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Deliverable D 3.3
Rail as benefit for EU society

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1. Executive Summary

The ambition of rail is to become "backbone of the Europe's sustainable multimodal transport system of the future, both for passengers and freight".

The segmented reports, including the analysis of the current situation of the rail ecosystem and trend projections, plus the significant case studies addressed in the deliverable D 3.2, already support such ambition. This WP3.3 report incorporates considerations and recommendations from previous visionary projects with a 2050 rail horizon focus such as Spider Plus, MARATHON, SPECTRUM, D-RAIL and Living Rail.

The progress in the desired directions seems to be somewhat slower than the objectives assumed in the 2010 Transport White Paper targets. In particular, national contributions appear to be behind the ambitions detailed in D.3.1 deliverable "Data Collection/As is situation".

In this document, in order to reinforce and justify positive perceptions of rail progresses, samples of recent virtuous actions have been summarized by exemplary categories:

- High speed rail & cross border developments,
- Local transport & smart mobility,
- Incentives & pricing policies,
- Network & infrastructure,
- Fleet & Rolling stock.

The strengths and weaknesses of the rail ecosystem were then combined with external forces or "drivers of change" that have already been identified and are expected to influence evolutionary change in the next few decades.

The strengths of the rail Ecosystems are the result of its positive relevance in the EU mobility system, the environmental and services dimensions, its highly extensive network and sub-systems, and their overall synergy.

In the last decades, rail has continued to build capabilities despite limited traffic gains but creating the conditions for accelerated growth in the near future. The successful experiences in virtuous countries and the demonstrated continuity of efforts, allow us to identify several strengths to be further exploited and expanded if rail is to become a pillar of European mobility.

Sustainability and cost competitiveness are major strengths achievable whenever economies of scale can apply. This potential will increase further after technology innovations. Technology is expected to improve efficiency, safety and security substantially supporting customers' seamless experiences. The co-modal redefinition of mobility can attract new traffic in a number of business segments. Rail infrastructure has both bottlenecks to be solved and significant free capacity, to be exploited with relatively limited "hard" and "soft" investments in order to achieve additional capacity relatively soon.

ICT, especially in exponential technologies, while having huge impact in all mobility segments, will facilitate co-modality (and therefore the role of rail), providing integrated offerings supporting seamless users' experience.

Rail will benefit from several industrialization and scale factors; price differential for users will

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incorporate increasing taxation for less sustainable modes and externalities. Harmonized infrastructural charges will occur partially as a consequence of this.

Rail freight, not only traditional long-distance transport, but also medium and short distances shows potential applying co-modal approaches. Within the various types of "Physical Internet" and other ICT enablers, combined transport has many new & relevant opportunities.

The terrible appearance of COVID 19 introduced new considerations likely to increase the points of strength of the rail freight system in general, but certainly favouring International rail Intermodal Transport compared to its main competitor the "road modality". Here drivers' crossing border operations associated to health control and quarantine seem to be an obstacle. Several Press articles and editorials have already underlined this situation.

Metro and light rail solutions are expected to be in good shape for increasing their role. In particular in urban space there is no alternative better solution (walking and biking excluded). Sustainability is a major strength. Increasing urbanization will create better condition for Metro & light rail because of better scale factors and less acceptance of congestion consequences of Road alternatives.

Passenger business is a natural space for growth. While most of the positive patterns are related to HSR innovation, lot of potential can be identified also in more traditional services both in serving commuting and local traffic and in serving other traffic segments. Being the investments planned according to new co-modal thinking, they are beneficial to the entire rail system, including freight and metropolitan needs.

There are still **Weaknesses** to face in the rail industry. The long lead time of any innovation has been unavoidable because of the rail complexity, the combination of 27 individually managed systems together with the network extension. The European uniform "Rail Space" is an objective yet to be achieved. High investment requirements are part of this complexity. Service performances can be a weakness unless new service policies enabled by the upgrading of operational capabilities, new processes of communicating and customer relationship management, allow to turn this weakness into a strength. The difficulties of the integration process with reference to liberalization, harmonization of regulations, infrastructural charges, etc… are part of the picture. Some EU countries participate to the European progress at different speed and conviction. In rail, unlike road, the service performance is as good as its weakest link and some Countries seem to be unaware of this, penalizing the whole rail ecosystem.

Identification of "drivers of change" contribute to point out **Opportunities and Threats** to the strategic scenario, suggesting ways to leverage Strengths and to mitigate risks related to Weakness. The overall impact of drivers of change is expected to play in favour of the increasing role of rail within the growing mobility demand.

The positive impact mainly includes (Opportunities):

- All modes will improve their sustainability patterns, but rail is expected to keep its advantages especially in terms of energy efficiency and emissions of pollutants versus Road and Air, even considering progresses in the other modes. Moreover, sustainability is becoming a central issue. COVID 19 may accelerate the transition towards smarter/responsible mobility due to increased environmental and safety/security

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awareness. The environmental dimension with the growing youth unrest driving towards energy conservation and the Planet resources respect, will be a driver for using more rail compared to other fossil fuels depending modes.

- Acceleration of policy developments in favour of public transport can be expected. Fiscal policies will favour more sustainable modes and rail centrality in co-modal perspective
- Growing demand patterns in future projections are expected better fitting rail (scale economies, intercontinental exchanges, urbanization, …)
- Public/private investments and new business models advantaging light assets and innovations, assume a growing role.
- Resiliency and mobility growing R&D capabilities are expected to develop effective solutions for managing dynamics
- Co-modal integration may benefit of long term more efficient time/space planning

Main bottlenecks and constraints to monitor include (Threats):

- Rail is a high capital-intensive business. Public resources are limited, and this represents a bottleneck.
- The EU Commission continuous efforts for the establishment of a genuine single market with adoption and implementation of the Commission Directives for achieving a fully interoperable systems are sometimes finding obstacles due to local interests of limited vision.
- Faster reaction of other modes to adopt ICT and exponential technologies and other dynamics

All these elements summarized with the SWOT (Strengths, Weaknesses, Opportunities, and Threats) methodology and are reported in Section 5 below according to the major segments of analysis (Freight, Metro & Light Rail, Passenger) plus the overall summary shown in the figure below.

Demand potential evolutions (due for instance to teleworking) and new requirements coming from Covid19 experience and the transition period from pandemic to the "new normal", have not been elaborated in their impacts. The impact and analysis of Covid-19 is too recent to be easily integrated within the project time frame.

Rail has much greater development potential for EU Society beyond the "Declared Opportunities". The "weaknesses" existing in rail services for many years, are mostly self-generated inside the system itself. If the EU Institutions together with the member States would undertake actions to achieve the uniformity of intents, objectives and modular organization as defined in the EU Railway Packages, the weaknesses would transform themselves in **positive elements** with benefits to EU Society beyond those currently evidenced.

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	STRENGTHS	WEAKNESSES
INTERNAL	• **Sustainability, energy efficiency and easier energy transition, safety differential also in future projections** • **Cost advantages in scale economies, long distances, high co-modality potential** • **Growing industrialization benefits from exponential technologies (ICT, DSS & AI, digitalization, materials, automation & mechatronics, maintenance, ...), interoperability, modularization** • **Core and Extended Network drive towards EU Rail area connecting most population and all big mobility nodes** • **HSR is rejuvenating all Rail ecosystem** • Limited de-bottlenecks to be overcome for satisfying demand and service growth • Local passenger transport solutions are fitting specific/relevant needs in self contained areas	• **Long lead time for implementing new services, investments, design/plan/build/ on new infrastructures/technologies** • **High capital intensity** • **Service performances not always competitive, inadequate mobility service integration in co-modal mind-set** • Slow EU harmonization (liberalization & regulations, infrastructure charges, etc...) • Multiple actors with inadequate collaborative Rail ecosystem approach • Aging staff with unclear replacement plans • Inadequate internationalization and competitive patterns • Limited service segmentation not always "inclusive" for passengers • Limited exploration of innovative use of available resources for synergies (HSR, City logistics, Postal/Express Services, ...)
EXTERNAL	OPPORTUNITIES	THREATS
	• **Fiscal policies favouring more sustainable modes and Rail centrality in co-modal perspective** • **Acceleration of policy developments in favour of public transport** • Growing demand patterns in future projections fitting Rail (scale economies, intercontinental exchanges, urbanization, ...) • Developments of light assets collaborative/ virtual integrated new business models and public/private partnership • Resiliency and mobility growing R&D capabilities for managing dynamics • Co-modal integration through long term more efficient time/space planning • Faster acceleration towards responsible mobility after COVID 19 crisis	• Rail is a high capital intensive business, public resources are limited • The EU Commission efforts for creating a uniform Rail space area are sometimes finding obstacles due to local interests of limited vision • Faster reaction of other modes to adopt ICT and exponential technologies and other dynamics

SWOT summary for the Overall Rail Ecosystem – Source: New Opera (2020)

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2. Abbreviations and acronyms

Abbreviation / Acronyms	Description
ADAS	Advanced Driver-Assistance Systems
AEA	Association Europe Airlines
AEI	Automatic Equipment Identification
AGV	Automatic Guided Vehicle
AI	Artificial Intelligence
ARE	Association for Research and Enlightenment
ATO	Automated Train Operation
ATP	Automatic Train Protection System
B2B	Business To Business
B2C	Business To consumer
BOP	Booking Optimization Platform
BSS	Business Support System
BU	Business Unit
CEF	Connecting Europe Facilities
CAGR	Compounded Annual Growth Rate
CER	European Centre for Research
CSI	Common Systems Interconnect
CT	Combined Transport
CTO	Carrier and Terminal Operator
CTS	Centre For Transportations
DRTS	Demand Responsive Transport Services
EEA	European Economic Area
ECMT	European Conference of Ministers of Transport
EFTA	European Free Trade Association
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
ERP	Enterprise Resource Planning
EU	European Union

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FP7	Seventh Framework Programme of the European Union
FTL	Full Truck Load
GDP	Gross Domestic Product
GNP	Gross National Product
GHG	Green House Gases
GPS	Global Positioning Systems
GSM	Global System for Mobile
GVA	Gross Value Added
HGV	Heavy Goods Vehicles
HSL	High Speed Lines
HSR	High Speed Railways
HVLDG	High Value Low Density Goods
ICE	Intercity-Express
ICT	Information Communication Technology
IM	Infrastructure Manager(s)
IOT	Internet Of Things
ISO	International Organization for Standardization
ITMMA	Institute of Transport and Maritime Management
ITU	Intermodal Transport Unit
JIT	Just In Time
KPI	Key Performance Indicator
LCL	Less Container Load
LD	Long Distance
LDC	Long Distance Commuting
LEZ	Low Emission Zones
LRT	Light Rail Transportation
LRV	Light Rail Vehicle
LTC	Less than Truck Load
LU	Loading Unit
MPI	Market Performance Indicator

