The 12 Capabilities – Summary

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1. Digital and Automated Train Operations

The Capability

Rail transport operations are increasingly automated, with new processes backed by safe, digital and modular systems.
Trains are able to operate themselves and run closer together driven by data. The role of humans could progressively decrease, but given the high level of safety needed and complexity of the system, Railway staff will remain necessary to organise, supervise and regulate, perhaps only at a high level, as well as to secure resilient and continuous operations.
With automated processes and new digital systems, network capacity and operational flexibility can significantly increase while providing better punctuality for customers and fewer negative externalities (energy, noise & vibrations, land use).
Massive efficiency gains can be achieved if autonomous and remote controls can be safely integrated and deployed in a harmonious way. Digital and automated train operations are more than just adding technologies to the railway. It should be supported by an evolving framework enabling simple and safe integration into existing trains and network. The migration roadmap should cover partly or fully automated train operation, for all kind of train traffic.
Special attention should also be paid to cybersecurity and effective protection against external interference.

Sub-capabilities

- Automated (passengers and freight) trains run closer together with increased flexibility.
- Passenger and freight train preparation processes are automated.
- Vehicles split and join on the move. New operational approaches (e.g. virtual coupling, convoying, reduced headway, communication connections between trains/units) are employed.
- Self-propelled automated / autonomous single units guide themselves through the system.
- Digital technologies enable operation performance leap and deployment breakthrough for instance modularity as driver for simple integration and continuous evolution.

Enablers

- **Breakthrough approach to implement, use and scale digital and automated train operation**
- Modularity as a frame compatibility, easy/remoted upgrade and investment protection
- New skills, affordable responsibilities and positive role for railway workers
- **Next generation technological platforms as a safe, secured and configurable backbone for:**
- Low latency and guaranteed communication supporting rail operation timed at the second,
- Digital and collaborative register giving everywhere a timely access to trusted data
- Centralised and decentralised computing power supporting multivendor applications.
- **New algorithm and (human) machine interfaces supporting enhanced operation**
- From fixed (virtual) blocks to full moving blocks: create new itineraries and optimise real time decision for a lean network capacity usage
- Automated and remoted train operation: make best use of rail resource, minimise externalities, help human to concentrate on tasks adding value to rail transport customers
- **Advanced sensoring within the railway system for an enhance supervision of assets conditions:**
- Enhanced navigation and positioning technologies
- Localisation of all trains, workers and obstacles, all time in any place of the rail system land
- Manage rolling stock and infrastructures health (available performance e.g. adhesion, diagnostic e.g. predictive maintenance for high reliability, self-healing)
- **Innovative operational solutions: explore concepts to do more with less**
- Virtual coupling: open possibilities for frugal control loop in the railway system
- Automatic protection system to adapt to any specific implementation case
- Support mixed traffic and best use of legacy devices with residual life span
- Intelligent and connecting digital infrastructure
- Automation, sensing, and robotics applications ....
- Computing continuum – EDGE computing, cloud computing, data analytics, processing power
- Space technologies as the basis for "omnipresent" and increasingly faster connectivity
- FRMCS
- TMS/TCMS
- **Human factor influence**
- Human role in the autonomous system
- Analysis of the human system in interaction with the machine, fatigue detection, stress
- Improvement of the Human/Machine interface (HMI)
- Human /man-machine teaming. Model based Human system integration / human in the loop.

2. Mobility as a service

The Capability

This capability is centred on the customer's mobility needs, that are fulfilled by combining a set of diverse services, through a seamless integration and orchestration.
Rail is at the heart of this efficient network of multimodal, synergic mobility-related services that are aggregated and personalised to respond to user needs through servitisation of mobility.
This is expected to be a booster for climate targets, improve life quality and mobility experience of people, sustain economic growth, and needs to be supported by technology, societal and policy enablers to overcome fragmentation.

