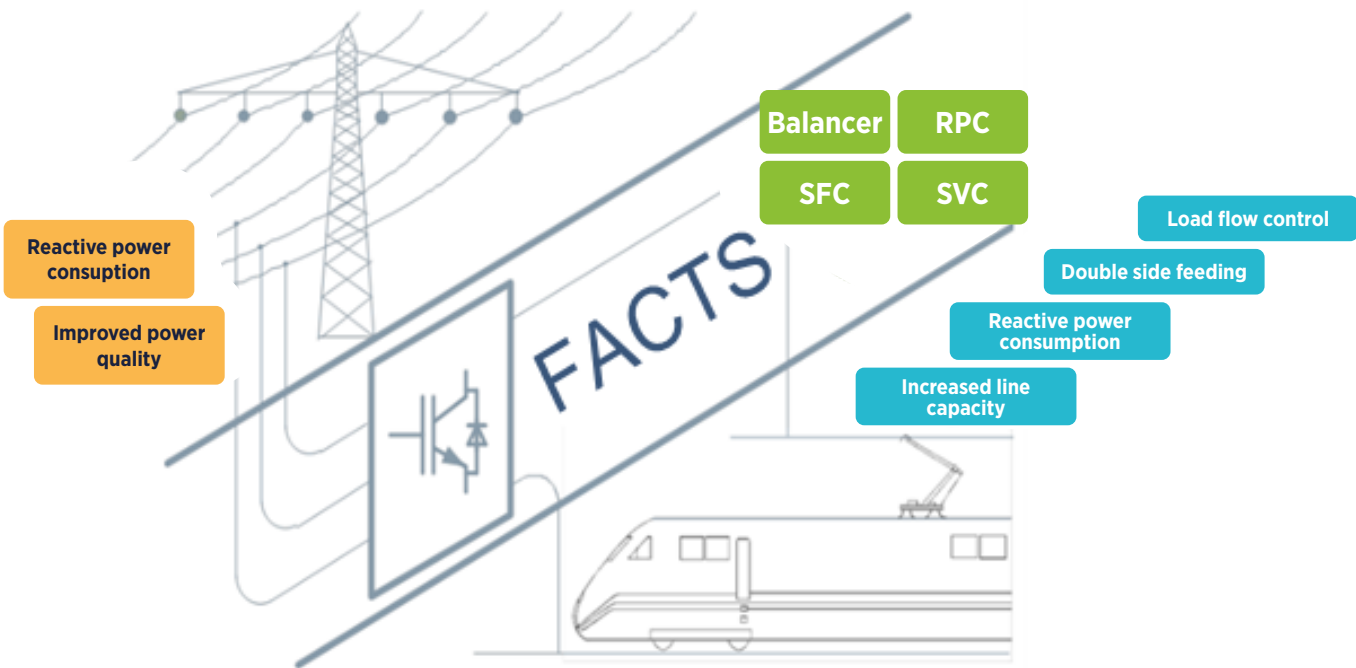
Mainly system and technology suppliers market

EU-Rail Solution available for industrialisation:

Solution ready

Market outlook:

Railway undertakings, infrastructure managers and suppliers



Copyright: Europe's Rail Joint Undertaking

ENERGY

Solution 42:  
SMART Control of Rail Power Supply

Process bus communication raises station control systems to a new level. The process bus transmits sampled values (SV: current and voltage), measured and digitized by merging units to the protection device. Leading to new control and protection functions.

Targeted market:

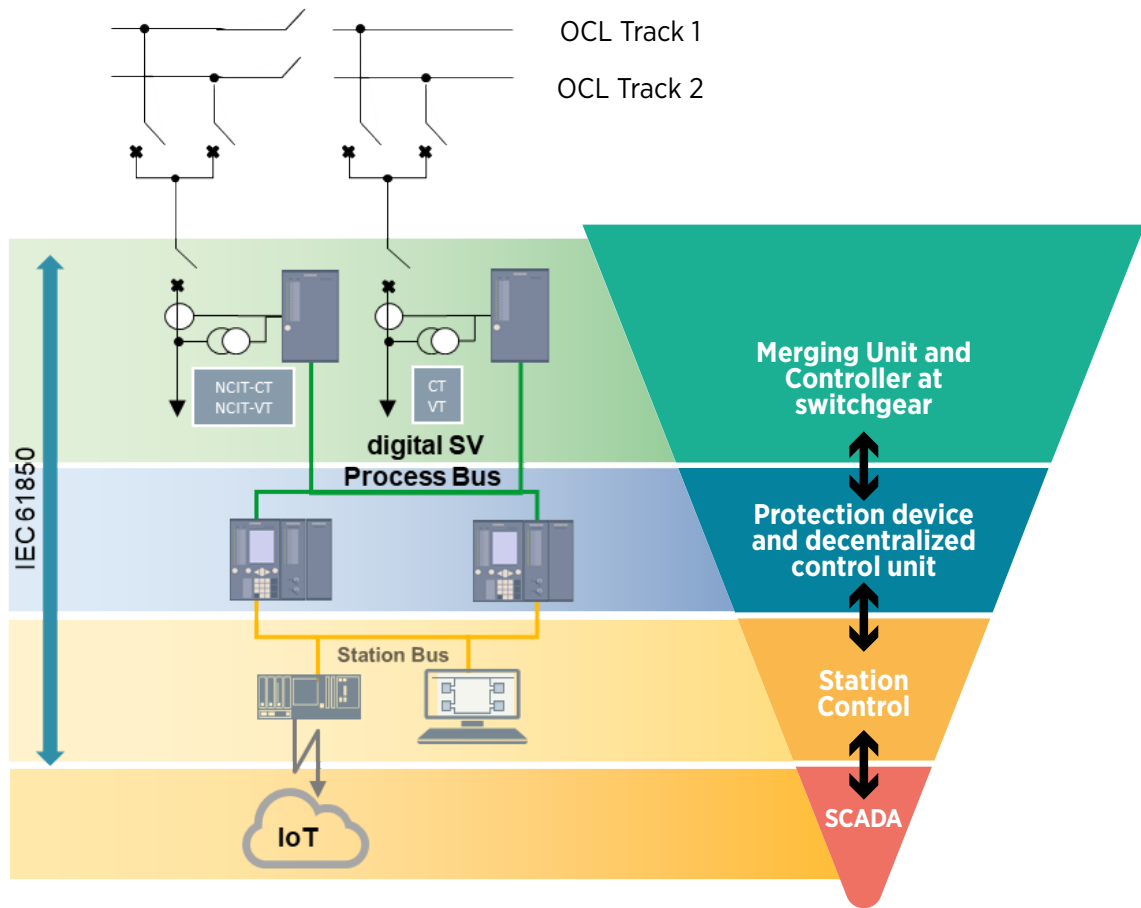
Mainly system and technology suppliers market

EU-Rail Solution available for industrialisation:

Solution ready

Market outlook:

Infrastructure managers and suppliers



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## ENERGY

## BENEFITS

### Potential benefits and market impact:

- Considerable improvement of the railway system's energy efficiency
- Help decision making process on operational issues
- Eases asset management tasks
- Contribution to better plan investments and evaluation of the railway system's energy efficiency
- Helps taking operational decisions based on real data
- Improves railway system's life cycle costs
- Shares information with travelers and promotes good practices for energy efficiency
- Improve power quality
- Reduce peak-loads
- Increased asset monitoring and remote control
- Increase the line traffic capacity and feeding section length

### Customer benefiting from the solutions:

Operator and infrastructure manager

# IP4

## Digital services

Towards “mobility as a service” engineered by railway

### MULTIMODAL ECOSYSTEM

**Solution 43:** “One Stop Shop”

### TRAVEL EXPERIENCE

**Solution 44:** Travel Companion

### TRAVEL PROVIDER TOOLS

**Solution 45:** Interoperability Framework for TSPs

**Solution 46:** Contractual Management Market Place

**Solution 47:** Business Analytics for Transportation

**Solution 48:** Crowd Management

**Solution 49:** SaaS Solution





MULTIMODAL ECOSYSTEM

Solution 43:  
“One Stop Shop”

The seamless multimodal travel experience solution will create an eco-system which allows one-stop-shops for pan-European door- to-door itineraries including multimodal travel planning, booking, ticketing and payment, trip tracking and additional services.

Targeted market:

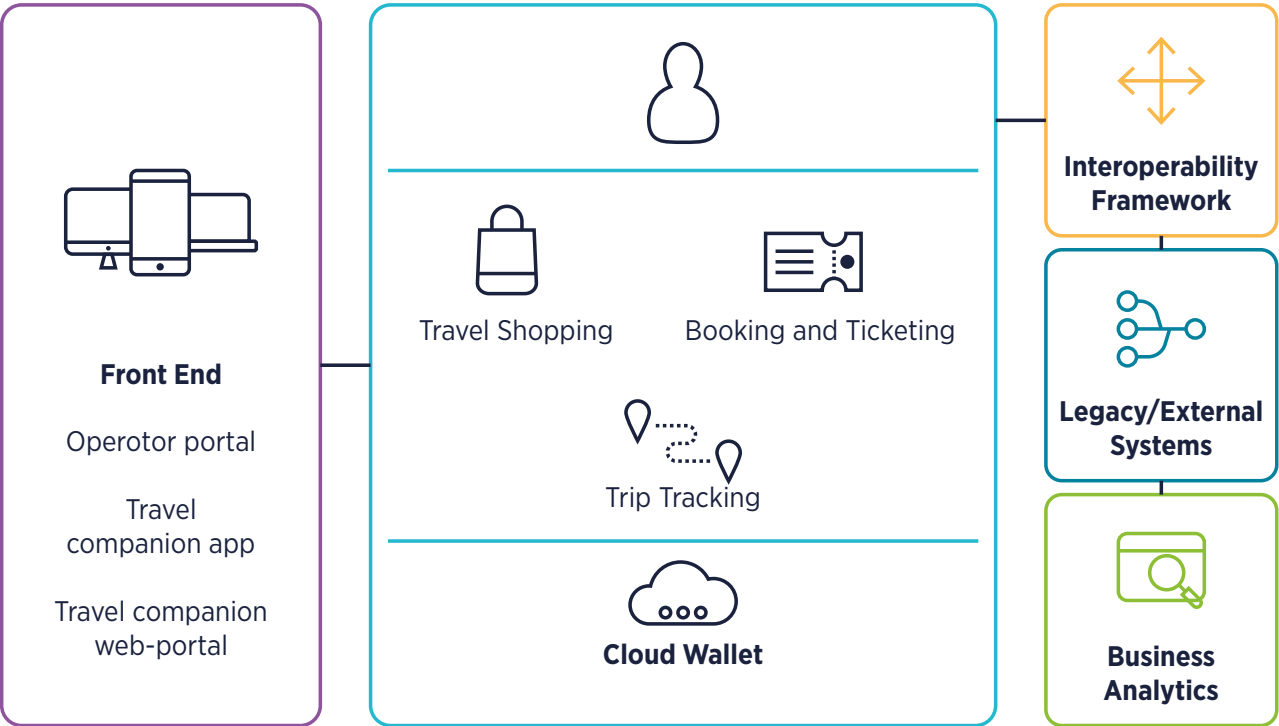
Mainly system and technology suppliers market

EU-Rail Solution available for industrialisation:

Solution expected to be ready in 2023

Market outlook:

Good perspectives for travel service operators, infrastructure managers and railway undertakings



Copyright: Europe’s Rail Joint Undertaking

MULTIMODAL ECOSYSTEM

BENEFITS

Potential benefits and market impact:

- Allows the user to search for the best itineraries and offers fulfilling their mobility needs
- Provides best routes to travellers taking into account their special needs and preferences
- Includes booking, payment, issue and validation functionalities and additional services such as after-sales and passenger rights
- Allows different validation and defines guidelines for setting business-to-business contracts and agreements
- Keeps the traveller informed through the whole journey
- Provides alternative routes whenever a disruption may happen
- Takes additional information like prognosis data into consideration

Customer benefiting from the solutions:

Final user, operator and supplier

TRAVEL EXPERIENCE

Solution 44:  
Travel Companion

The travel companion personal application will provide the travelers with an access to European door-to-door multimodal transport services through a unique user interface. It will enable the user to access information related to travel services and real time information.