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M&A	Merger and Acquisition
NDTAC	Noise Differentiated Track Access Charges
NOX	Nitrogen Oxide
NUTS	Nomenclature of Territorial Units for Statistics
OBU	On Board Units
OD	Origin-Destination
OEM	Original Equipment Manufacturer
OSS	One-Stop Shops
PKM	Passenger Kilometre
PI	Physical Internet
PPP	Public Private Partnership
PSO	Public Service Contract
PT	Public Transport
RFID	Radio-Frequency Identification
RMMS	Rail Market Monitoring Scheme
RO	Railway Operator
ROW	Right-of-Way
RPK	Revenue Passenger Km
RU	Railway Undertaking
SCM	Supply Chain Management
SCS	Supply Chain Specialist
SERA	Single European Rail Area
SME	Small Medium Enterprises
SO	Shunting Operator
SP	Service Provider
SWL	Single Wagon Load
TEN-T	Trans European Network
TEU	Twenty foot Equivalent Unit
TKM	Tonnes Kilometre
TPS	Train Planning System

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TSI	Technical Specifications for Interoperability
UCC	Urban Consolidation Centre
UIC	International Union of Railways
UIRR	International Union for road-Rail combined transport
VAT	Value Added Tax
VOIP	Voice Over Internet Protocol
V2I	Vehicles To Transport Infrastructure
V2V	Vehicles to Vehicles
V2X	Vehicles To many other resources
WLAN	Wireless Local Area Network
ZTL	Zone with Limited Traffic
WW	Worldwide

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3. Background, Objective and Methodology

This document constitutes the Deliverable D3.3 "Rail as benefit for EU Society" in the framework of the WP3 of TER4RAIL project S2R IPX-02-2018.

The objective is to build, based on statistics and information collected within WP3, strong arguments supporting the benefits of rail as backbone of the Europe's sustainable multimodal transport system of the future, both for passengers and freight.

The adopted methodology is aligned to the overall Project program.

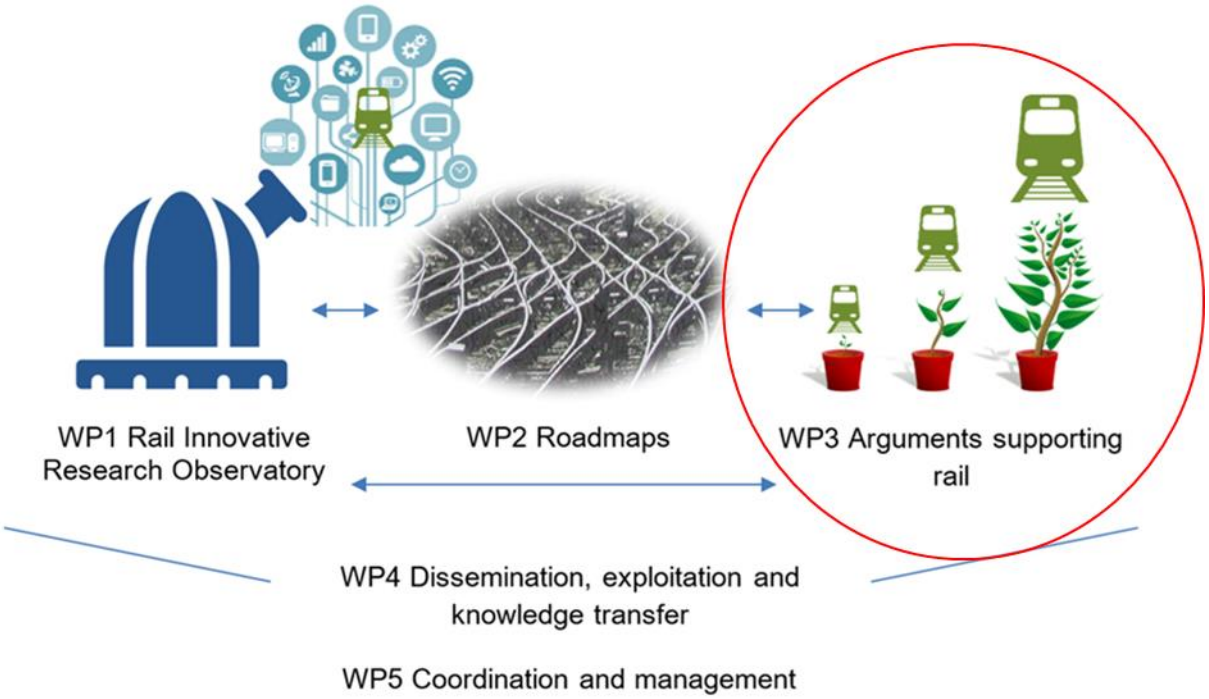

Figure 1 - *Overall Project Methodology (2018)*

The methodology includes both recaps and additional analysis regarding:

- identified variables such as climate, economics, and society in order to show rail as the safest, more sustainable, more reliable, less pollutant and most energy efficient mean of transport even considering the improvements in progress in all other modes
- emerging trends and scenario monitoring with regard to exponential technologies such as Internet of Things, smart communication, digitalization, big data, smart mobility in passenger and freight transport, blockchain)
- bottlenecks and gaps identification including considerations on how to overcome the gaps for increasing the rail role in future mobility

While keeping an open perspective to the entire mobility in continuity with the other WP3 tasks, here the focus became more concentrated on the Rail ecosystem.

The arguments in favour of EU strategies pursuing rail as preferred transport system of choice, are

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then further checked with two additional methodologies:

- Desktop study of examples of virtuous cases, past and ongoing at national level. These are further examined in order to confirm the consistency of measures and actions with the overall EU mobility strategy. These successful cases support the replication approach elsewhere and on EU scale.
- SWOT (Strength, Weakness, Opportunities and Threats) in order to summarize Rail strength and opportunities to be leveraged and weakness and threats to be overcome in order to manage successfully the recommended strategies. The methodology is applied according to the segmentation by individual "pillars" (Freight, Metro & Light Rail, Passengers) consistent with the previous analytical WP3 section and with a recap covering the entire rail ecosystem.

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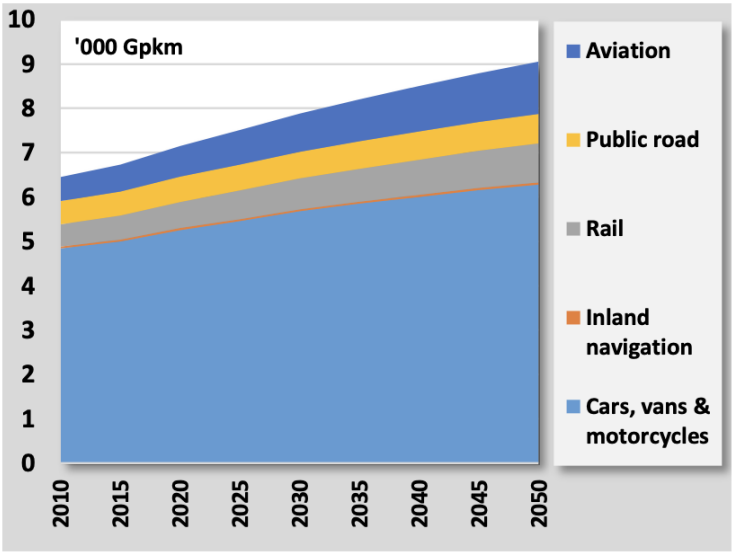
4. Reasons for growth

There is evidence to support that rail, is environmentally friendly mean of transportation (Kim & Van Wee, 2009; Pérez-Martínez & Sorba, 2010) and especially if more efficiently used can continue to satisfy large parts of the growing mobility demand for transport in a sustainable manner.

Social and demographic changes will affect passenger and freight traffic in the future. The change in customer behaviour will have to have been considered in every part of future rail development. Demand for mobility is predicted to rise to 2050 albeit at a slowing rate (Capros et al., 2016, pp. 58–60).



Note: The figure reports the aviation activity related to the domestic and inter-national intra-EU flights to maintain comparability with usual reported statistics

Figure 2 - *Passenger Transport Activity By Mode (Capros et al., 2016, p. 58)*

Older generations, a growing demographic, are forecast to use rail more frequently particular in urban and long-distance travel. On the other hand, young people are expected to have fewer cars and fulfil their transport demand throughout multi-modal transport options including walking and cycling using digital mobility services and active travel. The future user will expect rail to be fully integrated into the mobility landscape for a seamless maximum positive user experience, reliable and competitive in pricing and travel time with other modes. Personal well-being will be a user requirement that cannot be fulfilled by only physical transportation from A to B.

Leveraging the strengths of rail will justify the objectives of the ERRAC Rail 2050 Vision (Mazzino et al., 2017) to develop rail as backbone of the Europe's sustainable multimodal transport system of the future, both for passengers and freight. The following main items support this statement and are reported in the perspective of expected evolution to the year 2050.

While factors "internal" to the rail ecosystem have been largely addressed in the former WP3 deliveries (WP3.1 and WP3.2), here the attention is on "external" conditions consistent with an increasing rail role in mobility. It is not always easy to separate internal and external elements,

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being part of an integrated socio-technical system (Wilson, Farrington-Darby, Cox, Bye, & Hockey, 2007).

The following factors, identified mainly as external, justify:

- the need for a more substantial role of rail in contributing to overall mobility correlated to economic and social progress,
- the identification of favourable conditions for this to happen to meet this challenge.

Analytical quantitative evaluations are not in the scope of this project. While elaborating in support to the above statement, in this document there is no evaluation about the quantitative objectives in the White Paper and about the achieving full results in the target time frame.

In the following some considerations coming from projects on 2050 visioning, such as Spider Plus and Living Rail, are reported and shortly recalibrated for the advantage of this project, together with some additional notes. This is in preparation of the SWOT summary - the focal contents of the document.

4.1. Drivers of change and rail as transport system of choice for the future

Megatrends and drivers of change support Rail as transport system of choice for future. While their impact will be undoubtedly high, there are uncertainties over the method and speed of such drivers and change. Driver are listed by groups by bullet point, with short comments when necessary.