Sub-capabilities

- Personalised, simple and trustable guidance to the best use of available transport services is provided so that each customer improves life quality **and mobility experience**.
- Every journey is tailored intelligently and seamlessly, with rail physically integrated with the other modes as a green core, as the door-to-door service is customer-driven and supported by the interchange hubs.
- Minimalist and personalised information makes the journey easier by seamlessly guiding the travellers across the connections between the different modes.
- Profiling offers based on the history of behaviors and choices made by the passenger in the past
- Account-based, hands-free electronic ticketing and payment are the norm.
- Supported by reliable transport modes providing the necessary mobility when needed.
- Frugality of connectivity: resolution of current unsatisfactory situation for travellers.

Enablers

- Navigation and positioning
- Intelligent and connecting digital infrastructure
- Automation and robotics applications
- Digital AI-based travel assistantComputing continuum
- XaaS
- Federated Data Spaces -> various European initiatives to be connected for the rail mode
- Blockchain technology ?
- Account-based, multichannel ticketing and booking,
- Biometrics enabling digital payments
- Self-service technologies
- Innovative payment systems
- Optimisation platforms and applications
- Extended reality (including Virtual and Augmented Reality and Metaverse technologies)
- Space technologies as the basis for "omnipresent" and increasingly faster connectivity
- Data exchanges, especially with customers
- Interoperable data flows data flows for customers
- Information technology services (ITS)

3. Smart Logistics

The Capability

Smart logistics are driven by demand, concentrate on speed, maximum economy, sustainable use of resources with special focus on renewable energy and zero greenhouse gas emissions.
Use of big data, AI, telematics and prediction helps to optimise use of rolling stock, to reduce cargo costs and to optimise time of delivery.
Close cooperation with providers of "last mile" services and climate neutrality make smart logistics competitive against road transport.
The rail system is fully integrated with the multimodal logistic chain, especially by physical and smart terminals.

Sub-capabilities

- Cargo trains become significant part of logistic chain.
- Climate neutrality helps to fulfil requirements of ESG and CSR policies.
- Automation, exchange of data, communication help to speed up with cargo transfer and to increase cargo load.
- Leveraging technology for smart logistics, such as AI and Big Data
- Use of algorithms for managing freight cargo within the terminal premises to optimize storage and minimize loading operations

Enablers

- Predictive maintenance and harmonised railway diagnostics help to increase efficiency, improve planning and reduce costs of rolling stock.
- Telematics technologies allow to monitor location of vehicles and manage them online.
- Electrification and batteries/hydrogen power supply help to reduce CO2 emissions.
- Artificial Intelligence supports logistics optimization , efficiency and link with "last mile" which promote "door-to-door" shipment. Increased speed to reduce time of transportation.
- Longer trains and heavier loads to increase total cargo per course.
- IoT and M2M technologies to increase efficiency and to reduce time for reaction, better cooperation with Train Management Systems.
- Big data to help optimise information flow, cargo and rolling stock management – reduction of costs and time.
- DAC (Digital Automatic Coupling) – faster coupling and logistic with use of digital technology and automation.
- Hyperloop, magnet traction systems and autonomous.
- Smart terminal
- Automation of terminals and marshalling yards
- Automated driving

4. Ability to use data for changing needs

The Capability

To deliver on all these ambitious capabilities, the Railway sector must leverage digitalisation strategies and digital technologies. This approach will efficiently manage the ever-expanding volume of data, significantly contributing to the data economy. The necessity of handling such a large volume of data will bring new challenges on how to collect, analyse and utilize data, but will offer the opportunity of generating more value for all stakeholders, railway operators, customers, and the whole society. The consolidation of Data Spaces, the use of Internet of Things, smart edge computing and Artificial Intelligence, will enable automated big data processing and will guarantee up-to-date information and fast and well-informed decision making. Thanks to this, the railway sector will be able to offer more and better mobility services and will run more sustainable and reliable operations.
This is achieved through a robust, resilient, distributed, and secure information architecture, coupled with a well-structured governance framework taking in account the energy efficiency for managing and storing data. By meticulously considering aspects like data privacy management, data sovereignty, subsidiarity and trust, pertinent information will be disseminated across the industry and beyond, thus fostering the development of novel services and applications to the benefit of both the railway sector and its customers. At the same time, it is needed to ensure an appropriate level of cybersecurity and mechanisms for proper role management and data access