Targeted market:

Mainly system and technology suppliers market and travel service providers

EU-Rail Solution available for industrialisation:

Solution expected to be ready in 2023

Market outlook:

Good perspectives for travel service operators of every mode of transport and mobility services

TRAVEL EXPERIENCE

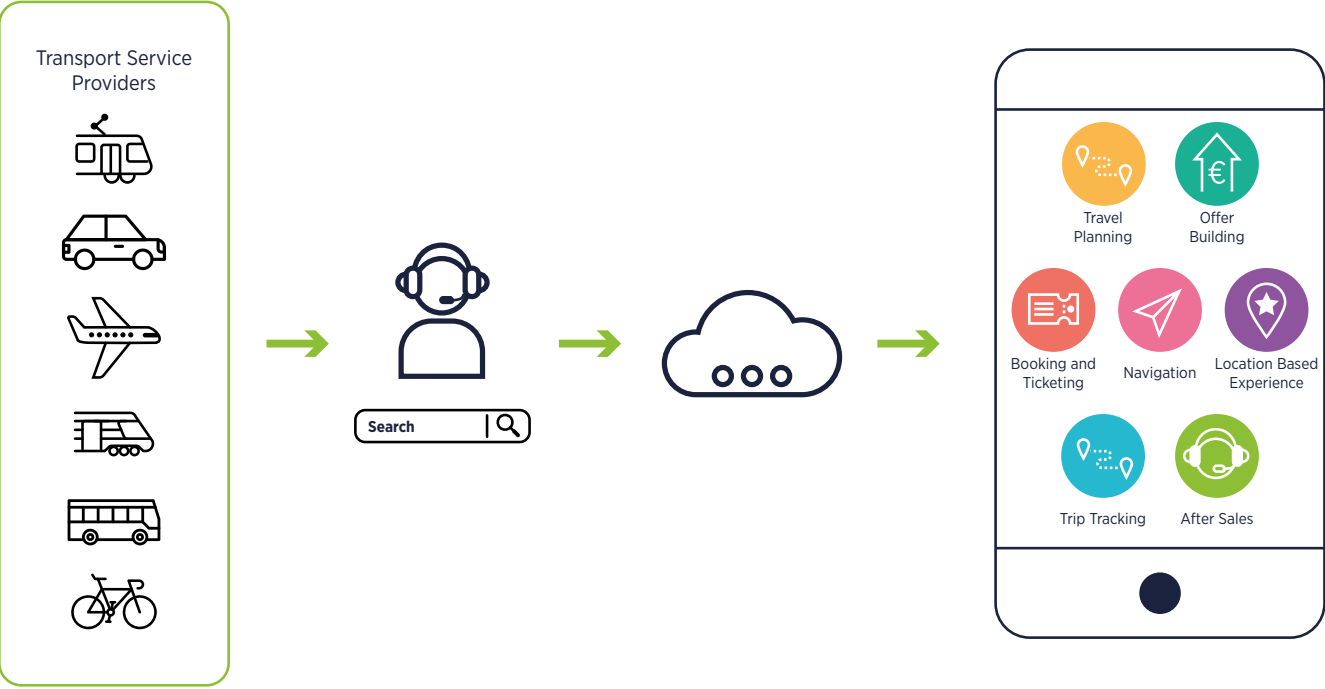
BENEFITS

Potential benefits and market impact:

- Provides a secured cloud-based platform to store user account data, passenger travel rights and travel wallets amongst other type of information
- Provides guidance and interchange navigation functions for indoor/ outdoor travel episodes
- Provides new forms of location-based experiences
- Takes into account services such as multi-user and group travel aspects
- Collects feedback data to improve real time information through the Trip Tracker
- Integration by other applications is foreseen and possible

Customer benefiting from the solutions:

Final user, operator and supplier



Copyright: Europe's Rail Joint Undertaking



TRAVEL PROVIDER TOOLS

Solution 45:  
Interoperability Framework for TSPs

The Interoperability Framework (IF) solutions will foster the digital transformation of the transport ecosystem and facilitate interoperability among heterogeneous system to make possible the provision of multimodal services that combine information and services from different TSPs.

Targeted market:

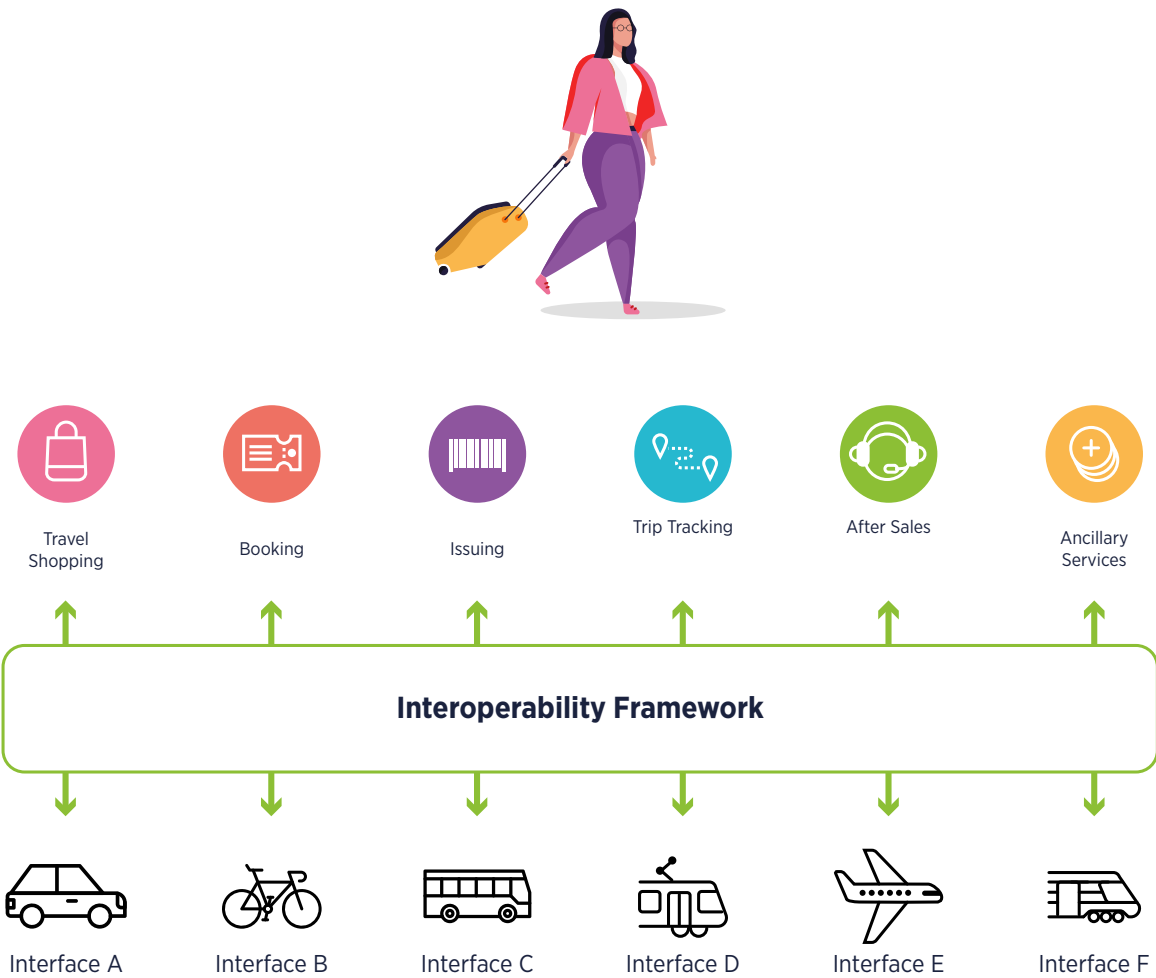
Mainly system and technology suppliers market and travel service providers

EU-Rail Solution available for industrialisation:

Solution expected to be ready in 2023

Market outlook:

Good perspectives for travel service providers of every mode of transport and mobility service providers



Copyright: Europe's Rail Joint Undertaking

TRAVEL PROVIDER TOOLS

Solution 46:  
Contractual Management Market Place

The contractual management market place (CMMP) solution consists of a web portal to which the Technology Service Provider (TSP) can register and create business rules involving other TSPs registered in the ecosystem. This solution enables a TSP to configure tariffs, specify the conditions and the benefits for the user and the revenue split among TSPs amongst other functionalities.

Targeted market:

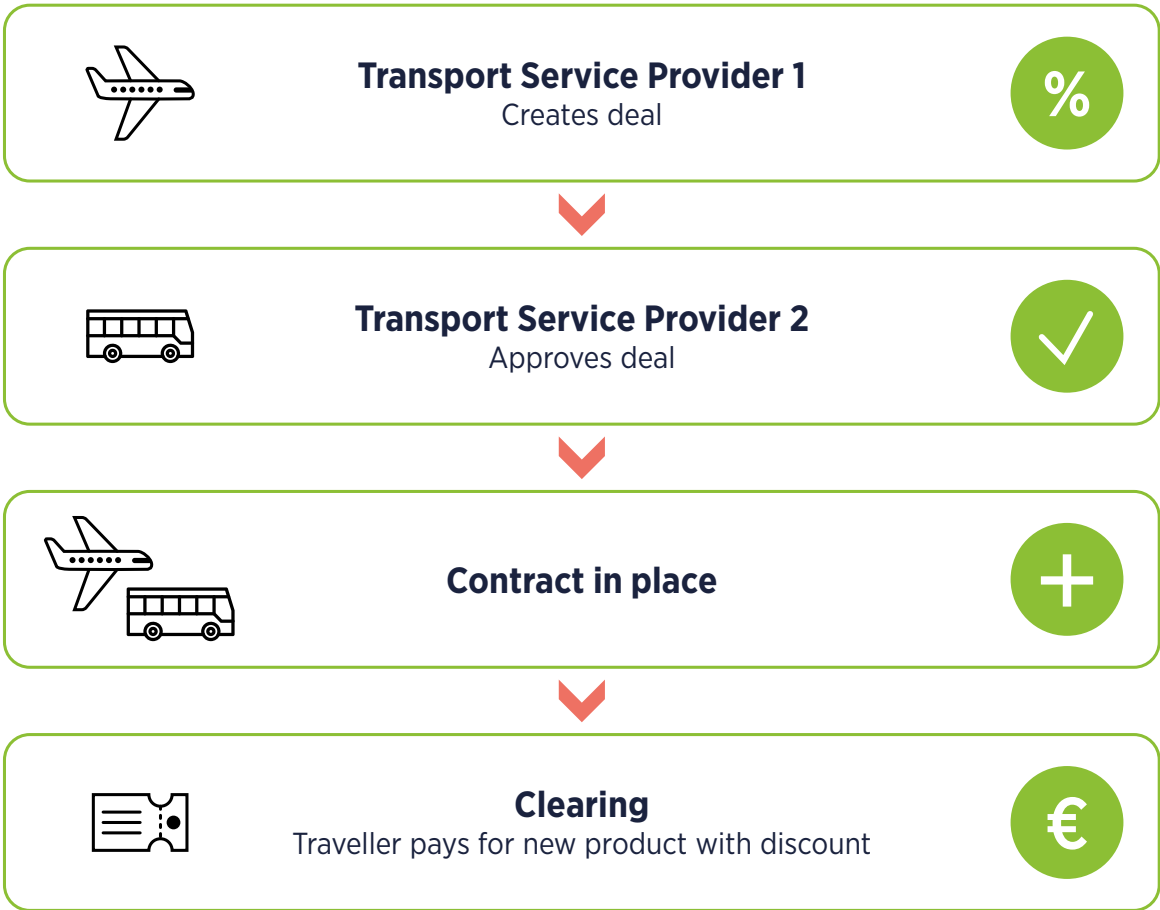
Mainly system and technology suppliers market and travel service providers

EU-Rail Solution available for industrialisation:

Solution expected to be ready in 2023

Market outlook:

Good perspectives for travel service operators of every mode of transport and mobility services



Copyright: Europe's Rail Joint Undertaking

TRAVEL PROVIDER TOOLS

Solution 47:  
Business Analytics for Transportation

The business analytics for transportation solution will provide a common foundation for all EU-Rail transport product and service providers based on data coming from TSPs in order to better adapt the level of service to the users demand.