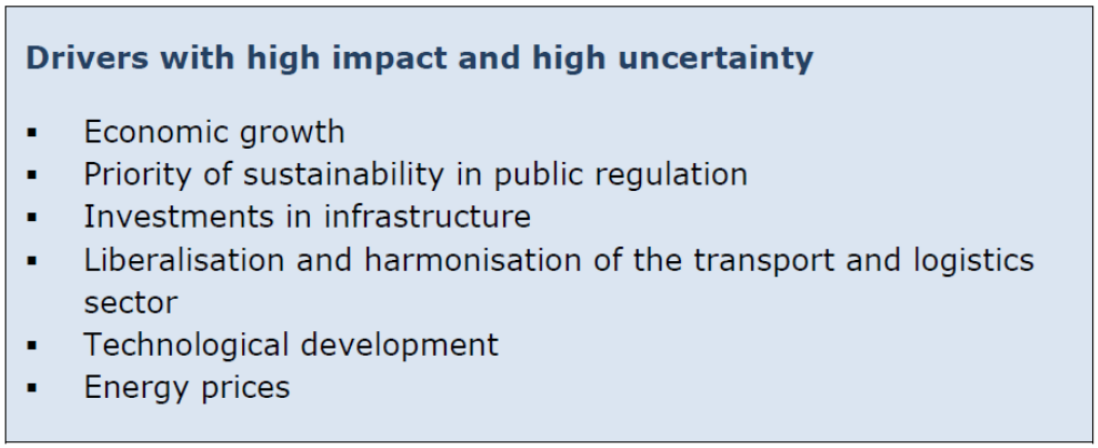

Figure 3 - *Drivers with high impact and high uncertainty - source Spider Plus project (N.Pieri & F. Castagnetti, 2013)*

4.1.1. Economics

Energy/Resources: Increasing energy costs; overall scarcity and distribution of natural resources,

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transition from fossil fuels, push for more efficient modes.

Financial resources: scarcity and increasing competition for public investments in infrastructures; pressure to better utilize existing assets (the capacity of the freight transport can accommodate 300% more volumes with 50% increase in assets (Punte, Tavasszy, Baeyens, & Liesa, 2019). Rail capacity, both for passengers and freight is generally considered largely unsaturated outside of certain dense urban areas.

Globalization: Increasing international trade to and from Europe results in relative higher share of long distance transport for freight.

Economic shift to the East: Growing exports/imports from the Asian bloc; in particular China and India imply increasing potential both for rail and co-modal transport for freight.

Economic shifts: Emerging markets; balance of global economic power; trading blocs; financial and economic uncertainties; larger container ships increase 'port centric' logistics.

4.1.2. Social & environmental

Demography - Population growth increases demand for transportation in the areas of growth. In Europe population dynamics is not homogenous both by countries and by regions. Expanding middle class societies: Increasing demand for consumer goods and growth in international trade & tourism. Ageing society: Creates growing demand for safe and secure transportation with user friendly solutions.

Lifestyle - Shifts in lifestyles: Environmentally conscious; hyper connected; collaborative consumption; focus on improving quality of life; less materialistic. Personal technology: Enabling social & economic change; new forms of mobility. Employment/working patterns: Shift to the knowledge/digital workplace; new flexible work styles, locations; remote working; continuing shift to service industries. Changing nature of demand: High Speed; convenience; reliability; improved distribution; high tech; inter-modal; individualization. All conduces towards sustainable mobility even if increasing demand of consumer goods (see above point on "demography") and other evolutions may apply differently according to increasing differentiated population segments.

Sustainability - Environmentalism: Growing international/national/local support for measures to protect the environment and create sustainable solutions. Consistent consideration of externalities helps in comparing real full cost of alternative mobility solutions. Carbon based energy depletion: it stimulates the adoption of alternative, renewable energy sources; it expands the market for renewable technologies.

Urbanization – Agglomeration trend and urban developments: Urbanization in Europe is taking different forms. The development of metropolitan areas and of similar mobility models not only for big cities but also for relatively smaller urban agglomerates, become the engine of economic growth and innovation. It places new demands on urban transit and spatial planning. Potentially increases congestion creating opportunities to metro and light rail. At the same time concentrates demand in points to be effectively linked with rail connections (HSR preferably). It increases urban logistics centre demand even in multi-channel retail, creating critical mass for multi modal city

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hub.

Regulation - Regulation & sustainability: Environmental goals drive innovation; regulatory measures encourage shift from road to rail. Tighter regulation impedes market growth but supports sustainability. Policy innovations: Infrastructure separation; expansion of private sector through franchising and Public Private Partnership; regulation changes; tempering of bureaucracy drive changes. Liberalization & structural separation: It creates increased competition, encourages new entrants; alters the cost base as operators seek efficiencies and leverage their scale.

4.1.3. Rail versus other modes dynamics

High innovation in all alternative modes and in particular in the road and the aviation sectors, justify expectations of much better performances in terms of sustainability and overall competitiveness. There is no expectation that rail will lose its advantages so continuing to be the central mobility option as individual mode and in co-modal perspective.

COVID 19 is likely to modify the mobility demand (due for instance to teleworking) and to introduce new dynamics on the traditional criteria of evaluations of the points of strength of the competing modalities such as Road and Air. At the time of writing this report COVID 19 is still unresolved and is likely to remain for some time in the near future. The long term effect of this permanence cannot be foreseen or evaluated however during this experience the rail system seems to be favoured by events at least for some transport segments as for instance for freight.

- Road – Vehicles: the progress mainly involves the reduction of the exhaust emissions aiming at zero emissions through advancement of powertrains, use of alternative fuels, preservation of natural resources and waste minimization through recycling of end-of-life vehicles as well as reduction of noise emission; improved active and passive safety. System concept: upgrades transport systems through application of traffic organization solutions such as design of road infrastructure hubs or traffic flow management; prevention and control improve safety.
- Road freight – Operational efficiency: Load optimization, Load consolidation and asset sharing (bundling shipments across product categories with similar characteristics - destination, time constraints - through horizontal collaboration, combined freight and warehouse exchange platforms, pooling and bundling/cross-docking, urban consolidation centres). High capacity vehicles, platooning, routing are all actions in the directions of cost reductions and increased effectiveness

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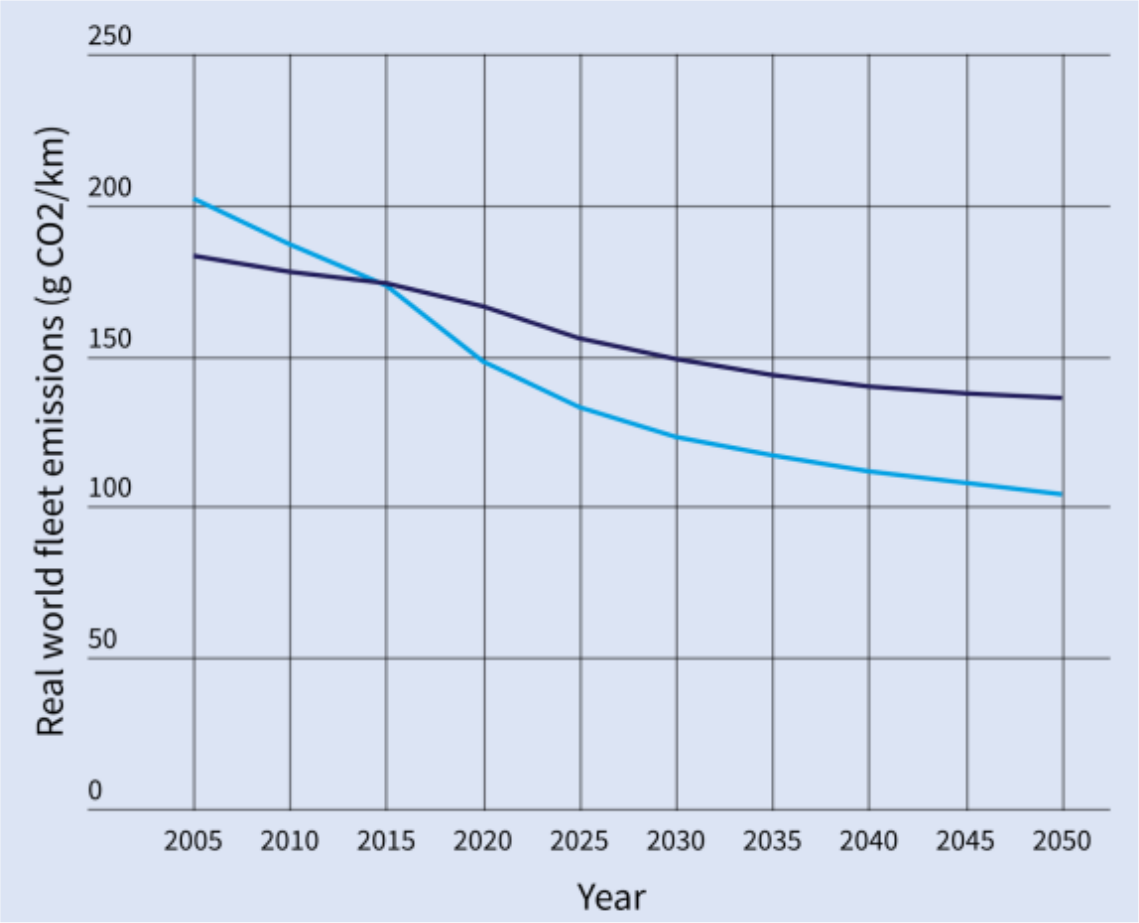

Figure 4 - *Comparing baseline for passenger and car fleet efficiency - Source CO2 EMISSIONS FROM CARS: the facts - European Federation for Transport and Environment AISBL (2018)*

- Air – Aviation being aware of the new citizens' awareness on atmosphere emissions is acting on technological improvements: aircraft, engines and systems, optimization of operating procedures, development of aviation infrastructure, direct flights. Fuels: availability of bio kerosene at large scale (the CO2 absorbed by the plants during their growth phase may compensate in a life-cycle basis up to 80% of their combustion CO2 emissions); hydrogen/electricity as an energy source; compensation of emission by funding the plantation of trees. Noise reduction: new ICAO certification standards; land use regulations in airport areas. Safety: advanced satellite-based navigation systems and more redundant man-machine interface should move the fatal accident rates to the 1 every 20 million flights in 20 years. Security: improving the existing access control system and introducing personal profiles at large scale. Structured solutions for reduced mobility people. All undertaken actions towards more acceptability and sustainability.