Sub-capabilities

- Effective change management processes for data governance, secure, robust, scalable, distributed and resilient open architecture and protocols allow full interoperability.
- The Internet of Things (IoT) supported by smart edge computing and Artificial Intelligence (AI) provide efficient capture, storage, management and interpretation of data.
- The customer and the rail system communicate intelligently with each other.
- Railway businesses exploit new data-driven revenue streams.
- Big Data analytics enables a range of new and improved services to be developed, state of the art cybersecurity ensures reliable and secure ICT services, protection of the rail system and business continuity in case of an incident.

Enablers

- Data Space and Federated Data Space
- IoT
- Artificial Intelligence and entrusted AI (EAI)
- Conceptual Data Model (CDM) to be applied for interoperability/data translation
- Cloud Computing
- EDGE computing where AI is processed onboard
- Connectivity
- Blockchain technology to support specific use cases
- Advanced & harmonised railway diagnostics (use case of data use both for vehicle and infrastructure)
- Quantum technology

5. Optimum energy use

The Capability

Railways maintain their position as the most environment-friendly mode of transport by decreasing energy consumption removing any use of fossil fuels. This is achieved together with lowered operating costs through the use of an intelligent energy management system. The introduction of new technologies and methods as supporting tools enable reduced and optimised demand-led energy use and energy efficiency.

Sub-capabilities

- New propulsion concepts such as fuel cells are introduced. Hybrid powertrains allow running over non-electrified track sections. Discontinuous electrification at stations and on branch lines dramatically reduces the capital costs of extending electrification.
- Driving Advisory Systems (DAS) and Automated Train Operations (ATO) improve energy efficiency. Reducing the energy used for the train traction is possible by giving appropriate instructions to drivers, so they can adapt acceleration and braking to the line profile and network condition (Eco-Driving).
- Optimised on-board and line-side energy storage and charging technologies (e.g. dynamic wireless power transfer) allow the railway to redistribute energy throughout the system according to supply and demand.
- A high proportion of energy is recovered through regenerative braking, and small-scale energy generation and harvesting technologies feed energy efficient trackside systems.
- A fully integrated system approach to intelligent energy supply maximises renewable energy generation and the use of smart grids, including those outside the railway system, through links with the wider energy supply sector.
- Efficient management of lighting and HVAC. Lowering consumption in lightning and heating processes is possible with a technological upgrade.
- Energy management to be considered in the system view, not only at the level of the technical assets subsystems (both Rolling Stock and Infrastructure)
- Energy-efficient railway line through energy sobriety
- People are key for achieving efficient energy use. Staff involvement can help reducing consumption.

Enablers

- Hybrid and renewable energy technologies (BEV (Battery Electric Vehicle) and Biofuels (HVO (Hydrotreated Vegetable Oil))
- Hydrogen and/or fuel cells
- Energy harvesting, Battery technology
- Alternative Energy sources and alternative fuels technological solutions for vehicle propulsion
- Carbon footprint measurement technologies and applications,
- Advanced innovative materials (e.g. smart, recycled, renewable, self-regenerating, lighter), metal alloys and biomaterials
- Studies of potential replacement of materials in terms of CO_2 footprint
- Energy Capture, Storage and Transmission