Targeted market:

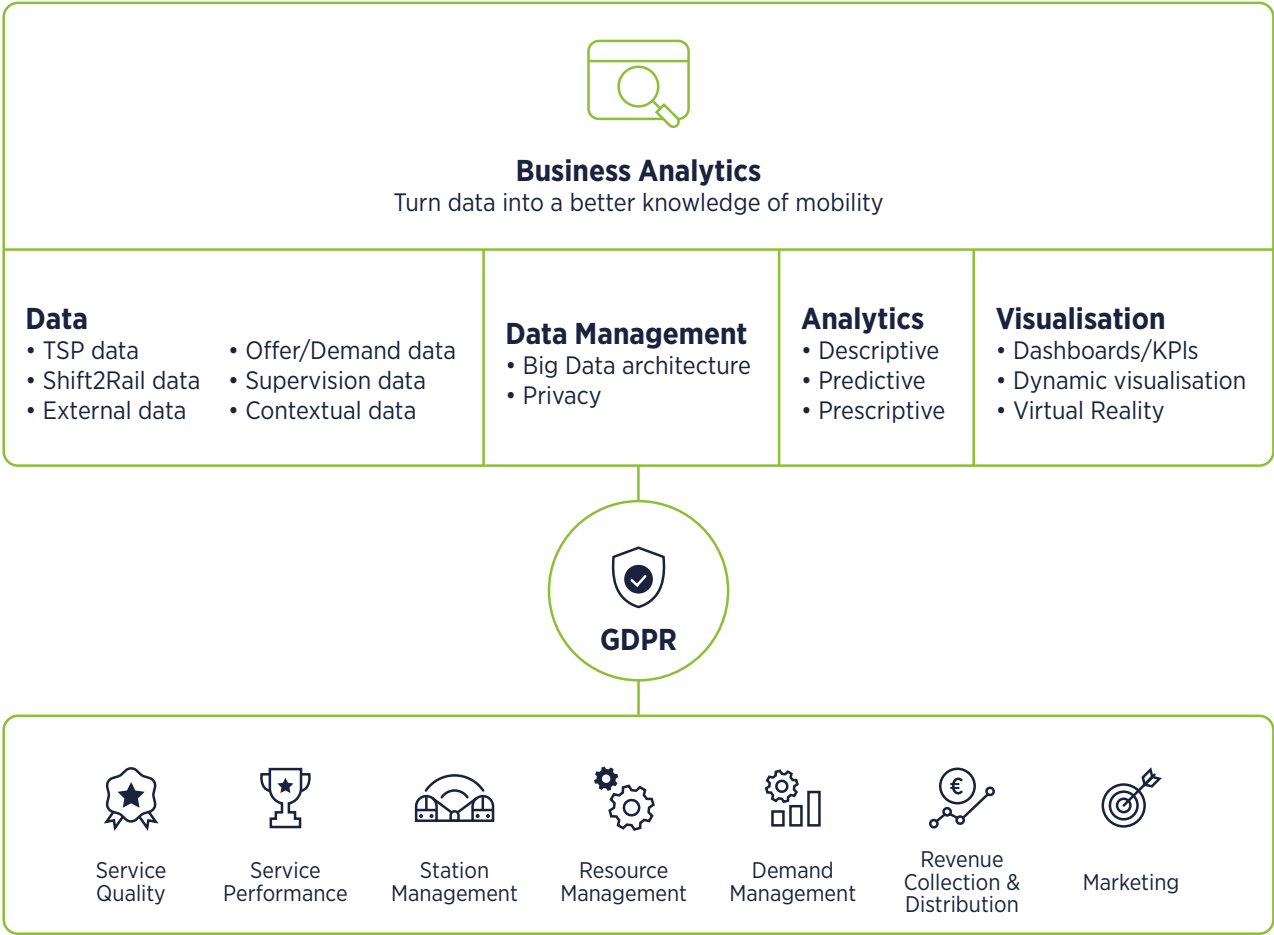
Mainly system and technology suppliers market and travel service providers

EU-Rail Solution available for industrialisation:

Solution expected to be ready in 2023

Market outlook:

Good perspectives for travel service providers of every mode of transport and mobility services, also for traffic managers



Copyright: Europe's Rail Joint Undertaking

TRAVEL PROVIDER TOOLS

Solution 48:  
Crowd Management

The solution develops modules to predict the occupancy of the train and the dwell time. It provides also a crowd management-based recommendation system. All this information can be used by the TMS (Traffic Management System) to optimize the timetable and by the Travel Service Providers to improve the passenger experience.

Targeted market:

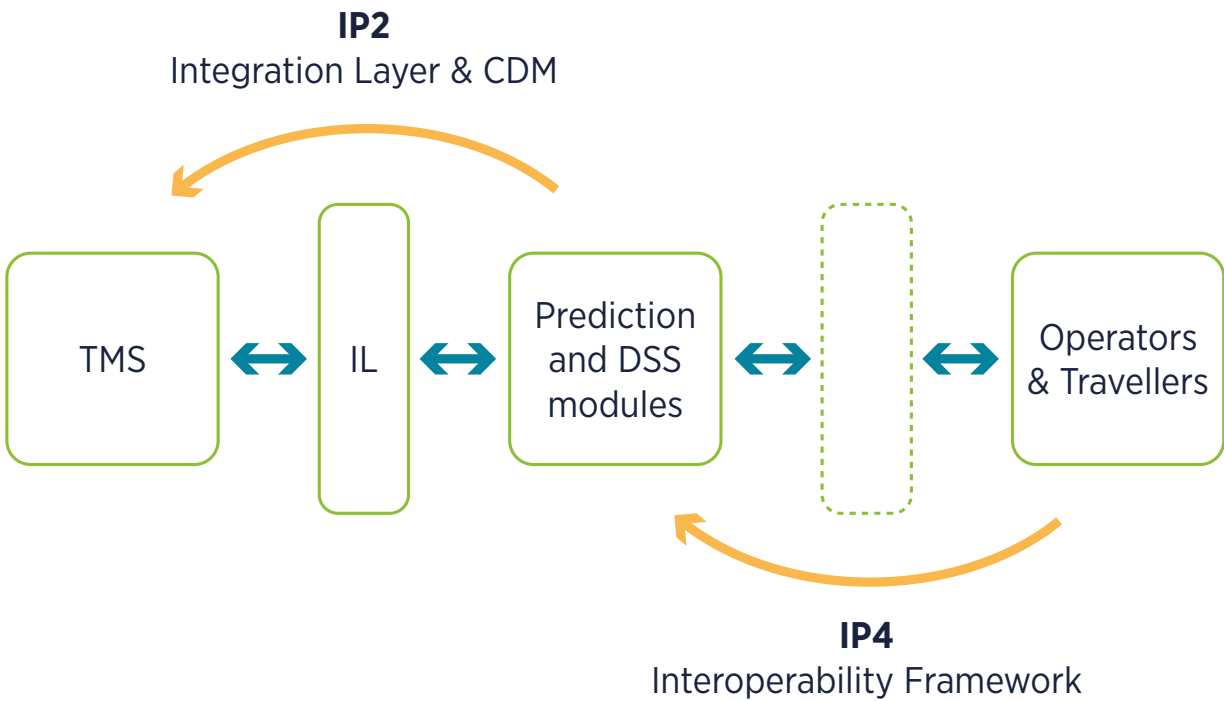
Mainly system and technology suppliers market and travel service providers

EU-Rail Solution available for industrialisation:

Solution expected to be ready in 2023

Market outlook:

Good perspectives for travel service providers of every mode of transport and mobility service providers



Copyright: Europe's Rail Joint Undertaking

TRAVEL PROVIDER TOOLS

Solution 49:  
SaaS Solution

The Software as a Service (SaaS) Solution will provide mobility services to small PTOs. The focus will be on a fast and easy integration through standardised processes and formats. Mobility Services will include aspects of Journey Planning, Offer Building, Real Time Information handling, improved Ticketing components and further operator services. The goal is to enable a seamless door-to-door travel experience.

Targeted market:

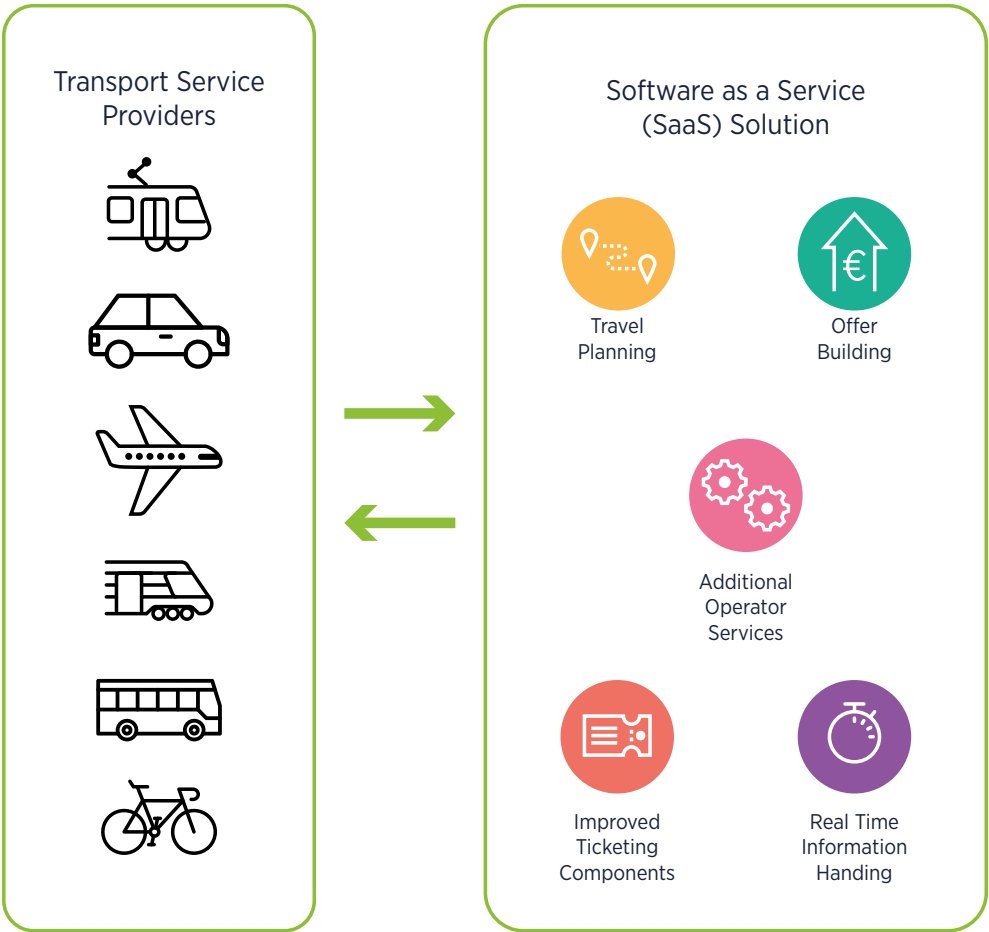
Mainly system and technology suppliers market and travel service providers