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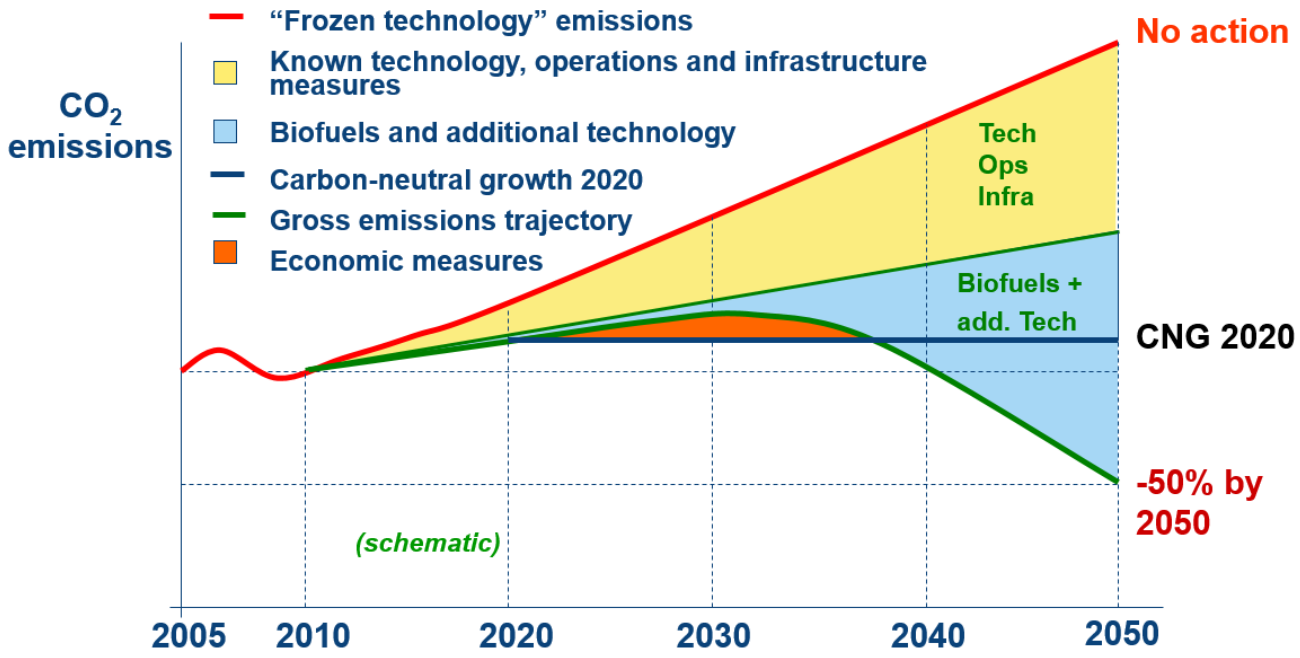

Figure 5 - *ICAO plan to mitigate aviation climate change contribution - Source A.Benito & G.Alonso - Recent trends in Air Transport Sustainability, Universitad Politécnica de Madrid (2016)*

- Rail – a number of technological improvements are coming. S2R programs, compiled in August 2019, show a structured list of 54 technologies illustrating "successful R&I results in the form of possible products and solutions including delivery dates, while highlighting the benefits for final users, operators, infrastructure managers and/or suppliers (Shift2Rail Joint Undertaking, 2019). These innovations as well as the exploitation of results already achieved in terms of R&I will contribute to rail performance both in terms of sustainability, safety & security and of overall business competitiveness. Energy efficiency and the reduction of emissions will be relevant results. The industry is certain to achieve these results for two reasons: the performance in last decades has been already much better than expected and the actions in place guarantee future success. So, when on 28 November 2018, the European Commission called for a climate-neutral Europe by 2050 in its Strategic Long-Term Vision, the rail industry welcomed the more stringent targets and the additional 2005 base line as reference for improving the monitoring of the progresses. This European Commission call follows previous CER and UIC resolutions. "In 2008, CER adopted voluntary targets for Greenhouse Gas Emissions (GHG). These were later developed and expanded in partnership with UIC to include targets to be achieved by 2020 and 2030, in addition to a vision for 2050" (UIC, 2019). Although the focus of data in picture below is not on urban rail, they apply to cities as well.

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... in the next 5 years		...in the coming decades	
Digitalisation	10	Digital transformation	10
Materials	8	Materials	7
5G	5	Artificial Intelligence	6
Automation	5	Automation	5
Batteries	5	Autonomous mobility	5
Big Data	5	Power sources	5
Energy	5	Hyperloop	4
Condition based maintenance	4	Big data	3
Artificial Intelligence	3	Energy	3
Building Information Modelling - BIM	3	5G Wireless connectivity	2
Automatic Train Operation	2	Condition based monitoring & predictive maintenance	2
Augmented Reality	2	Environment necessities	2
Block Chain	2	Internet of Things	2
Communications	2	Nanotechnology	2
Internet of Things	2		
Monitoring technology and sensors	2		
Power sources	2		
Signalling technology	2		

Figure 6 - *The most promising technologies or innovations that have the potential of transforming the Rail sector - Source EURNEX elaboration based on a number of documents from different sources and notably from ERRAC, Shift2Rail and STRIA (2019?)*

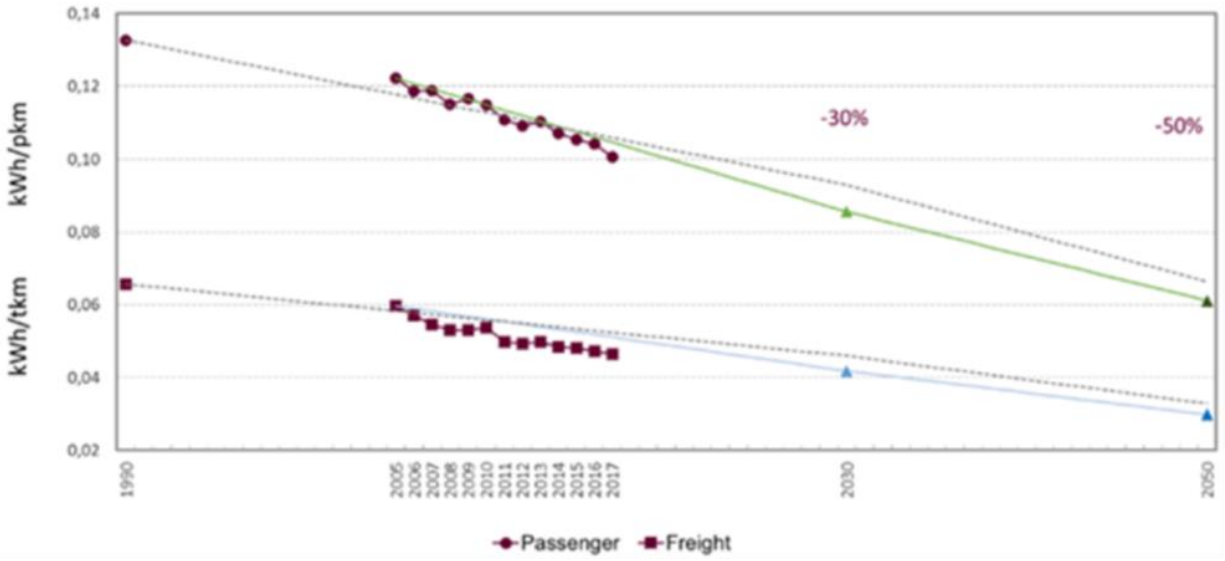

Figure 7 - *Specific final energy consumption of passenger trains in kwh per pkm (top) and freight trains per tkm (bottom) - ESRS 2019 - Source UIC Adoption of new sustainable mobility commitments (2019)*

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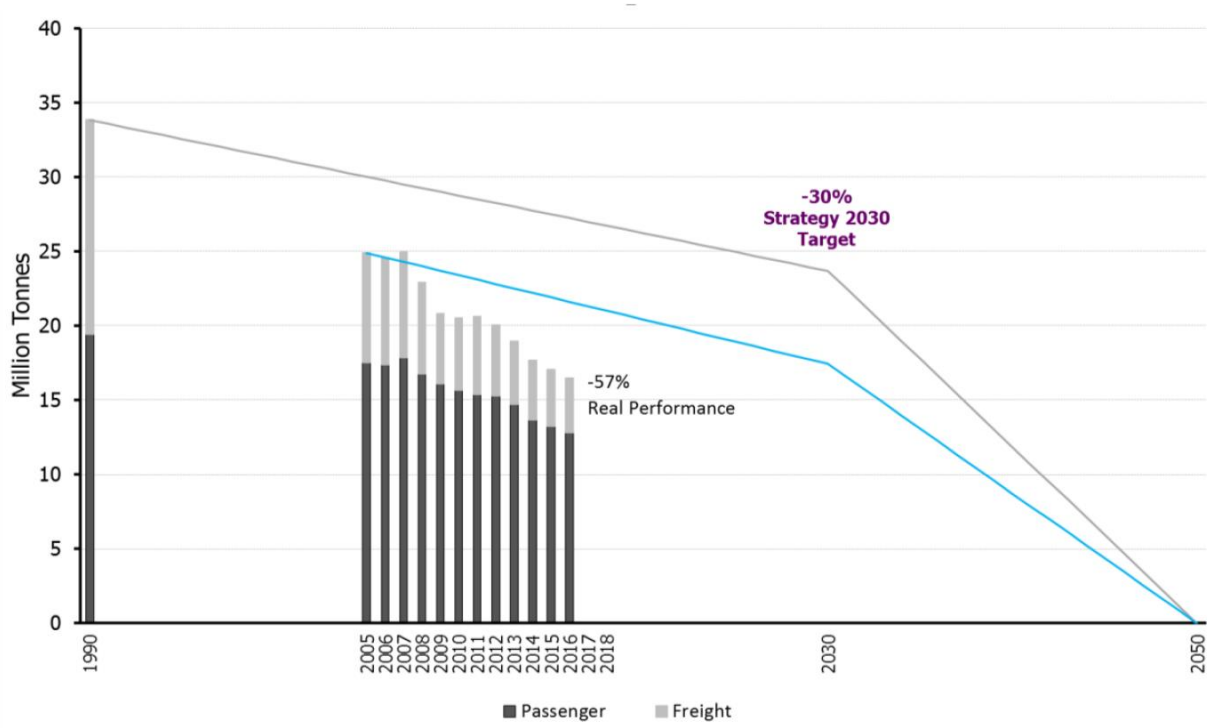

Figure 8 - *Total GHG emissions in million tons CO2eq - ESRS 2018 – source UIC Adoption of new sustainable mobility commitments (2019*)

4.1.4. ICT and innovative technologies

All technologies will show substantial progresses often leveraging incorporation of ICT in traditional technologies.

But ICT itself is expected to play as "Exponential Technology" in peculiar applications. An Exponential technology in each period, doubles in capability or performance (or halves in cost in each period). Its price-performance makes possible solving business problems in ways that were not previously possible.

For mobility the key enabling technology will be C-ITS (Co-operative Intelligent Transport Systems) which will enable data exchange through wireless communications so that vehicles can connect and interact with each other, the road infrastructure and other road users. C-ITS is a subset of ITS, Intelligent Transport Systems. These are computer applications, communications and other information technologies for improving the efficiency, robustness and safety of transport (Zunder, 2019).

How the rail ERTMS systems and automotive C-ITS systems integrate and enable MaaS, "mobility as a service", will be key to whether this is an exponential technology for rail as well as road, and over what period(s).