6. Service timed to the second

The Capability

Situational awareness, in which the location, speed, physical parameters, and emergency response capabilities (automated or autonomous exception handling) of each train are always known, and this is in real-time, i.e., the service's the operation and monitoring are accurate to the second. (10 seconds preferred to the minute).
This results in increased and improved operational flexibility and contributes to an attractive, more robust, and resilient service, as well as a better and more flexible use of existing infrastructure with the possibility of increasing the capacity of the infrastructure unit under consideration (connection from point A to point B) and in terms of infrastructure networks. Achieving the ability to operate and manage a just-in-time service with real-time accuracy ('to the second'), reducing the risk of delay, provides the capacity for more efficient planning of the use of the rail network, the implementation of flexible safety margins and more efficient energy management and use of rolling stock on the network shared between freight and passenger services. From a safety point of view, similar priority for opposing traffic on single-track sections (in emergency or assistance and recovery situations) can be managed by dynamic priority allocation with synchronisation of both sides

Sub-capabilities

- Precise, continuous and ready for automation and autonomisation, vehicle identification in the network with real-time monitoring is the basis for precise service operation.
- Intelligent traffic and flexible distance management ensure that every train is in the right place and travelling at the right speed.
- Depending on the current network section management strategy, precise energy management is also possible.
- Automated dynamic timetables can be better deployed.
- Automated scenario-based reactivation is implemented and safe.
- Automated reactivation after a disruption ('self-healing' process") quickly restores standard service.
- Increased flexibility and attractiveness of rail services are highly likely.
- Innovative Vehicle ready for operations with flexible safety zones (operational phase).
- Increasing the existing network's capacity is possible if expanding the network to provide the expected capacity is not the most desirable option.
- Entrusted generative artificial intelligence (AI) enables more effective analysis of real-time traffic on the network.
- Positioning of vehicles, passengers and goods moving on the network is available with high accuracy (every second).
- Intelligent energy and capacity management adapted to operational priorities.
- Two-way data exchange and high-performance computing
- Enabling full deployment of mirror worlds (digitalisation) to improve safety and dynamic train pool management in operational conditions.
- Construction of the transport plan in the decasecond

Enablers

- Automated dynamic timetables
- BIM
- Digital Twins and simulation
- Sectoral / Railways Metaverse
- Edge computing
- Federated Data model/space
- IoT
- Big Data
- entrusted AI
- Cloud computing
- Real-time two-way communication and data exchange
- Real-time positioning
- Natural Language Processing (NLP)
- Space technologies as the basis for “omnipresent” and increasingly faster connectivity

7. Lower cost railways for low density areas

The Capability

New models to deliver accessible efficient and affordable rail transport on local destination lines. Trusted infrastructure, rolling stock and railway operation allow the rail mode to reasonably compete for new transport links, together with possessing the potential for cooperating with other modes of transport. The capillary lines, both line and point infrastructure, are treated as the part of rail system in long life cycle. Design, service solutions, technologies draw inspiration from other sectors such as light rail, automotive and aviation, while keeping considerations on the interoperability of lower cost railway networks and trains with conventional rolling stock and infrastructure design: low-cost railway is a chance and should not be a threat for railway transport availability and resilience.

Sub-capabilities

- Holistic approach to application of measurements to apply reduction of costs, especially for low level traffic services, including assessment of differential value drivers
- The use of low-cost, accessible and affordable mobility for various groups of users, including PRM, elderly people, considering demographic changes.
- Linear and point railway infrastructure incorporated into the spatial tissue of the location/town, economic, social, environmental impact.
- Function of the railway's stations and rail passengers' mobility for local society, transit travellers, regional development.
- The use of automation and autonomy, long service life, long MTBF (Mean time between failures) technologies along with reusable, lightweight materials for the lifecycle costs reduction.
- Simplified control-command system appropriate for low-intensity operation is used, allowing various degrees of autonomy.
- A whole life operating cost approach balances the use of low-cost technical assets and good value service.
- Tailored – made solutions for the location/town or cluster of locations, using various modes of transport (multimodality, DRT, first/last mile).
- Well designed and reliable, integrated passenger information system, including situations of delays.