EU-Rail Solution available for industrialisation:

Solution expected to be ready in 2024

Market outlook:

Good perspectives for small PTOs



Copyright: Extensive Consortium

TRAVEL PROVIDER TOOLS

BENEFITS

Potential benefits and market impact:

Interoperability Framework for TSPs:

- Allows heterogeneous systems interoperating without changes in their interfaces
- Reduces implementation costs on the side of multimodal business apps and on the side of TSPs
- Facilitates the registration of TSPs into the ecosystem and provides a unified access Point
- Manages assets and ontologies
- Permits not only addressing rail but also other modes. Independent of a rail-specific standard or other standards

Contractual Management Market Place:

- Allows registered users to create and configure multimodal agreements and business rules
- Users can manage the agreements (accept/reject/modify) and contracts
- Possibility for users to see financial transactions (tickets sold, compensation, etc.)
- Future evolutions will create intermodal agreements and MaaS mobility packages and evolve to offer other capabilities to TSPs

Business Analytics for Transportation

- Data integration inside a powerful big data architecture
- Development of anonymization techniques to address GDPR
- Rich algorithms perform descriptive, predictive and prescriptive analytics
- Implementation of a Decision Support System, based on optimization algorithms, to manage disruptions considering multimodal solutions
- Interactive and dynamic visualization capabilities such as Virtual Reality

Crowd management:

- Allows information exchange between TSP/TMS and other systems
- Support for the timetable optimization of the TMS using the prediction of the occupancy and of the dwell time
- Crowd management-based recommendation system to improve the TSP operation

SaaS solution:

- Travel Service Providers can quickly and easily be integrated into the EU-Rail Ecosystem through standardized processes and provide further services to their customers.
- Travel service providers can manage the data generated by travellers on the Collaborative Space and request travellers feedback on a region
- Travel service providers can create custom report structures deploying new services to collect feedback from the travellers

Customer benefiting from the solutions:

Final user, operator and supplier



# IP5

## European Railway Freight:

Technologies for sustainable and attractive European Rail Freight

### AUTOMATION AND DIGITAL OPERATION

**Solution 50:** ATO GoA 2 for Existing Fleet

**Solution 51:** Freight Digital Automatic Coupler

**Solution 52:** Connected Heterogeneous Multiprocessing Architecture for Digitalisation of Freight Applications

**Solution 53:** Yard and Network Management

**Solution 54:** Intelligent Video Gate

**Solution 55:** Digital Brake Test

### MAINTENANCE

**Solution 56:** Condition Based and Predictive Maintenance

### TRACTION POWER

**Solution 57:** Distributed Power for Long Trains

**Solution 58:** Full Electric Last Mile Propulsion

**Solution 59:** Battery Module

### WHEELS AND AXLES

**Solution 60:** Light Thermostable Wheel

**Solution 61:** Silent Wheelset

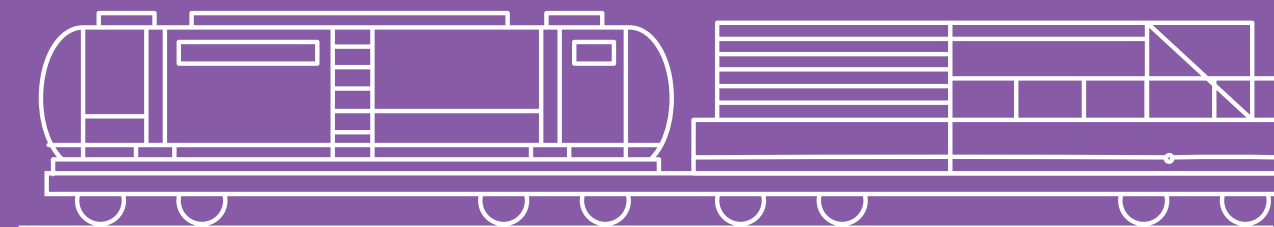
**Solution 62:** Axle Mounted Power Harvester

### WAGON

**Solution 63:** Extended Market Wagon

**Solution 64:** Core Market Wagon

**Solution 65:** Indoor-Outdoor Wagon Positioning



### AUTOMATION AND DIGITAL OPERATION

## Solution 50: ATO GoA 2 for Existing Fleet

The tested solution is driven by a standard approach (input into TSI) and look for interchangeability of GoA2 modules, as basis for future solutions to be implemented. The solution will also give insights into functionality with freight set-up on track.

#### Targeted market:

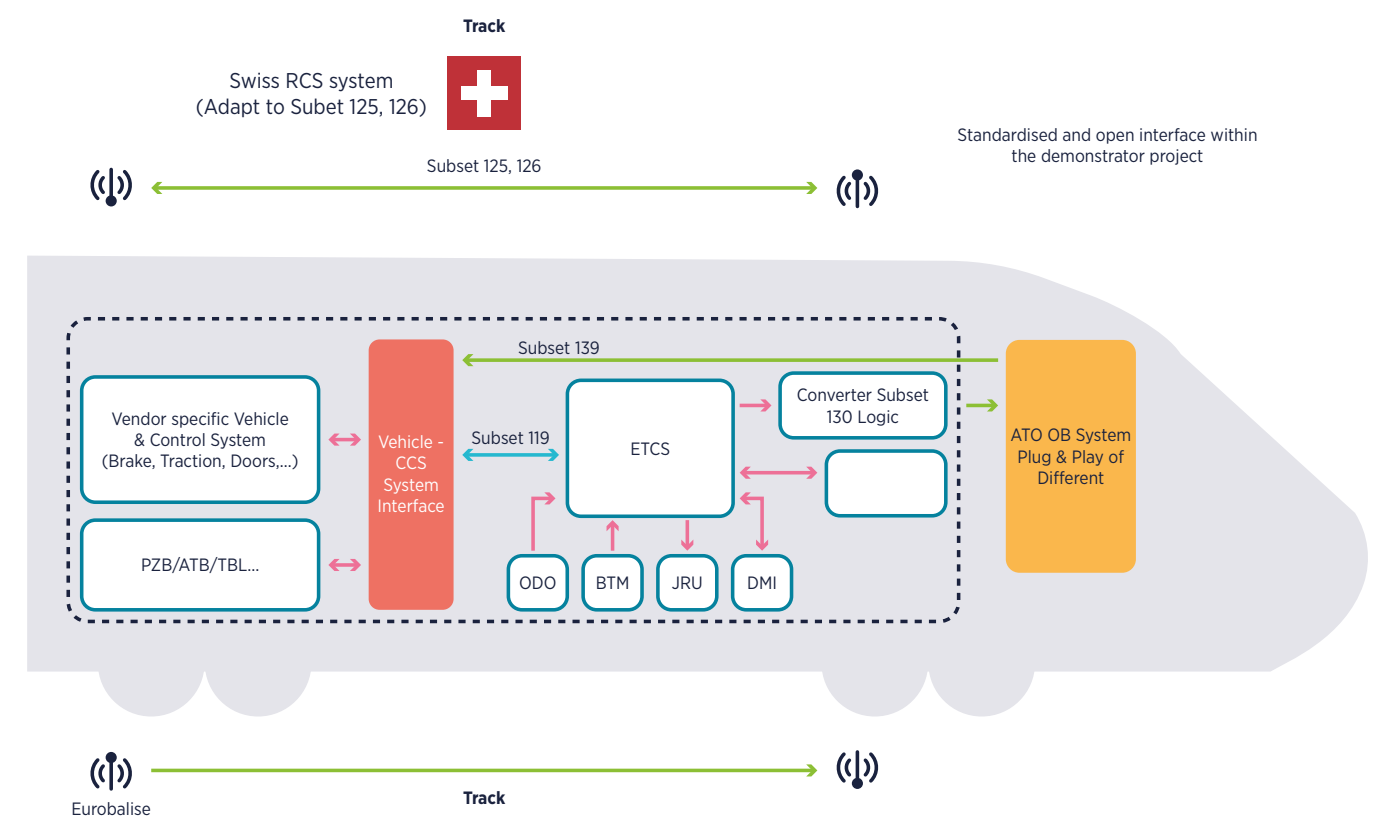
Mainly railway undertakings focussed on the growth of pan- European mainline operations market

#### EU-Rail Solution available for industrialisation:

Solution ready

#### Market outlook:

Good perspectives for infrastructure managers and European railway undertakings



Copyright: Bombardier

## AUTOMATION AND DIGITAL OPERATION

### Solution 51: Freight Digital Automatic Coupler

This new Freight Automatic Coupler solution will be a key component that will contribute to the automation of shunting operations and will include additional functionalities to the system by introducing electricity into the wagons, aligned with the European DAC Delivery Plan.

**Targeted market:**

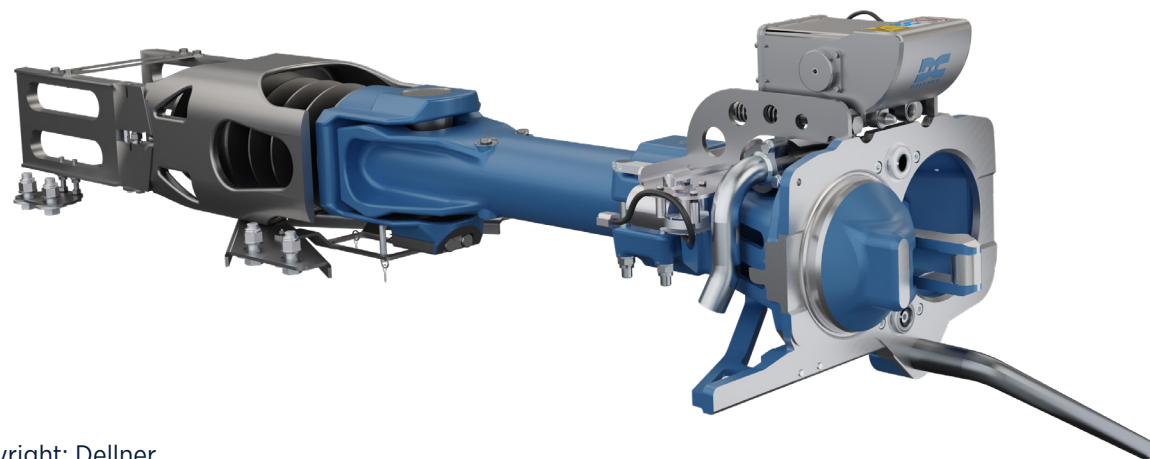
Mainly all European freight wagons market

**EU-Rail Solution available for industrialisation:**

Solution ready for prototype testing

**Market outlook:**

Good perspectives for infrastructure managers and European railway undertakings



Copyright: Dellner

## AUTOMATION AND DIGITAL OPERATION

### Solution 52: Connected Heterogeneous Multiprocessing Architecture for Digitalisation of Freight Applications

This new solution will contribute to the agile deployment and connection of the sensors and subsystems needed for the digitalization of the freight wagon providing connectivity with other on-board systems and locomotive. The solution is compatible with operational processes such as brake test and CBM data processing.