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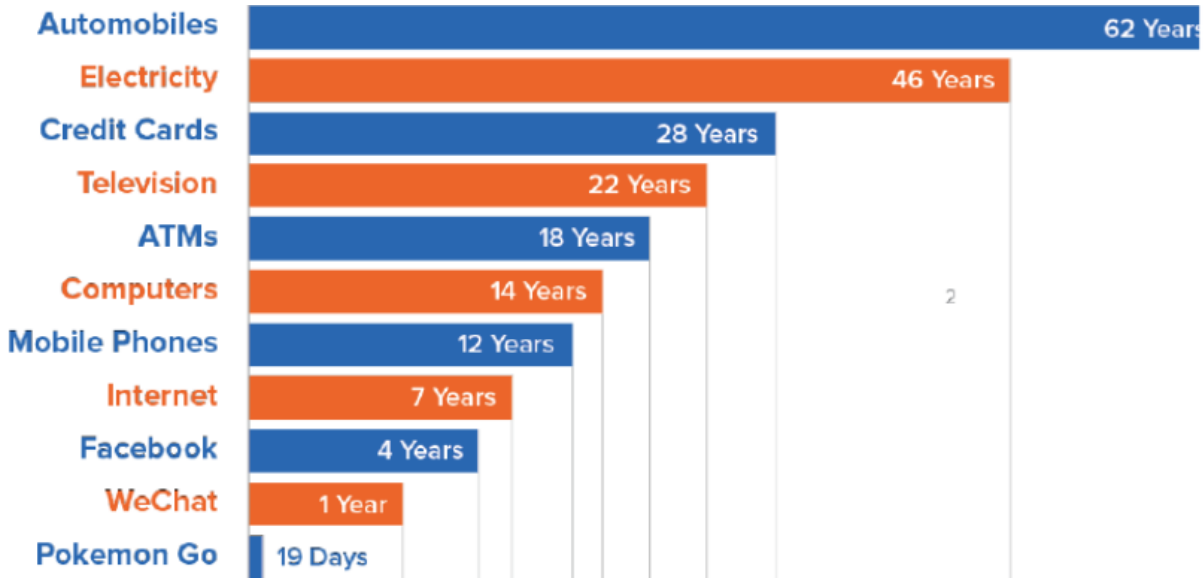

Figure 9 - *Time for a given product or technology to reach 50 million users - source internet blog*

Exponential technologies are intended: Internet Of Things (IOT), Blockchain (BC), Physical Internet (PI), Additive Manufacturing and 3D printing, Drones, Robotics and autonomous vehicles, Artificial Intelligence (AI) and Explosion in Connectivity, Data science, Augmented Reality & Virtual Reality (AR/VR), Voice Recognition, Digital design, simulation and integration, Energy storage, Nanotechnology, Cyber security, High performance computing, (other names to be added according to preferred segmentations, different criteria as reference timing and applicability to mobility). All these will drive disruptive evolutions and benefit all modes. They will favour integration between modes enabling much more user-friendly co-modality.

Enabling SW: they include actions to extend the competitive range of mobility services; to improve efficiency and communications; to favour integration and control of systems operations; to reduce costs; to reduce need of investments because of better use of infrastructure and other assets; to improve the service quality safety and sustainability; to introduce new business models.

Communications: involve availability of integrated information and services based on internet of things standards and communications between vehicles and infrastructure as well as integrated on-board/home-based computer systems that are interconnected via data links based on GSM/WAP or mobile internet.

Seamless: it means seamless passenger experiences with information chain from booking to client updating. Transparent logistics in freight services matching customer requirements.

Air to rail to road co-operation: Greater levels of co-operation will set and deliver new standard of end-to-end performances.

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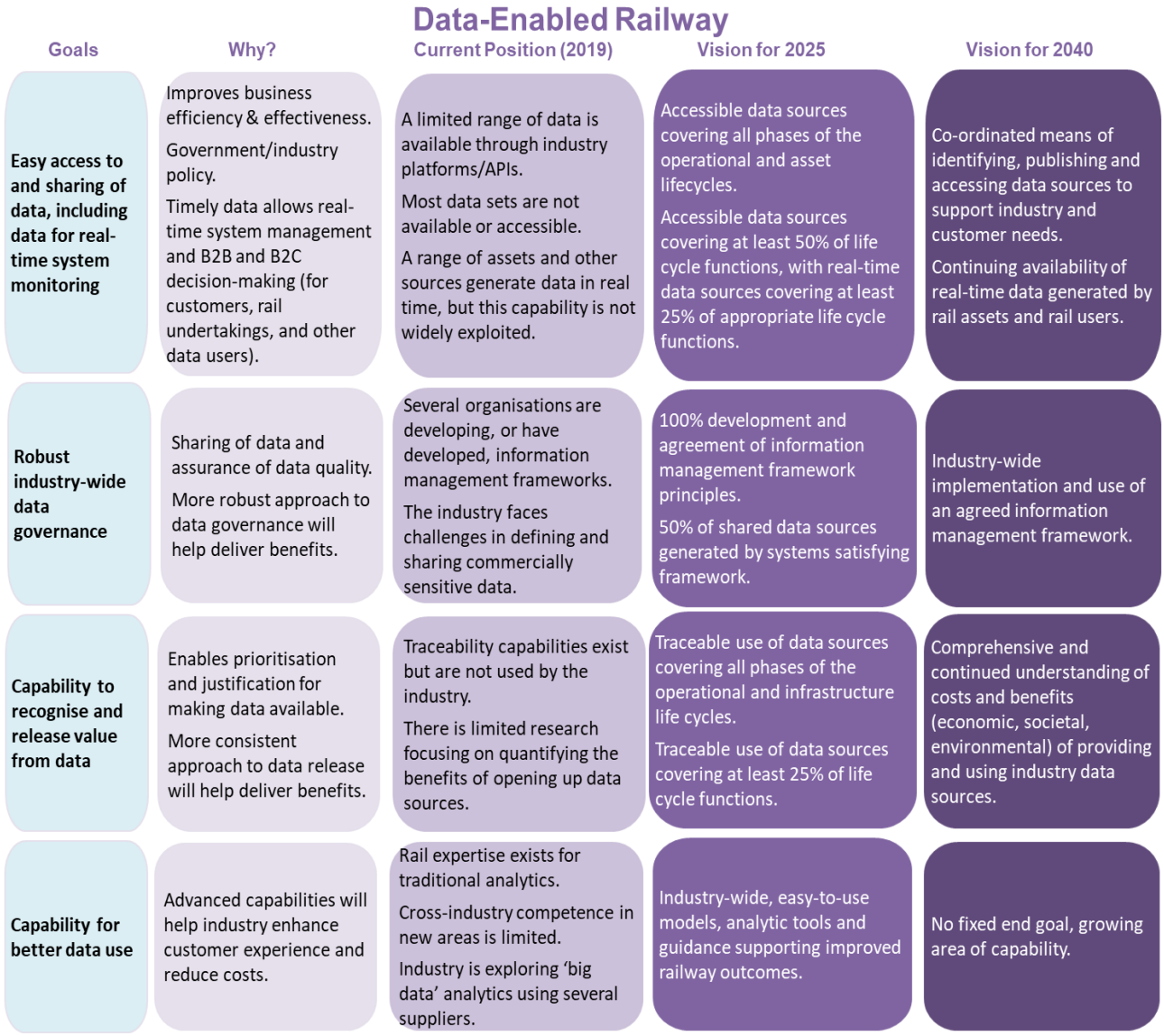

Figure 10 - *Data enabled Railway – source; UK Rail Technical Strategy – RTS (2019)*

4.1.5. Constraints and bottlenecks to overcome

A number of constraints and bottlenecks are to be overcome such as:

- Wide public support: Level and pace of investments: Risks of underinvestment and even infrastructure decaying. Rail does not receive sufficiently high visibility on the national or European agendas.
- Coordinated national government commitment: Resistance to change from national rail operators together with increased investment in roads. Political challenges from national governments. Nationalism/Protectionism.

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Figure 11 - *Cross Impact crucial to achieving progress – source Spider Plus project (2014)*

- Public/private investment: Financial barriers hindering the rapid adaptation of new Trans-European rail solutions. Actions of hostile lobby groups. Unclear economic setting for involving private financial resources.
- Establishment of a genuine single market: Tardiness of Member States' adoption and implementation of Commission Directives. Non-interoperable systems. Market liberalization varying significantly between Member States. Lack of competition impeding a single European Railway area.
- Adoption of new technologies: Bureaucracy involved in introducing innovations. Challenges to rail's environmental credentials.
- Redefinition of segmented requirements and their incorporation in normal business against pandemic risk as emerged from the Coronavirus experience.

4.1.6. Rail 2050 Vision: Agreement and Dissent

In TER4RAIL Task 2, a comprehensive Delphi Study confirmed the following core statements of the Rail 2050 Vision (Mazzino, N. et al., 2017):

- Rail Freight transport units in 2050 in Europe can communicate with one another as well as with infrastructure and operational facilities, minimising downtime.
- Passengers across Europe are able in 2050 to access real time personal communication and new services for work or leisure continuously, before, throughout and after the journey.
- Rail in Europe in 2050 is the backbone of urban mobility, with intelligent stations at the heart of smart cities, being life-centric places to work, meet and communicate.
- The rail sector of 2050 manages a growing volume of data in Europe contributing to the data economy. Collection, analysis interpretation and prediction are automated to provide consistent up-to-date information, supporting fast, well-informed decisions and business benefits.

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- By 2050 rail has maintained its place as the safest transport mode and this is recognised and valued by European citizens. Zero casualties per year is the current status of the rail sector at urban, regional and inter-city level.
- In 2050, rail transport in Europe is the backbone of an intermodal Mobility as a Service for passengers within cities and beyond, meeting the needs of customers, EU citizens and society.
- By 2050 innovative logistics services in Europe are driven by customer demand. Shipments are moved effectively, efficiently, safely and securely through the "Physical Internet". [https://en.wikipedia.org/wiki/Physical_Internet]
- Manned and unmanned autonomous intelligent vehicles operate safely on the same European railway network of 2050, controlled by artificial-intelligence based traffic management systems.
- By 2050 European railways are a core part of any smart city planning, mobility management systems, and city fulfilment and delivery services, promoting interconnection by freeing up land which was previously needed by private road vehicles and minimizing pollution and congestion
- By 2050 new energy-efficient station designs in Europe provide easy access and seamless interchange across all transport modes, enabling railways to manage growing passenger volumes and mobility demands
- The European rail system of 2050 is fully integrated with the automated multimodal logistic chain forming the backbone infrastructure, comprising new intelligent, automated cross-modal shipment transfer nodes.