- **Enablers** Sustainable Development Goals
- New models of mobility (e.g. DRT, shared-mobility, multimodality)
- Automation and autonomisation
- Transport accessibility.
- Cost optimisation
- Stakeholders' engagement
- Vulnerable users' needs
- Regional development
- Asset Lifecycle Management
- Intensive use of composites and lightweight materials
- New sources of energy

8. Intelligent asset management

The Capability

Towards a continuously open railway regarding its basic data features and health condition of its assets seems a prerequisite to minimise disruption of train services. Efficient design and monitoring are base requirements for optimised maintenance where robust modular units and infrastructure are easily maintained and repaired through a robotic automated system, making the operation punctual, safe and quick. Real-time monitoring of asset health feed the predictive maintenance decision-making process, and asset health and availability is further improved by a digital twin backed by machine-learning, artificial intelligence and big data analytics. Increased reliability and plannability will be an overall result, better if further steps are taken to link traffic management and asset management in an automated and continuous manner. Attention should also be paid to cost-effectiveness, i.e. the optimal selection of resources that guarantee response to the highest-cost emergencies

Sub-capabilities

- Real-time monitoring and testing through connected sensors (ground/air/embedded).
- Monitoring and testing of rail assets undertaken and integrated in the digital twin landscape, providing information to the supply chain. Parametric and generative Artificial Intelligence (AI) supports both the design process as well as predictive maintenance decision-making and subsequent planning to reduce manual interventions on infrastructure and rolling stock.
- Greater use of robotics, modularity and automation simplifies design, construction and maintenance (including inspection) and reduces the number of components.
- Remote maintenance of trains and infrastructure allows operations to continue uninterrupted.
- Performance based design and service specifications encourages a diverse design process as well as supply chain.
- Synchronized development for both Smart Maintenance & Smart Factory concepts, involving optimization of service contracts and automation of the supply chain and scheduling of service terms.

Enablers

- Computer Vision
- Drones and robots (also in swarms)
- AI and ML (Machine learning)
- Digital Twin
- Federated Data Spaces
- BIM modelling
- Virtual environment
- Optimisation platforms and applications
- (Harmonised) Railway Diagnostics: Data Models and exchange of information
- Additive manufacturing

9. Intelligent services

The Capability

Intelligent services are based in trains as autonomous vehicles which, depending on their roles – passenger or cargo units, can fully cooperate with their surroundings in three pillars: "Customers and Markets", "Society and Economy" and "Environment and Energy". Such trains can communicate internally and externally with users providing them with required information about themselves, their passengers/loads and their surroundings. Optimisation of energy use, preventive and predictive maintenance, security, proper info to infrastructure and station managers about loads/passengers and unexpected situations, on-time information to passengers about timetable and potential delays, alternative connections and info related to other transport modes, which may help passengers to travel quickly and comfortably. Level of autonomy depends on level of security linked to human factor. A network of train-based intelligent services is managed by centralised AI systems supervised by humans.

Sub-capabilities

- Autonomous trains can monitor and regulate themselves, they can heal and self or remotely repair up to a certain extent.
- Communications is possible between trains, between train and infrastructure and between train and passenger/freight customers.
- In-train signalling capability is used to resolve conflicts at junctions and stations with a use of CCC and AI.

Safety procedures in case of breakdowns or other emergency situations.