**Targeted market:**

All freight wagons market

**EU-Rail Solution available for industrialisation:**

Solution expected to be ready by 2024

**Market outlook:**

Good perspectives for operators for operation and maintenance purposes



Copyright: CEIT

AUTOMATION AND DIGITAL OPERATION

Solution 53:  
Yard and Network Management

The solution to efficiently manage yards and rail network will result in identifying the difficulties and shortcomings of a yard manager and provide improved algorithms and specifications. The tool provided to support decisions will increase automation in planning and traffic control tasks.

Targeted market:

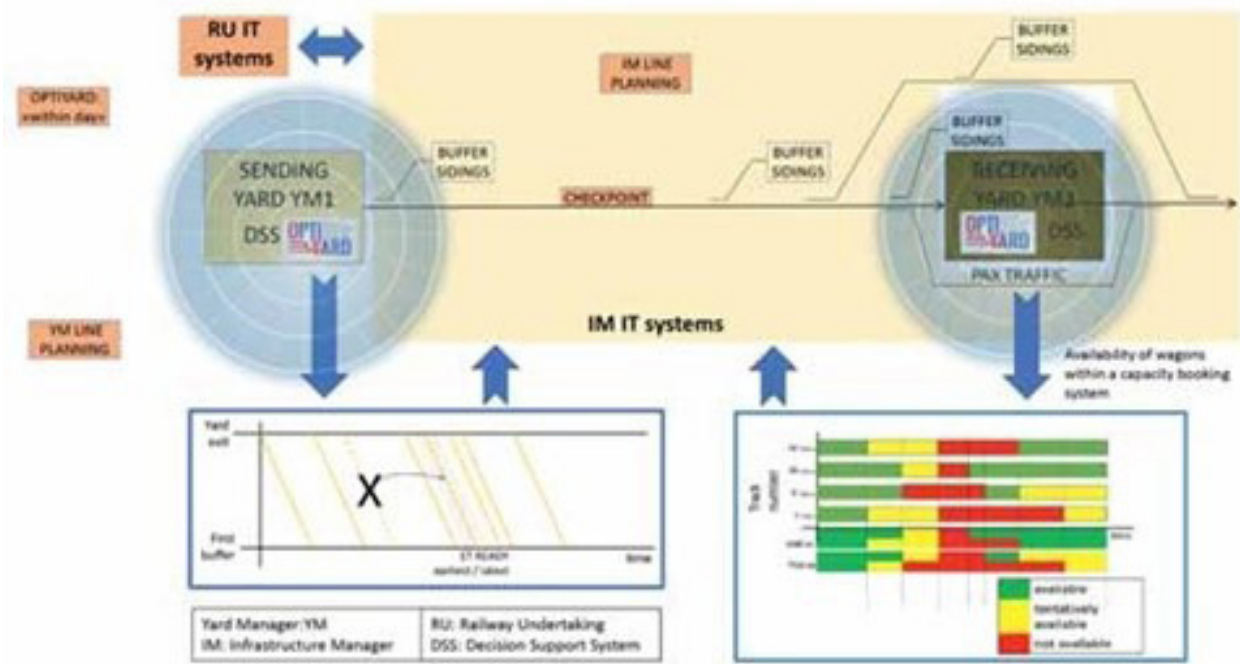
Mainly railway undertakings focussed on the growth of pan- European freight operations market

EU-Rail Solution available for industrialisation:

Before 2025

Market outlook:

Good perspectives for freight operators, infrastructure managers and railway undertakings. Next step is to develop real-time functions, perform real-time demonstrations and integrate with relevant systems/ information platforms



Copyright: Europe's Rail Joint Undertaking

AUTOMATION AND DIGITAL OPERATION

Solution 54:  
Intelligent Video Gate

This solution will help to identify and verify incoming trains to marshalling yards automatically. The Intelligent Video Gate solution will automatise these activities at intermodal terminals, improving data quality and reliability of inbound processes with a significant impact on terminals' capacity.

Targeted market:

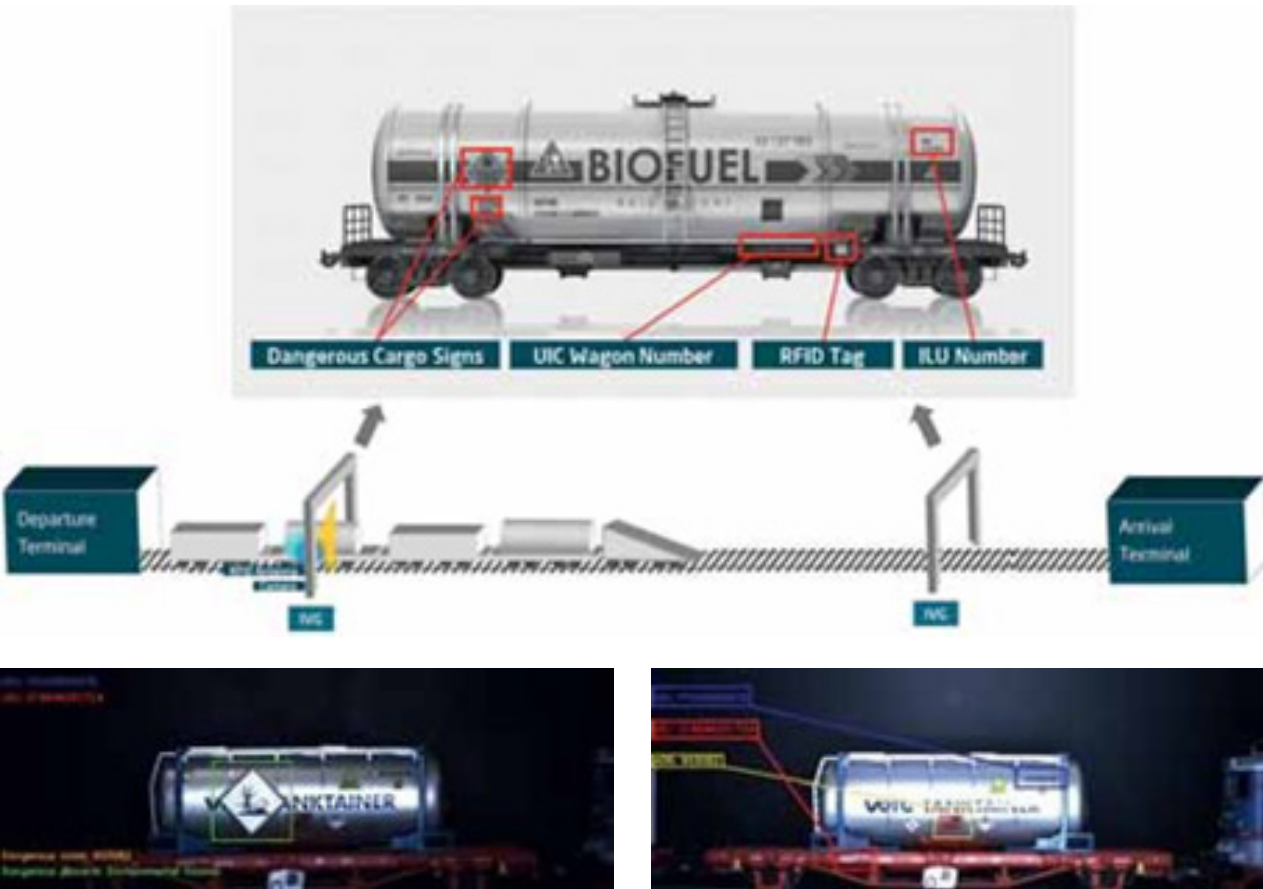
Mainly all European freight wagons market

EU-Rail Solution available for industrialisation:

Solution ready

Market outlook:

Good perspectives for terminal operators, railway infrastructure managers and railway undertakings



Copyright: Trafikverket



AUTOMATION AND DIGITAL OPERATION

Solution 55:  
Digital Brake Test

This solution will end up with the past 100 years obligatory brake test that has to be performed on freight wagons prior to departure by kicking the brake blocks. Thanks to this solution in conjunction with the opportunities delivered by a Digital Automatic Coupler, the brake test can now be performed digitally.

Targeted market:

Mainly all European freight wagons market

EU-Rail Solution available for industrialisation:

Solution ready for DAC operational testing in 2025

Market outlook:

Good perspectives



Copyright: SNCF – Fret

AUTOMATION AND DIGITAL OPERATION

BENEFITS

Potential benefits and market impact:

- Capacity increase by more efficient usage of existing infrastructure and operations.
- Reduction of costs and optimisation of operational processes
- Energy savings of up to 10%
- Improved and faster operational handling and reduction of manual and arduous work of up to 20%.
- New services and solutions for automated corridor operation
- Increased safety for the operation staff and against derailment due to the central buffer coupler and the autocentering joint
- Faster arrival and departure processes
- Ease of implementation on marshalling facilities and cargo terminals
- Facilitation of information management, exchange and enabling Internet of logistics
- Heterogeneous and adaptable processing capabilities for edge computing or cloud-based applications

Customer benefiting from the solutions:

Operator, infrastructure manager and supplier

MAINTENANCE

Solution 56:  
Condition Based and Predictive Maintenance

The solution will result in the development of an overall condition based and predictive maintenance strategy for freight rolling stock that will lead to a further reduction of cost and increase of fleet usage efficiency.