However the panel also noted dissent and nuances in the following modified statements that were finally agreed in addition:

- By 2050 the rail freight sector will have to have addressed some fundamental issues around cost, asset utilization and customer facing connectivity.
- Rail is more of a mass transit solution. Tailor-made autonomous journeys will not be the solution. By 2050 as a backbone, rail in Europe will provide journeys on a regular time table so other "light" transport modes can offer autonomous trips.
- In 2050, by obliging access to data from all providers for all modes and all asset and service providers, relevant information is shared across the European rail stakeholders as a part of the data economy.
- The majority of citizens in urban areas across Europe will have easy tailored access to mobility services by 2050.
- Only if the rail sector is financially supported through capital investment, large amounts of which are needed now, can the European rail system in 2050 be able to detect, understand and respond to individual and collective European citizens' mobility needs, delivering tailored, on demand, integrated end-to-end mobility solutions.
- In 2019, Europe is still a leader in the railway products and services. But by 2050, companies from Japan, South-Korea and China would probably be the new leaders.
- People in cities feel safe and secure using European rail services in 2050 thanks to non-blocking security systems.

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Dissent and nuance were found in the common themes from the Delphi panel and these resonate with this SWOT analysis:

- Market orientation;
- Cost, competition and efficiency;
- Leadership, political issues, lobbying, government intervention for good or ill;
- Lack of seamlessness for many reasons;
- Inadequate speed of reaction/investments compared to Asian competitors;
- Lacking technical/technological innovations and skills;
- Language barriers;
- Different regulations barriers in EU rail space;
- Info, data availability sharing and management;
- Safety and security issues;
- Accessibility and capacity;
- A limiting of scope from universal visions to
    - Urban,
    - Native,
    - Backbone.

4.2. Examples where rail is fast building success

Quick examples of recent initiatives taken at national and local level for pushing the rail as preferred mode are reported hereafter. The virtuous ongoing examples confirm the applicability of measures and actions consistent with the overall strategies. Their successes already in progress support the strategy being potentially replicated elsewhere and possibly on EU scale. The selection of examples is based on qualitative/quantitative elements privileging very recent information (about last two years).

4.2.1. Competitive models: HSR & Freight

HSR has been described in previous deliveries (Data Handbook and Case Studies) of this WP as the most innovative element of the entire rail ecosystem, including its central role in shifting traffic from air and attracting new categories of travellers. But innovation has still to deliver full results since progresses are still being made.

The competition is progressing overcoming residual barriers still existing for protecting incumbent rail operators. This dynamic is bringing positive evolution as experienced especially in Italy on Milan-Rome route.

As example of most recent events there is the Trenitalia's award of HSR services for the Madrid-Barcelona, Madrid-Valencia/Alicante and Madrid-Malaga/Seville connections. "The ILSA consortium, comprised of Trenitalia and Air Nostrum, has been selected by ADIF, the Spanish Railway Infrastructure Manager, as the first private operator to enter the Iberian market. The commercial service is set to commence in January 2022 and shall have a duration of ten years (https://www.fsitaliane.it/content/fsitaliane/en/media/press-releases/2019/11/27/spain--trenitalia-awarded-hs-services.html)".

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This new move is an important example of internationalization of rail operators in the passengers' arena, even if the business remain largely national and local. Trenitalia subsidiaries are present in Great Britain with Trenitalia c2c (commuter transport) and Trenitalia UK that will operate InterCity services from London to Glasgow/Edinburgh (West Coast Partnership) as of 9 December 2019; ; in UK the construction of the London/Birmingham leg has been contracted out signifying an important milestone for HSR diffusion; in Germany with Netinera (passenger services); in France with Thello (international Italy-France connections); and in Greece with TrainOSE (passenger services).

Similar examples of progresses in the passengers' business international presence are provided by other major "incumbent" players as SNCF and DB.

As said, competition on long distance (LD) and especially cross-border traffic appear at an early stage of development. In HSR International connections are still very limited confined to London/Paris, London/Brussels and Paris/Brussels just to indicate the most representative. The HSR is not yet an international option for millions of passengers in continental Europe and this represents a very substantial area for growth.

Their natural evolutions facilitated by HSR investments and the EU's large-scale approach for liberalization coming from the fourth railway package, will support new strategies addressing a market (only rail revenue pool), according to a McKinsey analysis of approximately EUR 25 billion/year (with 20 to 30 percent EBITDA margin). On such routes intra modal competition appear low while new HSR performances may shift large traffic from air in continental medium distance routes.

Current national experiences such as in Italy and Spain, on different aspects, support large growth expectations on continental basis on similar distances while real traffic are still relatively modest.

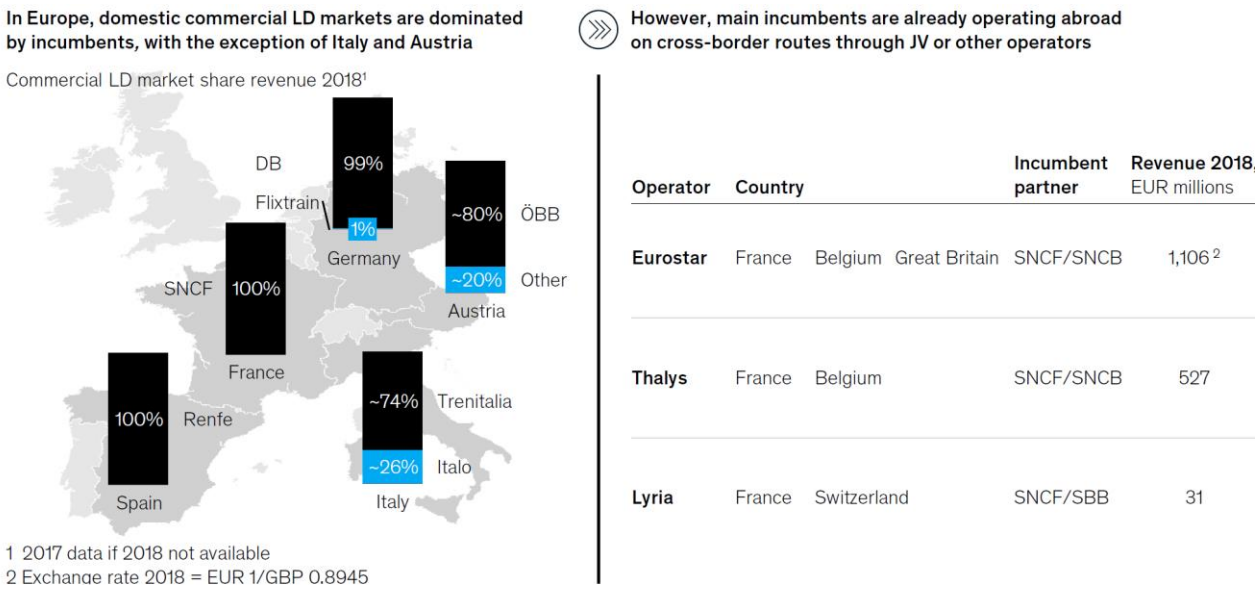

Figure 12 - *The liberalization of the EU passenger rail market – Growth opportunities and new competition - source McKinsey & Company (2019)*

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While investing in HSR it is important Rail does not forget other market opportunities. An example is "Night train services" which nearly disappeared in Europe because of the uncompetitive service quality compared with aviation. Starting in late 2021, night trains connecting European capitals will be reshaped: Paris-Vienna, Paris-Berlin, Brussels-Berlin, Köln-Zürich, Zürich-Barcelona, Zürich-Roma, as examples. This market segment is a new opportunity for Rail through fast and modern restructured services.

In the Freight business, internationalization has much longer story (see delivery 3.1), because of business peculiarities, but not yet consolidated. Relatively more recent are vertical integration moves with sea transports that can speed up the rail success. In fact, intermodal transport is foreseen the segment with higher potential. Here are reported recent moves of Cosco in connecting by rail, sea and inland operations.

On November 2019, OceanRail Logistics S.A. affiliated to Cosco Shipping Europe acquired a 60% stake in PEARL S.A. "OceanRail Logistics S.A. specializes in sea-rail intermodal transport with the Piraeus Port as the hub and related logistics business, while Piraeus Europe Asia Rail Logistics S.A. (PEARL) is a Greece-based company engaged in railway operations. The China-Europe Land-Sea Express Line, which starts from the Piraeus Port in Greece and expands to the hinterland of Central and Eastern Europe, covering North Macedonia, Serbia, Hungary, Austria, Czech Republic and Slovakia, is the third new trade corridor from the Far East to Europe and effectively connects the 21st Century Maritime Silk Road and the Silk Road Economic Belt (https://www.logistik-express.com/cosco-shipping-takes-control-of-greek-railway-company-pearl-s-a/)".
This move is parallel to the one in Croatia. "The new shipping and intermodal service COSCO Rijeka Land Sea Express, connecting the northern Croatian Adriatic port to central Europe, was formally launched at the port's Brajdica container terminal (https://www.total-croatia-news.com/business/39170-cosco)" on October 2019. The traffic targets routes to Budapest and Belgrade.
Similar move is expected by Cosco group in Italy (already preliminary announcement in 2020) where other players had similar move. Other examples of vertical integration to be remembered are MSC (with Medway Italia - 2019) and less recently Contship. CMA made in 2019 a major logistics acquisition "CEVA Logistics" having a European and global reach. In North Europe several Joint ventures have been in operation since long time between deep/short sea carriers and intermodal rail operators.

4.2.2. Local transport & Smart mobility

Rail actors can play proactively in order to encourage co-mobility in key nodes where the different modes are connected.

The 2019-2023 plan of Italian State Railways (FS) include the building and implementing the connections with regional airports including Bologna, Catania, and Genoa. Venice will start to be improved from 2020 onwards. For freight, the plan includes rail links to ports such as Civitavecchia and Genoa with impact not only on freight but also on reducing urban congestion.

"Such investment plan envisages a new role for FS in cities. To this end, FS will invest a total of €5.3bn, with €1.9bn allocated to upgrading intermodal hubs, €1.8bn for smart city and smart station projects, and €1.6bn for improving urban transport. In addition, €1.9bn will be spent on

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redeveloping urban spaces (https://www.railjournal.com/in_depth/fs-sights-new-horizons)".

A number of initiatives are in place for increasingly coordinated development of smart and co-mobility (sharing mobility, bus terminals, parking, etc…) in major cities centered in local hubs with the support of local authorities and local transport companies.

The Luxemburg move to offer free local transport is by far the most significant recent event to point out about local mobility. Limiting congestion due to commuting, looks to be the main target.