Enablers

- AI and advanced communication technologies
- 5G and newer communication infrastructure at transportation corridors to allow IoT and M2M communication to trains.
- IoT and M2M technologies for exchange of data within and outside the train.
- Engagement of AI and algorithms for train schedule, planning and management like CCC or TCS,
- Proper positioning of cargo waggons with use of GPS, RFID and other technologies, such as space technologies.
- Integration of variable transport modes and their management systems to allow data exchange and "last mile" planning.
- DAC (Digital Automatic Coupling) - faster coupling and logistic with use of digital technology and automation.
- Development of advance processing solutions in Smart Trains via edge computing
- Fostering V2V (vehicle-to-vehicle) communications in support of centralized management in addition to V2X (vehicle-to-everything)

10. Stations and smart city mobility

The Capability

Rail is the backbone of rural and urban mobility, with stations at the heart of 'smart' cities, being places to work, live, meet and communicate, where individual transport modes, including public transport and long-distance rail transport, are physically connected. New station designs provide easy access and seamless interchange between the transport modes, enabling railways to manage growing passenger volumes and mobility demands. What is more they offer consolidated data about all means of transport enabling passengers to possess the necessary information in real time both at the HUB being the smart train station and mobile way by using smartphone applications. In order to deliver proper services all, train stations have to be divided into small local ones supplying the bigger being the HUBS – DIGITAL HUBS of the cities. Needs of analysis of the interchange node as a cluster of interconnected railway stations in a city, taking an agglomerative approach rather than a point-to-point one and reacting globally to various events occurring at railway stations within the cluster

Sub-capabilities

- Railways are a core part of smart city mobility management systems and city fulfilment and delivery services. Stations are key to smart city governance structure and development plans.
- Railways are connected to smart city mobility platforms for a seamless end to end journey within and beyond the city both in terms of physical transport such as buses, taxis, trams, etc. as well as connected in terms of data sharing.
- New designs of infrastructure and rail vehicles provide easy access and interchange between transport modes – capsules.
- Flow management systems guide customers safely and efficiently through stations and to/from adjacent transport hub and city infrastructure, using dynamic way finding, barrier free access and multi-sensory information systems.
- Platform management systems help passengers position themselves for their train and facilitate efficient boarding.
- Security and revenue protection at stations and interchanges are based on electronic gates using smart wireless technologies, ticket detection systems and biometrics.

Enablers

- Digital twin technologies
- Delivery of up-to-date data for services, connections, trains disruptions and other transport means
- Implementation of coherent rail and public transport timetables (rail-city/city-rail)
- Integration of data between rail and last mile providers
- CCTV systems and passenger flow technologies
- BMS systems at each train station for the purpose of management
- Digital display areas for consolidated information system and marketing purposes

11. Environmental and social sustainability

The Capability

Railways continue to deliver sustainable transport solutions as overall travel demand intensifies. Rail makes an increased contribution to the transport economic mix, decoupling environmental harm from transport growth. Railways are able to operate with minimal environmental impact and with a low carbon footprint. Inclusive and easy access is available for all citizens to railway facilities, products and services.

Sub-capabilities

- Adoption of 'circular economy and recycling on all kind of assets' principles enables the railway to move towards 'zero-waste' operation.
- Sustainable and ethical procurement and production reduces the carbon footprint, with a whole life approach and focus on inputs to the system, recycling, transport of materials, renewable energy, operations and disposals.
- A climate change adaptive approach supported by strategies at national and European levels mitigates the impact of climate change on the railway
- Green technologies enable the railway to operate exhaust emissions free and with low noise and vibration levels.
- Information and accessible facilities put railways within the reach of citizens as an inclusive, affordable and accessible transport system.
- Noise and vibrations as a permanent constraint associated to stricter regulations in terms of emissions and perceptions.
- Passengers comfort, onboard the trains and in the stations

Enablers

- Alternative Energy sources and alternative fuels technological solutions for vehicle propulsion
- Carbon footprint measurement technologies and applications,
- Advanced innovative materials (e.g. smart, recycled, renewable, self-regenerating, lighter), metal alloys and biomaterials
- Zero carbon or decarbonised materials.
- Geostrategic availability of the raw materials and the associated concerned assets
- Energy Capture, Storage and Transmission.
- Energy Harvesting.
- Interiors rolling stock modularity to ease permanent adaptation.
- Ease of connection to soft emissions level transport modes and micromobility.
- Development of more sustainable ESS (Energy Storage Systems) / Batteries.