Targeted market:

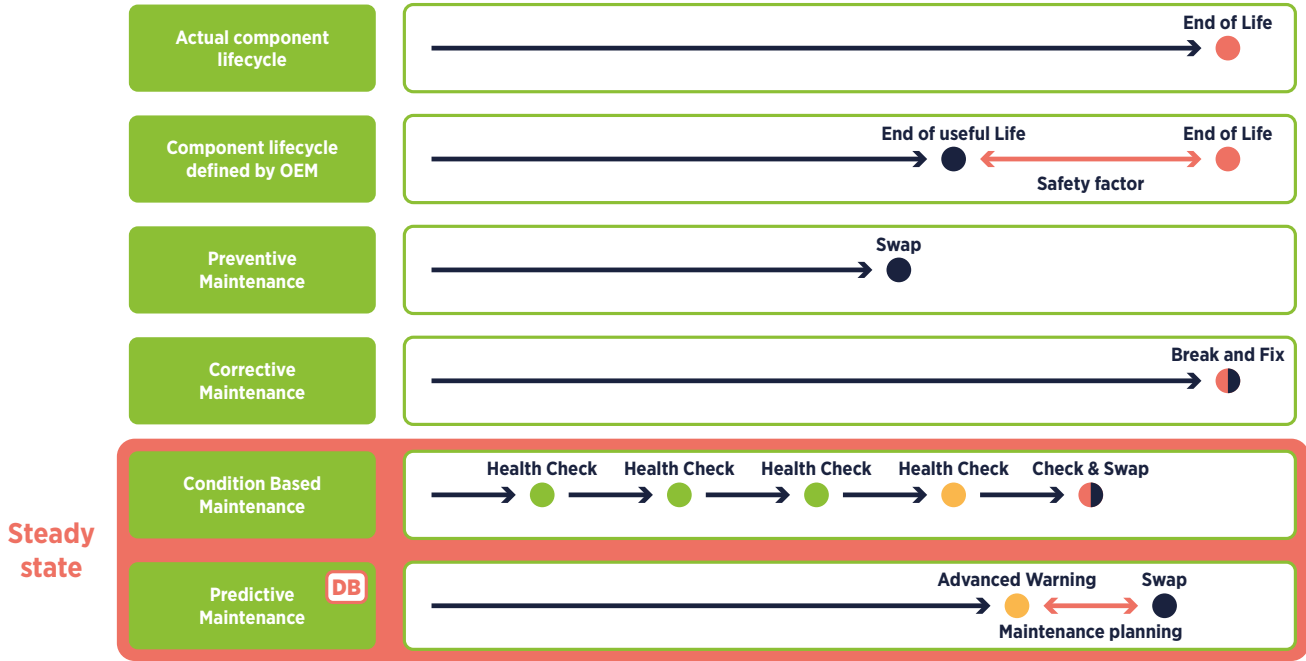
Mainly railway undertakings focussed on growth of pan-European mainline operations market

EU-Rail Solution available for industrialisation:

Solution ready in first version, final version expected in 2024

Market outlook:

Good perspectives for railway undertakings and entities in charge of maintenance



Copyright: Deutsche Bahn

MAINTENANCE

BENEFITS

Potential benefits and market impact:

- Reduce the maintenance cost of up to 10%
- Increase the attractiveness of rail mode for logistic operators
- Foster the generation of new services and solutions for automated corridor operation

Customer benefiting from the solutions:

Operator and infrastructure manager

TRACTION POWER

Solution 57:  
Distributed Power for Long Trains

The distributed power for long trains solution will enable the possibility to increase the length of the trains focusing on radio remote controlled distributed power technology for freight trains.

Targeted market:

Mainly railway undertakings focussed on the growth of pan- European freight operations market

EU-Rail Solution available for industrialisation:

Solution ready

Market outlook:

Good perspectives for freight operators, infrastructure managers and railway undertakings



Copyright: Bombardier, Deutsche Bahn, Faively

TRACTION POWER

Solution 58:  
Full Electric Last Mile Propulsion

With this solution EU-Rail develops a scalable electric last mile propulsion system that is capable to complement or replace existing last mile diesel engines.

Targeted market:

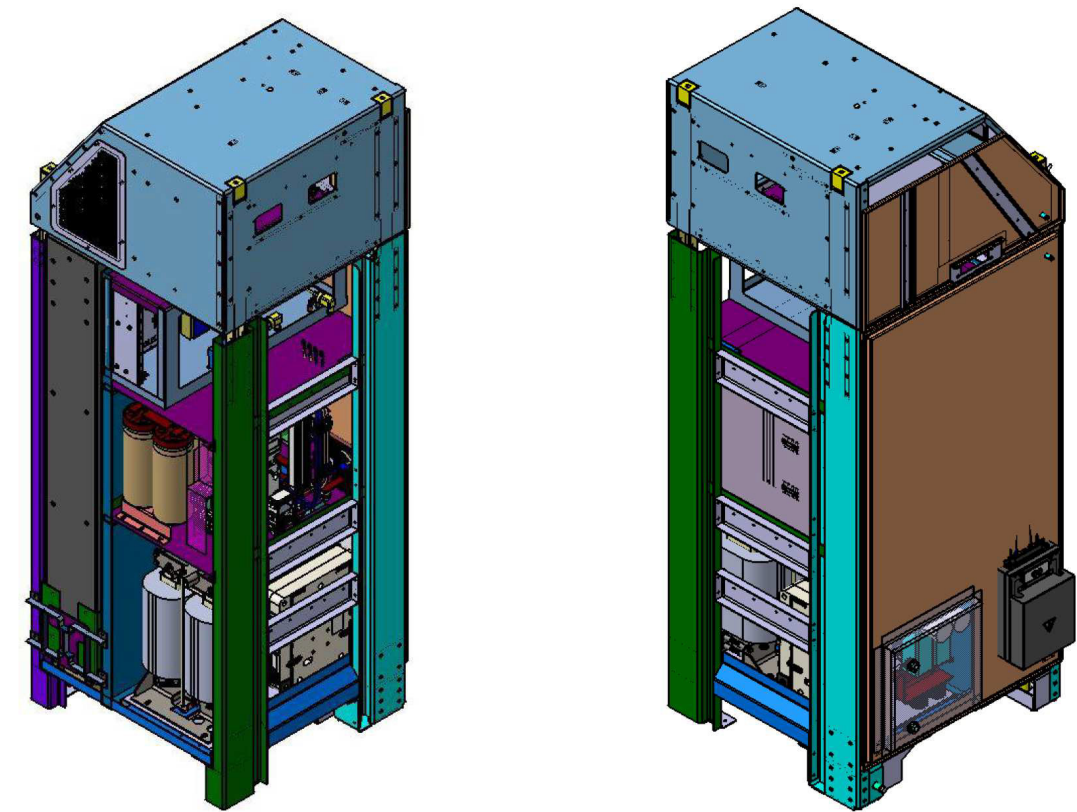
Mainly freight trains market, running into non electrified yards, harbours, but also passenger trains market running on non- electrified lines (diesel) with the need to enter sensitive areas, like underground stations

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2025

Market outlook:

Increasing, especially with the availability of low cost batteries



Copyright: Bombardier



TRACTION POWER

Solution 59:  
Battery Module

With this solution EU-Rail develops a scalable battery module for locomotive application based on automotive sector’s battery cells considering the potential downsize of actual diesel engines and with the goal to target the market worldwide.

Targeted market:

Mainly freight trains market, running into non electrified yards, harbours, but also passenger trains market running on non- electrified lines (diesel) with the need to enter sensitive areas, like underground stations

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2025

Market outlook:

Increasing, especially with the availability of low-cost batteries



Copyright: CAF

TRACTION POWER

BENEFITS

Potential benefits and market impact:

- Productivity increase of up to 100% by doubling train length up to 1,500 m
- Capacity increase by more efficient usage of existing infrastructure
- Reduction of cost per unit
- Significant increase of competitiveness for the sector
- Punctuality increase because there is no need to wait for external shunting services
- Acceptance also in ecological sensitive environment
- Running in tunnels and stations, where exhaust gases are not allowed
- Energy savings due to possibility to store braking energy in the last mile battery, especially under DC networks and on non-electrified lines
- 3x peak power compared to Last Mile Diesel propulsion
- More than 6x more installed energy compared to existing electric last mile propulsion systems

Customer benefiting from the solutions:

Operator, infrastructure manager and supplier

## WHEELS AND AXLES

### Solution 60: Light Thermostable Wheel

This new solution will solve the load constraints and safety issues related to one of the most extensively used wheel at EU level and will enable safety increase, noise reduction emission as well as an increase on the load capacity.

#### Targeted market:

Mainly all European freight wagons using composite brake blocks

#### EU-Rail Solution available for industrialisation:

Solution ready

#### Market outlook:

Good perspectives for rolling stock owners and operators



Copyright: CAF

## WHEELS AND AXLES

### Solution 61: Silent Wheelset

The solution will result in the development of an overall condition based and predictive maintenance strategy for freight rolling stock that will lead to a further reduction of cost and increase of fleet usage efficiency.

#### Targeted market:

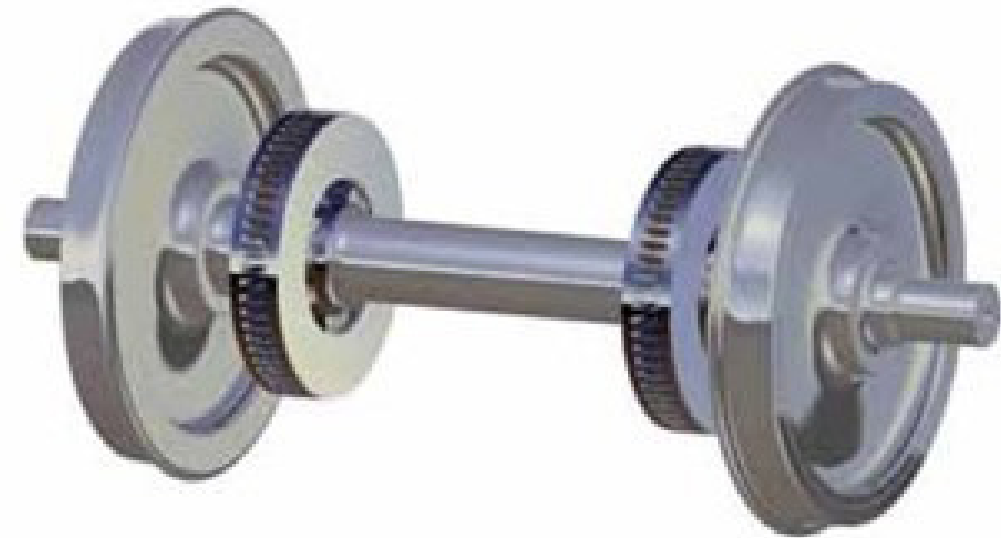
Mainly railway undertakings focussed on growth of pan-European mainline operations market

#### EU-Rail Solution available for industrialisation:

Solution ready

#### Market outlook:

Good perspectives for railway undertakings and entities in charge of maintenance



Copyright: CAF

WHEELS AND AXLES

Solution 62:  
Axle Mounted Power Harvester

The solution will provide the required energy for the telematics components of the non-electrified intelligent wagons. By design the axle mounted power harvester offers an easy way to be installed on the axle.