"Luxembourg is proud to be the first country in the world to offer nationwide free public transport. Since 01/03/2020, your travels are a lot easier: you no longer need a ticket to board any national bus, train or the tram. However, first class train tickets and passes remain valid and there is no change or discount for them. Free public transport ends at the border. This is why cross-border tickets have been reassessed. Commuters from neighbouring countries benefit from reduced fares! (https://www.mobilitegratuite.lu/en/free-mobility/)".

Since public transport in cities is largely subsidised, some cities in Europe, have switched to free public transport. The increase of financial support to public transport, extended to metropolitan areas/entire regions, can be a paradigm shift favouring rail transport. The large success of the trial periods in the cities where free public transport has been introduced could become a driver for more extensive implementation throughout Europe.

Because of Coronavirus mobility is slowing down because of limitations. The impact evaluation and implications into the various modes need to be consolidated. Also, the phasing of any decision with long term planning required for infrastructure and mobility services, should be part of such evaluations. This is a political and economic decision.

There are also initiatives more addressed to building the culture of smart mobility than to influencing the rail share. But they are in any case worth to be mentioned. An example is Lahti somehow reshaping the concept of "crediti mobilità" explored some 15 years ago in Genova.

"The city of Lahti, in Finland, has launched (September 2019) the EU-first Personal Carbon Trading (PCT) scheme in a bid to promote a shift towards sustainable mobility from private car use. The scheme is based on a mobile app, CitiCAP, which calculates the personal weekly emission budget for each user and encourages trips that require fewer CO2 emissions (https://www.eltis.org/discover/news/lahti-launches-eu-first-personal-carbon-trading-pct-scheme-mobility)". Each participant shall receive a weekly allowance of CO2 corresponding to approximately 90 km per week. Users that spend less than their CO2 emissions budget, thereby polluting less, will receive a reward.

4.2.3. Incentives & Pricing policies

"Germany's government coalition on 20 September 2019 agreed on a strategy paper that outlines its policy ideas to reach the 2030 climate targets and reduce emissions in all sectors of the economy. …. Germany will introduce a national carbon pricing system in the transport sector, which are not part of the existing European emissions trading system (ETS) - except for aviation emissions. The national carbon pricing will start in 2021 with a fixed allowance price of 10 euros

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per ton of CO2. Allowances prices are then going to rise to 20 euros in 2022, 25 euros in 2023, 30 euros in 2024 and finally to 35 euros in 2025 …. The government wants to do away with flawed incentives regarding low flight ticket prices and plans to increase the aviation levy by 2020 to avoid that airlines use "dumping prices ….. Tickets must not be cheaper than the combined costs of applicable taxes, surcharges and other fees (https://www.cleanenergywire.org/factsheets/germanys-2030-climate-action-package)."

"In 2019 Germany will reduce railway track costs by up to 50% for a period of five years, allowing railway companies to invest and improve competitiveness, while in Italy incentives are in progress and in the process of discussion in other countries, and in Switzerland, two-thirds of the current state subsidies for intermodal transport can be offset by productivity gains thanks to the base tunnels and the 4-meter corridor (https://www.ioriotrasportielogistica.it/en/news/46/hupac-continuity-for-incentives-for-the-development-of-intermodal-transport)".

"Switzerland's Federal Office of Transport (BAV) has proposed reducing track access charges by up to SFr 90m ($US 89.8m) from 2021 …. BAV plans to adjust the track access charges accordingly from 2021 onwards, with charges for regional traffic reduced by more than SFr 30m while long-distance passenger rail and freight would each see a reduction of between SFr 20m and SFr 30m … BAV says the savings should be passed on to passengers and freight customers to improve the competitiveness of rail …. In addition, BAV now plans to introduce a discount on long freight trains for track access charges in order to further promote the efficient use of the Gotthard Base Tunnel (https://www.railjournal.com/passenger/main-line/switzerland-proposes-sfr-90m-cut-in-track-access-charges/)".

"The European Commission has approved a support scheme amounting to 70 million Euros in order to significantly reduce the track access charges for rail freight in the Netherlands. The scheme, which will run from 2019 to 2023, will be open to all railway companies operating in the Netherlands and with an access agreement with Dutch rail infrastructure manager ProRail. The EU funds are in support of the subsidy scheme as promised by the Dutch government in the measure package (https://www.railfreight.com/railfreight/2019/07/09/eu-approves-e70-million-aid-to-lower-dutch-track-access-charges/)".

The Euro vignette is a system to charge and control road user charges in Denmark, Luxembourg, the Netherlands and Sweden. The vignette applies to Heavy Goods Vehicles with a total permissible weight of 12 ton and more on motorways and selected A–roads in these countries.

"After 20 years in operation, the tariff structure will become more differentiated in order to take better care of environmental aspects: the cleaner a truck is, the lesser the tariff will be increased. The tariff changes will be realized in a two-step-process: The first-step increase for Heavy Goods Vehicles with Euro-0 up to Euro-4 standard will be valid as of 1st July 2019. Euro 5 and 6 remain unchanged with the exception of the one-day-vignette that will be 12 € for all emission classes. Effective on 1st January 2020, there will be a moderate second-step increase only for Euro-5. The new tariffs will be released on 27th May 2019 and valid from 1st July 2019 (https://zoek.officielebekendmakingen.nl/trb-2018-2.HTML)".

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4.2.4. Network & infrastructure

Germany takes new steps to enable 740 m-long freight trains (August 2019) - Reacting to the request of the German Greens Deutsche Bahn is currently compiling a list of investment measures – divided into 3 packages – that would need to be implemented in order to enable the circulation of 740 m-long freight trains on the German rail infrastructure network (http://www.uirr.com/en/news/mediacentre/1260-gueterzuege-massnahmen-fuer-das-740-meter-netz.html).

740 m-long freight trains to be allowed in The Netherlands (September 2019) - Following successful trials in 2018, Dutch infrastructure manager ProRail has confirmed that the commercial operation of 740 m-long freight trains will be permitted on the Dutch network from 2020 (http://www.uirr.com/en/news/mediacentre/1299-irj-dutch-to-introduce-740m-long-freight-trains.html).

After opening "Galleria dei Frentani" on the Adriatic route from Bologna up to Lecce, trains can travel with High Cube containers and accompanied trucks (loading gauge PC80). On the same route investments are in progress for increasing capacity and allowing 750 m trains up to 22,5 ton axel weight (News December 2018 https://www.ferrovie.info/index.php/it/archivio/archivio-news-2018/7435-ferrovie-aperta-la-galleria-dei-frentani-in-adriatica). Other actions for 750 m trains are progressing in other major freight traffic line such as on the Genoa-Rotterdam corridor.

"The Rail Baltica project is currently in the design process for 411 km of the main line and the next 233 km are being procured for design works. At the same time, the national project implementer in Latvia, SIA Latvijas Dzelzceļa līnijas, is carrying out design works at the Riga Central Station and Riga International Airport. Construction of the main line is scheduled to begin in 2022 (news October 2019 http://www.railbaltica.org/info/en/news/geotechnical-exploration-works-on-the-rail-baltica-route-section-vangazi-salaspils-misa-will-begin-this-week)

"On 3 November, Implementing Body of Rail Baltica project in Latvia –Eiropas Dzelzceļa līnijas, Ltd. – has announced an international construction tender for the Rail Baltica station and related infrastructure in Riga International Airport. The first phase is devoted to the selection of qualified candidates. The entire scope of the tender includes the Rail Baltica station building in Riga International Airport, overpass, access roads, embankment, 6 km long section of railway tracks and overpass over K. Ulmaņa gatve (news November 2019 http://www.railbaltica.org/info/en/news/international-tender-announced-for-the-construction-of-rail-baltica-station-and-related-infrastructure-in-riga-international-airport)

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	Rail Baltica		Auto		Bus		Plane*	
	Time	Cost	Time	Cost	Time	Cost	Time	Cost
Tallinn - Pärnu	0:40	14€	1:39	19€	1:50	7€		
Pärnu - Rīga	1:00	24€	2:26	28€	2:30	10€		
Rīga - Panevėžys	0:55	15€	1:54	23€	2:40	10€		
Panevėžys - Kaunas	0:37	12€	1:25	23€	2:10	9€		
Kaunas - Vilnius	0:38	11€	1:20	20€	1:35	6€		
Tallinn - Rīga	1:42	38€	4:05	47€	4:20	17€	1:50	125€
Rīga - Vilnius	1:54	38€	3:30	45€	4:00	25€	1:50	125€
Tallinn - Vilnius	3:38	76€	7:00	91€	8:50	42€	2:10	101€

Figure 13 - *Time and estimate cost by different types of transport mode – Source: Rail Baltica Cost-Benefit Analysis (2017) and Rail Baltica Operational Plan (2019)*

"THE Hungarian National Infrastructure Development Agency (NIF) has called for tenders for a contract to upgrade and electrify the single-track line between Püspökladány and the Romanian border near Biharkeresztes. The project involves the electrification of 55.6km of track at 25kV 50Hz ac as well as the reconstruction of the substructure and superstructure for 100km/h operation and 22.5-tonne axle loads on 35km of line and through tracks at three intermediate stations. In addition, new electronic signalling and passenger information systems will be installed and connected to the CTC centre at Püspökladány. Hungarian State Railways (MÁV) has already rebuilt the Berettyóújfalu – Biharkeresztes section of the route. The deadline for submission of tender documents is October 15. The EU-funded project is due to be completed within 36 months of contract signing. Five lines cross the Hungary-Romania border, three of which carry freight traffic. However, at present only one of these, the Lökösháza – Curtici line (part of European Rail Freight Corridor 7) is electrified. The Püspökladány – Biharkeresztes line is part of the corridor from Budapest to Oradea, Cluj Brasov and Bucharest. Although the line is not part of the Rail Freight Corridor network, it is an important link between Hungary and Romanian regional centres. On the Romanian section of the Budapest – Bucharest route, modernisation of the Brasov – Cluj line is currently underway, while Hungary has already modernised the Budapest – Pürpökladány line. The rollout of ETCS Level 2 on this stretch will enable the introduction of 160km/h operation, significantly reducing journey times between Budapest and Oradea (News September 2019 https://www.railjournal.com/regions/europe/hungary-romania-line-to-be-electrified/)."

Both Rail Baltica and the route Hungary-Romania support links to the silk route as well as other investments planned in Eastern and Central European countries in continuity with transcontinental routes.

A number of by-passes are under construction for decongesting urban areas (mainly avoiding interactions with road), connecting freight villages more efficiently and increasing capacity in urban nodes both for passenger and freight rail. Part of them is combined with HSR investment

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programs.