12. Rapid and reliable R&D delivery

The Capability

An ecosystem for R&D, based on effective collaboration, the provision of greater technology testing, verification, and demonstration capabilities, and the rapid integration of technology into the railways, remove barriers to the adoption of new technologies and decrease time to market. This ecosystem is helped by relevant stakeholder groups devising the impending implementation scenarios and the corresponding deployment strategies, aiming to an overall increase of trust in the reliability of R&D solutions.

Sub-capabilities

- An R&D ecosystem with centres of excellence fosters a high participation in knowledge networks, opening new forms of collaboration, knowledge, and technology transfer from other industry sectors and keeping railway skill sets fresh and relevant.
- The sector has a strong commercial focus and awareness of the maturity levels of new technologies. There is a well-coordinated and fast decision-making process, reducing levels of risk and time to market.
- Virtual testing and verification, and efficient implementation processes speed up production and deployment of new products: digital continuity is supported from design to maintenance. There is close cooperation across the sector for standardisation and testing. Component- and sub-system driven development, and modularisation, are key elements of rapid deployment of innovation to market. Railways have a permanent focus on disruptive technologies, using their challenges and pain points to increase their innovation capabilities and pace of development.
- Agile development approaches, collaboration, a clear focus on outcomes, and early involvement of customers are the elements of customer centric innovations. Open innovation models invite potential collaborators.
- Reduction of formal barriers in introducing changes in the preparation and implementation of R&D projects, i.e., easy integration of new partners, flexible budget management, and the ability to verify assumptions in case of negative outcomes of research and development work.
- Ensuring synergy among activities carried out in various projects and partnerships.
- Elaboration of deployment strategies via dedicated groups with the relevant stakeholders can advise the rail sector on the market uptake of the innovation developed. Their work will support deployment of the innovative solutions via performance-based decisions. Outputs shall include clear roadmaps including migration plans, transition phase regimes and funding and financial schemes. helping to earn trust in the implementation of R&D present and future solutions in the European rail network.
- Removal of barriers and the integration in already existing sub-systems and corresponding rail system architecture

Enablers

- Enhanced testing, trialling, and validation facilities; piloting in real environment (such as test labs/test rigs/ test beds).
- Demand-driven & output-oriented research: RU/IM as consumer of research; focused work on use cases.
- Revised understanding of risks and requirements for proving new technologies and solutions.

- Consideration of human factors and socio-economic scope, involving training to obtain the development of a matching skills agenda correctly and timely coordinated.
- Incentivisation of developing innovative solutions to drive operational improvements, cost reduction, etc.
- Enabling collaboration between industry, academia, and other relevant actors
- Strategic coordination of R&D/innovation and technology roadmaps.
- Use of integration methodologies, including integration engineering to develop and support architecture framework as tool for fruitful collaboration, simple implementation and qualified innovation
- Resolution of interoperability issues slowing down the introduction of technology and innovative processes
- Provision of corresponding funding for innovation and deployment, important as railway market is mainly composed by public entities.
- Deployment strategies and groups
- Harmonised railway sandboxes, tackling legal and technical framework aspects, operational singularities and facilities involved (test tracks, test rigs, labs and pilot sections)
- Reduction of complexity and bureaucracy (red tape)
- Configuration of the related governance and its bodies in the rail system according to the vision and mission required.

Capabilities are not about isolated discipline that can be studied in parallel. Capabilities should drive R&I activities guided by a desirable impact. Industrial integration activities shall ensure that innovation can effectively be deployed, architecture should secure that innovations address concrete stakeholders expectation and investors needs.

Now we should find the general needs guiding our R&I (green box bellow) and use theses general needs to break down refine needs and new fields for R&HI, beyond the capabilities and their enablers.