Targeted market:

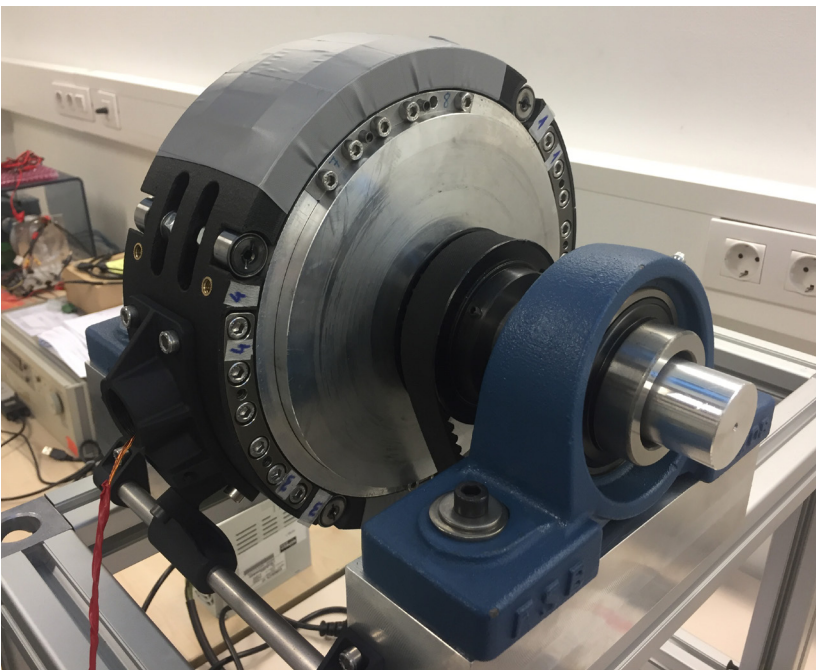
European freight wagons market

EU-Rail Solution available for industrialisation:

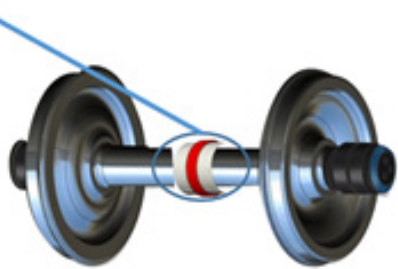
Solution expected to be ready by 2025

Market outlook:

Good perspectives for Rolling Stock owners/operators, wagonload operators



Operating speed from 20km/h  
Output power 20-120W  
Output Voltage 24-48 VDC  
Up to one week of battery life  
Weight 4.6kg



Copyright: CEIT

WHEELS AND AXLES

BENEFITS

Potential benefits and market impact:

- Increased load capacity per axle up to 10% for European freight wagons
- Light wheel design (339 kg) allowing to increase load capacity in wagons
- Safety is increased thanks to a thermostable solution that reduces the risk of radial cracks on the rim
- Noise reduction in the wheel emission up to 2 dBA fostering class A “very silent wagons”
- Compatible with 205 and 215 mm diameter ESFA axle wheelset standards
- Reduced wear on the wheels, increased wheel life and I reduction of life-cycle costs.
- Increased load per axle, from 22,5 to 25 Tn
- Reduction of operational costs
- New services and solutions for the logistic chain

Customer benefiting from the solutions:

Final user, Operator, infrastructure manager and supplier



WAGON

Solution 63:  
Extended Market Wagon

This light-weight, fast running and electrified wagon solution in block train operation will attract transports that today are carried on the road and will strengthen competitiveness of existing rail bound transports and therefore contribute directly to the overall goal to shift transports from road to rail. Wagon intelligence conducted by wagon on-board unit in combination with a safe train integrity system will lead to high availability and predictable, stable performance. Significantly lower noise emissions will minimise the societal impact of the increase rail freight operations transport volume foreseen.

Targeted market:

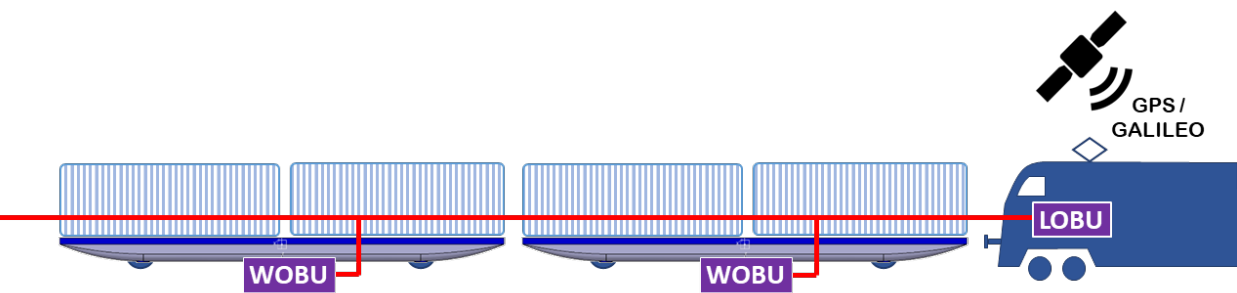
Mainly all European freight wagons market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2023

Market outlook:

Good perspectives for Rolling Stock owners/operators



Copyright: DLR

WAGON

Solution 64:  
Core Market Wagon

This innovative wagon design includes several subcomponent optimisations. Taken the TIS 5L-factors into consideration, the work on sub-components including digital automated couplers, optimized running-gear and car-body components as well as modifications on aerodynamics and acoustics will contribute to a greener and more efficient operation. The telematic and electrification systems enhances logistics capability and CBM concepts.

Targeted market:

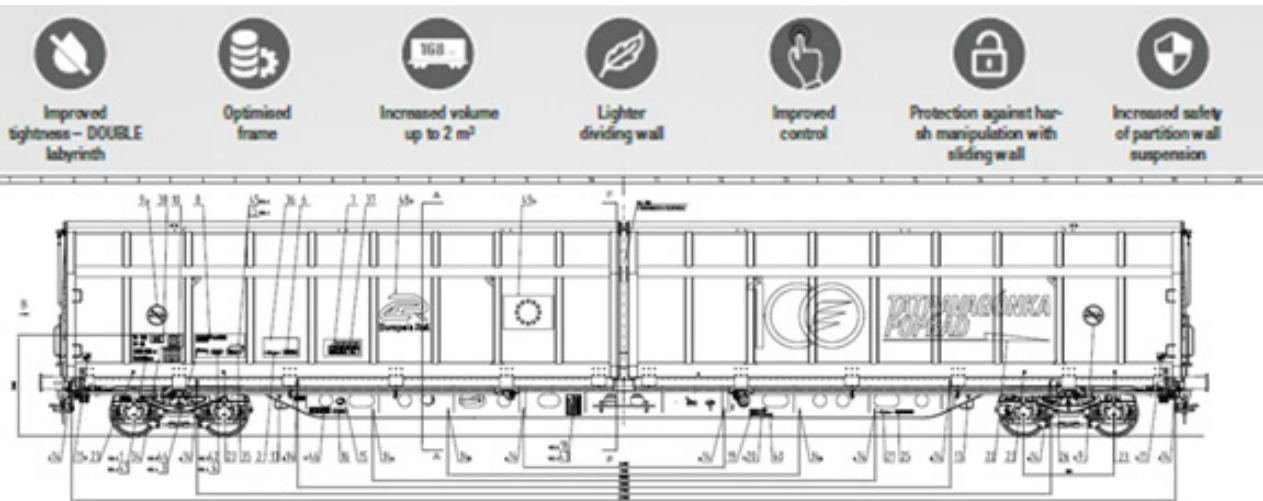
Mainly all European freight wagons market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2023

Market outlook:

EU-wide deployment until 2025



Copyright: Tatravagónka a.s. Poprad

WAGON

Solution 65:  
Indoor-Outdoor Wagon Positioning

The solution will provide the operators with a continuous seamless indoor and outdoor position of the wagon. This solution will be an enabler for new services and automation both in the outdoor lines, yards and terminals, and in the indoor yards, terminals, stations, tunnels and workshops.

Targeted market:

European freight wagons market

EU-Rail Solution available for industrialisation:

Solution expected to be ready by 2024

Market outlook:

Good perspectives for Rolling Stock owners/operators, wagonload operators



Copyright: CEIT

WAGON

BENEFITS

Potential benefits and market impact:

HIGHER PRODUCTIVITY

- Significantly improved utilisation: higher payload ratio due to lower tare weight (capacity increase)
- Lower dwell times: no shunting along the route

MORE FLEXIBILITY

- Higher maximum speed allows access to day routes (capacity increase)
- Aerodynamically optimised low noise operation also in night times

LOWER OPERATING COSTS

- Maintenance costs -30%
- Energy savings approx. 10
- Low noise

New services and solutions for the logistic chain and for automated corridor operation

Customer benefiting from the solutions:

Final user, operator, infrastructure manager and supplier

# CCA

## Horizontal Innovative Solutions for Railway:

Cross-cutting activities

### CCA HORIZONTAL INNOVATIVE SOLUTIONS FOR RAILWAY

Solution 66: Simulation Model for Large Networks

Solution 67: Energy Labelling of Rail Vehicles

Solution 68: KPI Model for Impact Assessment

Solution 69: Modal Shift Evaluation Model for Impact Assessment

Solution 70: Energy Simulation Tool



### PROTON

## Solution 66: Simulation Model for Large Networks

The railway interaction simulation model solution (PROTON) enables the simulation of large networks within a short runtime to predict the impact of disturbances on the punctuality. It is a relevant tool for short-term timetable planning to select the best solution, e.g. to optimise the timetable for required adoptions due to construction works.

#### Targeted market:

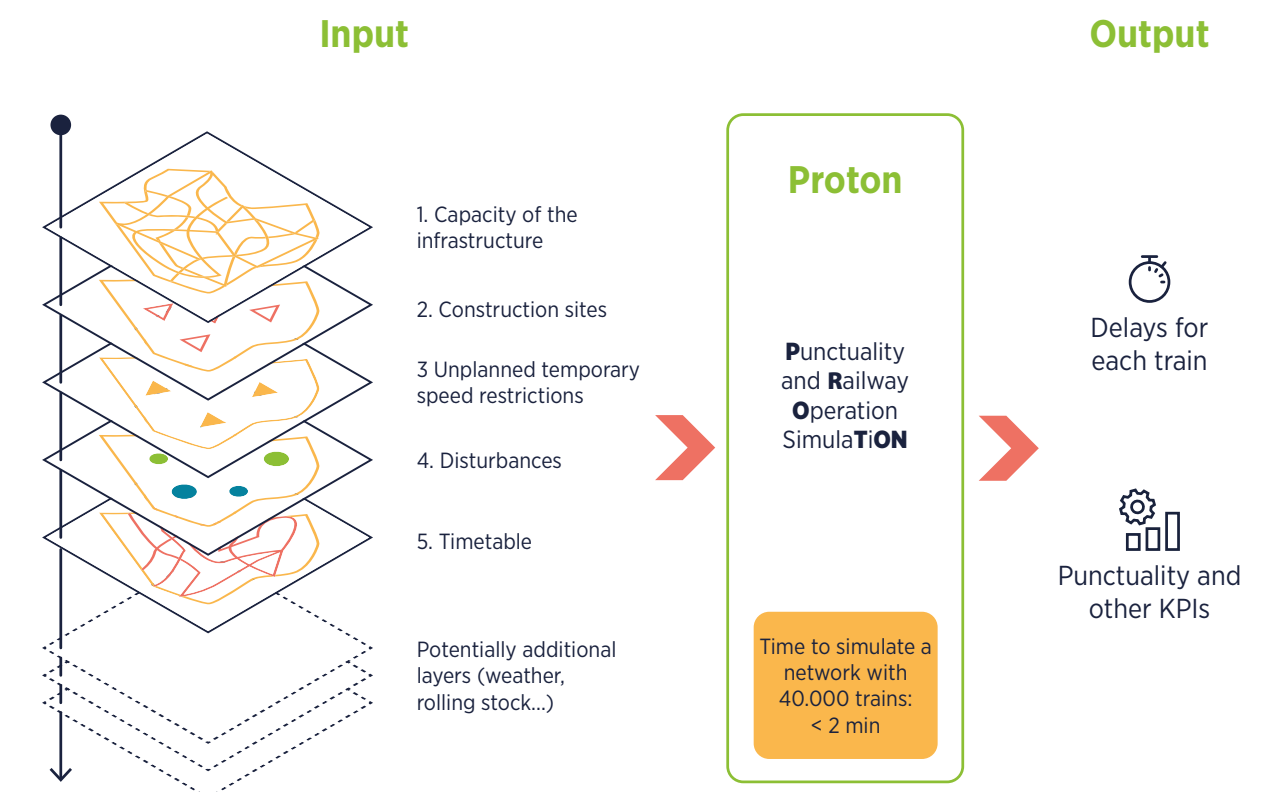
Infrastructure managers

#### EU-Rail Solution available for industrialisation:

Solution ready

#### Market outlook:

Good perspectives for all market segment



Copyright: Europe's Rail Joint Undertaking



PROTON

BENEFITS

Potential benefits and market impact:

- Capacity increase to be expected due to fewer conflicts resulting from better planning
- Cost efficiency because of optimization of decisions in mid-term planning and timetabling
- Punctuality increase due to improved timetables and potentially optimization of decisions in operational planning and dispatching
- It will foster the generation of new services and solutions for railway planning

Customer benefiting from the solutions:

Operator and infrastructure manager

ENERGY LABELLING OF RAIL VEHICLES

Solution 67:  
Energy Labelling of Rail Vehicles

The solution propose an energy labelling for rail vehicles will result in the alignment with the energy standard EN 50591 and with the review of existing energy label in different sectors.

Targeted market:

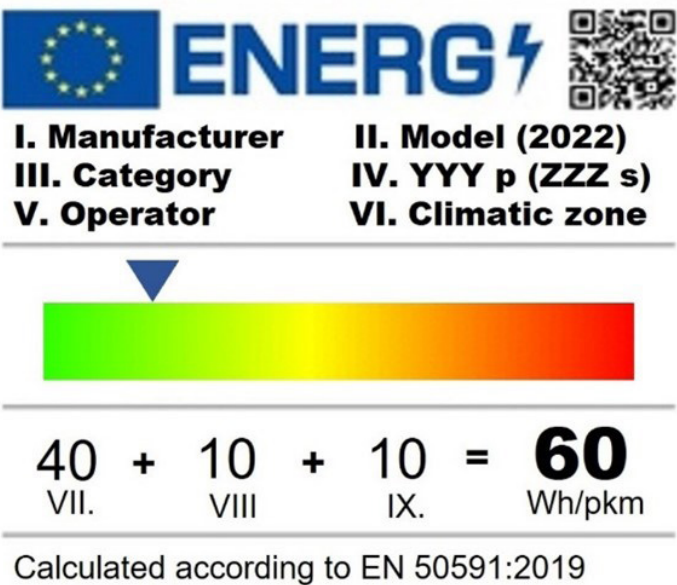
Mainly for end customers, train operating companies, transport authorities, homologation authorities and train manufacturers

EU-Rail Solution available for industrialisation:

Solution expected to be ready after 2025

Market outlook:

Good perspectives for all market segment



BENEFITS

Potential benefits and market impact:

- Support the development of more energy efficient rail vehicles
- Encourage improvement of CO2 efficiency in the transport sector
- Reduce energy costs and rail system life-cycle costs
- Raise awareness of stakeholders, including potential passengers and transport buyers
- Contribute to rail attractiveness and a shift to rail

Customer benefiting from the solutions:

Final user, operator, infrastructure manager and supplier

Solution 68:  
KPI Model for Impact Assessment

The KPI model solution allows the evaluation of changes in the KPIs Life-Cycle-Cost, Reliability & Punctuality and Capacity caused by enhanced technology solutions developed within the innovation programmes. Based on defined scenarios, the changes can be applied on a level considering the integrated railway system for different market segments.

Targeted market:

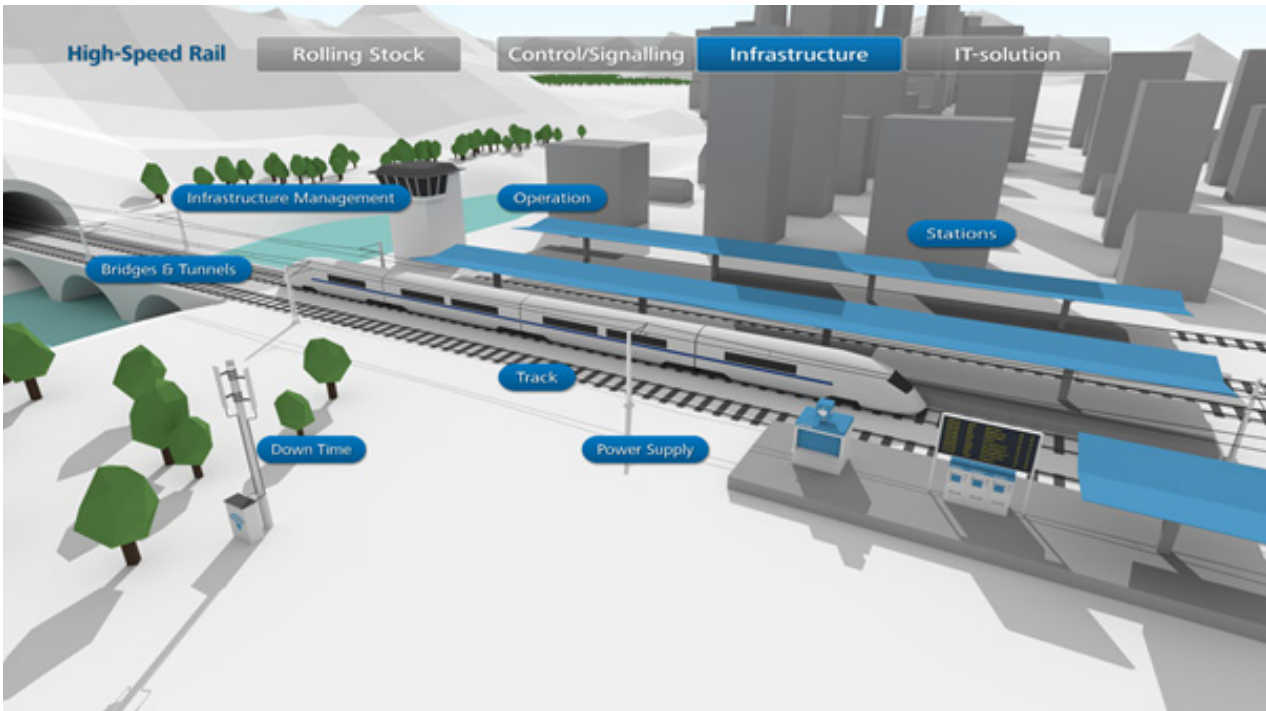
Mainly policy makers

EU-Rail Solution available for industrialisation:

Solution ready its current iteration, expected to be finalised in 2023

Market outlook:

The assessment of impacts for all market segments



Copyright: Europe’s Rail Joint Undertaking

SOCIO-ECONOMIC ASSESSMENT

Solution 69:  
Modal Shift Evaluation Model for  
Impact Assessment

The modal shift evaluation model for impact assessment solution enables for a set of use cases, based on input data from the KPI model and customer experience model, estimation of the actual modal shift to rail that can be expected from implementation of the Programme innovations in the railway sector. The results show that the Programme innovations have potential to deliver substantial increases in modal shares mainly for High-speed passenger rail, regional passenger rail and rail freight.

Targeted market:

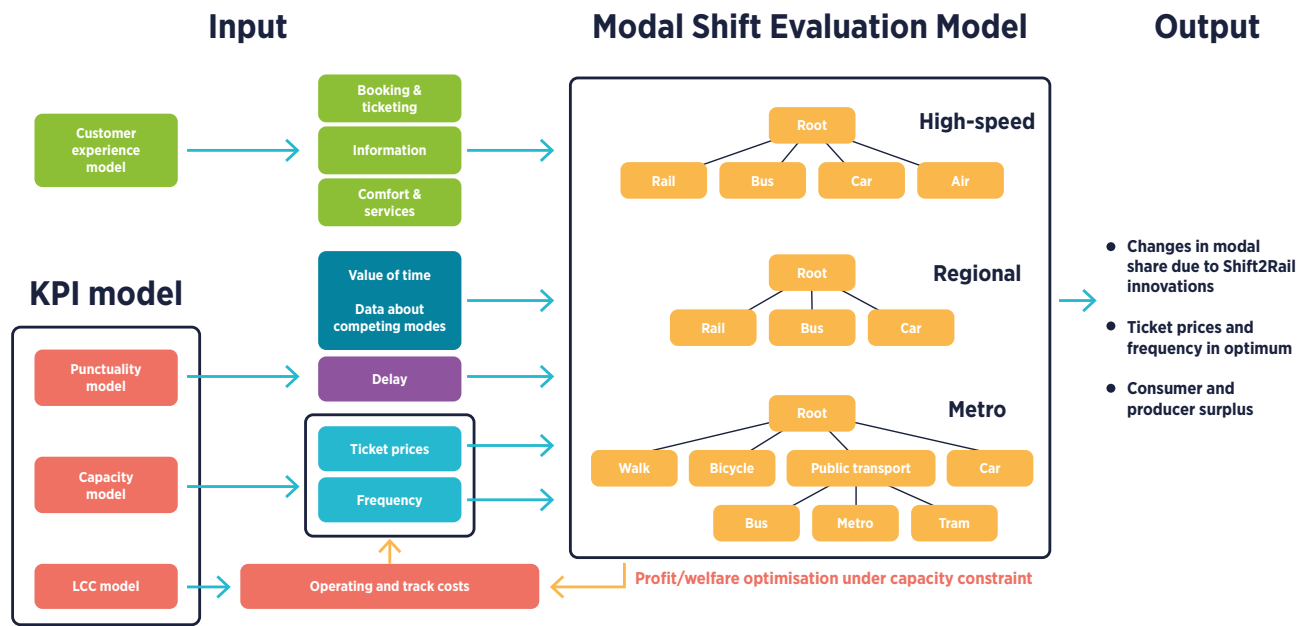
Mainly policy makers

EU-Rail Solution available for industrialisation:

Solution ready its current iteration, expected to be finalised in 2023

Market outlook:

Good perspectives for all market segments



Copyright: Europe's Rail Joint Undertaking

SOCIO-ECONOMIC ASSESSMENT

BENEFITS

Potential benefits and market  
impact:

- Allows decision makers to get an indication on rail attractiveness and the modal shift to rail because of technology solutions.
- Consideration of KPIs as well as customer satisfaction factors when improving the railway system possible.
- Applicable for various railway market segments and in different grades of detail.
- The socio-economic assessment is based on rich data collection

Customer benefiting from the  
solutions:

Final user, operator, infrastructure manager and supplier



ENERGY SIMULATION TOOL

Solution 70:  
Energy Simulation Tool

The use of a tool (OPEUS) for the assessment and optimisation of energy usage aspects of rolling stock will contribute to the quantification of the potential benefits that the introduction of innovative technologies can bring to the development of cleaner vehicles for all market segments, contributing to decarbonisation efforts at system level.

Targeted market:

Usage by all types of stakeholders but particularly train manufacturers , train operating companies, transport authorities, and homologation authorities

EU-Rail Solution available for industrialisation:

Solution ready

Market outlook:

Good perspectives for all market segments but particularly for railway stakeholders

ENERGY SIMULATION TOOL

BENEFITS

Potential benefits and market impact:

- Support the development of more energy efficient rail vehicles;
- Encourage improvement of energy efficiency in the transport sector
- Reduce energy costs and rail system life-cycle costs
- Accelerate the implementation of technological innovation
- Improve procurement processes

Customer benefiting from the solutions:

Final user, operator, infrastructure manager and supplier



## **EU-Rail**

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Avenue de la Toison d'Or 56-60,  
B1060, Brussels/Belgium

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[communication@rail-research.europa.eu](mailto:communication@rail-research.europa.eu)

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