4.2.5. ICT Technologies

"As part of its digitalization strategy, Kombiverkehr has brought another modern application for forwarding and logistics customers onto the market. As announced at this year's partners' meeting, the "Train monitor" pilot project was launched at the start of July with the publication of real –time information in Combined Transport for the first time. The test version is the first one to be available online and can be used for all Kombiverkehr's own direct and shuttle trains to view the geographical position/last reporting point and current timetable deviations of all trains at selected terminals. An important milestone for the new internet application is the provision of an estimated time of pick-up (ETP): this information is important to customers as it lets them know when their transport units are expected to be ready for collection at the destination terminal. Kombiverkehr is thus visibly putting into practice the results developed within the "ELETA" project funded by the European Union with the aim of improving arrival forecasts for all customers.

Kombiverkehr has initially started the train monitor with seven national and international terminals – Köln-Eifeltor, München-Riem, Hamburg-Billwerder, Duisburg Ruhrort-Hafen DUSS, Ludwigshafen BASF and Verona Quadrante Europa as well as Verona Interterminal in Northern Italy. Scheduled and other interested customers can now view within the online-based application on Kombiverkehr's website their cargo position. The train movement reports, including timetable deviations and ETP, are displayed for each of the seven terminals on information boards, similar to the ones seen in airports and railway stations (New September 2019 https://www.kombiverkehr.de/en/service/customers/news/:Kombiverkehr_launches_digital_train_monitor_pilot_project).

"DB aims to use digital technologies to increase the rail network's capacity, making room for thousands of additional trains each day. First highly automated S-Bahn to start operating in Hamburg in 2021. The core components of the Digital Rail for Germany program for the future are the European Train Control System (ETCS) and digital signal towers. These sophisticated digital technologies are creating brand new opportunities for increasing railway reliability and rail network capacity by up to 35 percent … The primary goal of the program is to generate the greatest possible profit for all railway customers that use the rail network. Innovations in digital rail operations will also serve to reinforce Germany's position as a business location and promote climate protection … Preparations are underway in Hamburg to launch the first highly automated S-Bahn in Germany. A cooperation agreement for the *Digital S-Bahn Hamburg* was signed on July 12, 2018 by Deutsche Bahn, Siemens and the Free and Hanseatic City of Hamburg. By October 2021, four trains and a 23-kilometer-long section of the S-Bahn Line 21 between the Berliner Tor and Bergedorf/Aumühle stations will be equipped with the required technology (https://www.deutschebahn.com/en/Digitalization_new/digitalrail-3625818).

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4.2.6. Fleet & Rolling stock

"In Cologne, DB Cargo has received its 50.500th quiet freight car, converted with LL-type quiet composite brake block whisper brakes. According to the company, 80% of its freight wagon fleet is equipped with so-called whisper brakes … Until 2020, 63,000 wagons of DB Cargo fleet that operate in Germany will run with quieter brakes, being retrofitted with low-noise brakes and quiet pads, allotting additional EUR 200 million funds. These additional costs are due to the retrofitting and maintenance activities, including the installation of LL-brake blocks. In 2020, around 7,000 more freight cars will be equipped with modern brake pads .... As part of the voluntary noise reduction program launched last year, the federal government and the railways invested around EUR 100 million in noise protection walls, noise protection windows and other measures ... The federal government provided a subsidy of approximately EUR 150 million for the conversion of the existing freight wagons operating in Germany. The DB network has introduced the noise-dependent route pricing system (LaTPS) as a financial incentive for converting wagons to quieten brake blocks. In addition to the national subsidy, there is also a limited subsidy from the European funds of the Connecting Europe Facility (CEF). In 2018, two-thirds of DB Cargo's own fleet was retrofitted with whisper brakes, that keep the wheel service smooth when the brakes are applied, halving the noise emissions generated by the wheels as they roll (News February 2019 https://www.railwaypro.com/wp/80-of-db-cargo-german-wagon-fleet-goes-silent/).

"SWISS rail Freight Company SBB Cargo has initiated a pilot automatic coupling process for locomotives and rolling stock, which the company says is potentially the first step towards automation of last mile operation. The company has equipped around 100 freight wagons and 25 locomotives with automatic couplers over the past year. The fleet entered regular service at the beginning of May on combined transport routes carrying containers between the hub at Dottikon and terminals in Dietikon, Oensingen, Renens, Cadenazzo and Lugano Vedeggio as well as to Biasca and Mendrisio … SBB Cargo is also working to develop automatic braking technology, which has been installed on the wagons fitted with the automatic coupler. Partners here include Voith, PJM and VTG and two rail freight operators, Rail Cargo Austria and Mercitalia. The manual brake test takes a 500-metre-long train up to 40 minutes today, while the automated test takes just 10 minutes. Intensive testing will take place over the next year and the technology is expected to enter operation in spring 2020. SBB Cargo is also testing a collision warning system on shunting locomotives using a remote-control system with visual and acoustic signals (News May 2019 https://www.railjournal.com/freight/sbb-cargo-pioneers-automatic-couplers/).

Innovative freight wagons are key to being able to take full advantage of the Internet of Things (IoT) and automation. As part of the 5L initiative, SBB Cargo, Hupac, VTG and the Federal Office for the Environment (FOEN) as well as many suppliers are developing the next generation of freight wagons. The next generation is being completely redesigned. The chassis, for example, is considerably lighter than that of a conventional standard flat wagon. The middle segment is not welded but riveted and bolted – just like the lightweight production methods from the lorry sector (https://www.sbbcargo.com/de/unternehmen/inno-lieferanten.html).

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5. Summary of SWOT

SWOT methodology have been applied at the rail overall ecosystem as a summary after the exercise application to the individual sub systems as defined in the previous WP3 deliveries.

The strategic objective towards identification of Strengths, Weaknesses, Opportunities and Threats is defined as "Rail to become the backbone of the Europe's sustainable multimodal transport system of the future, both for passengers and freight".

The time horizon is intended to be the year 2050.

Having so defined the strategic objective, the methodology does not directly enter into the elaboration of the White Paper strategic objectives whose definition additionally include a set of quantitative targets whose likelihood to be achieved in given time frame (both intermediate steps and final results) is not in the scope of TER4RAIL project.

For Passenger Rail

- Triple the length of the existing high speed rail network by 2030 so that, by 2050, the majority of medium-distance passenger transport should go by rail and high-speed rail, should outpace the increase in aviation for journeys up to 1000 km
- By 2050, connect all core network airports to the rail network, preferably high-speed
- By 2020, establish the framework for a European multimodal transport information, management, and payment system

For Freight

- 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050
- Rail freight should be almost doubled adding 360 billion ton km (+87%) compared to 2005
- Deployment of ERTMS on the European Core Network by 2030
- By 2050, connect all seaports to the rail freight system
- Rail freight corridors as the backbone of the EU freight transport system

For Urban Mobility

- Halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050
- Achieve essentially CO2-free city logistics in major urban centres by 2030
- By 2020, establish the framework for a European multimodal transport information, management and payment system

Figure 14 - *Transport White paper goals related to Rail – source: S2R multiannual action plan (2015)*

In this perspective:

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- With focus on "internal" competition frame of the rail Industry towards other modes
  - **Strengths** are the characteristics of the rail industry to be leveraged, being relative or absolute advantages, that justify the ambitions to play a substantial role in the overall mobility and support strategies having such a target
  - **Weaknesses** are the characteristics of the rail Industry to look after, being unfavourable, that may put at risk the achievement of the strategic objective. Nevertheless appropriate actions may allow to turn some weakness into strengths.
- With focus on "external" comprehensive environment where the rail industry compete
  - **Opportunities** are the drivers of change that could exploit the advantages of rail
  - **Threats** are elements whose dynamics could cause trouble for the strategic objective.

In the following paragraphs main points – in bold in the pictures - have been shortly commented.

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5.1. Rail Freight

	STRENGTHS	WEAKNESSES
INTERNAL	• **Sustainability, energy efficiency and easier energy transition, safety differential also in future projections** • **Cost advantages in scale economies, long distances, high co-modality potential** • **Growing industrialization benefits from exponential technologies (ICT, DSS & AI, digitalization, materials, automation & mechatronics, maintenance, ...), interoperability, modularization** • **TEN-T corridors drive towards EU Rail area** • **Application of Regulation European Rail Network for competitive freight** • Limited de-bottlenecks to be overcome for satisfying demand and service growth • Leveraging HSR investments as capacity increase and express freight services	• **Long lead time for implementing new services, investments, design/plan/build/ on new infrastructures/technologies** • **High capital intensity** • **Service performances not always competitive, inadequate mobility service integration in co-modal mind-set** • Slow EU harmonization (liberalization & regulations, infrastructure charges, etc...) • Multiple actors with inadequate collaborative Rail ecosystem approach • Many stakeholders • Traditional market segmentations and inadequate logistics engineering approach in market propositions • Concentration on Core Network may dismantled traffic and capacity • Aging staff with unclear replacement plans
	OPPORTUNITIES	**THREATS**
EXTERNAL	• **Fiscal policies favouring more sustainable modes and Rail centrality in co-modal perspective** • **Cost dynamics versus Road (Drivers shortage and other expected cost increase)** • **China policies about Rail drive traffic developments especially in Eastern regions** • Growing demand patterns in future projections fitting Rail (scale economies, intercontinental exchanges, urbanization, ...) • Developments of light assets collaborative/ virtual integrated new business models and public/private partnership • Growing logistics outsourcing in segments with professionalism and qualified actors • Co-modal integration through long term more efficient time/space planning • Faster acceleration towards responsible mobility after COVID 19 crisis	• Rail is a high capital intensive business, public resources are limited • The EU Commission efforts for creating a uniform Rail space area are sometimes finding obstacles due to local interests of limited vision • Fragmentation of Road transport industry and social protection to SME as barrier to increased Rail role in co-modal approach • Dramatic evolution in manufacturing foot print and distribution channels • Faster reaction of other modes to adopt ICT and exponential technologies and other dynamics

Figure 15 - *SWOT Freight – Source: New Opera (2020)*

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Freight and logistics is a natural space of growth for rail, based on capabilities built with continuity over decades, allowing to identify a number of strengths. In fact, not only long-distance transport, traditional target for rail transport still shows a potential to growth, but also medium and even short distances, especially in the co-modal redefinition of mobility, can unveil new relevant segments of business. Infrastructure has significant free capacity, to be exploited with relatively limited investments (ports, longer trains, bottlenecks) while a number of additional factors – notably technology applications - are expected to improve cost performances and luckily also sustainability, safety and security. Technology may enable new business models beneficial for better use of capacity (as for instance smart contracts and dynamic pricing) as well as enhanced operation planning.

There are still in the rail industry weaknesses to face of which the long lead time of any innovation is unavoidable because of the complexity of a huge ecosystems with dense structure of correlations. High investment requirements are part of this complexity. Service can be a weakness, unless new service policies together with new processes allow to turn it into a strength.

The drivers of change are expected to influence the external conditions in an overall positive way.

Main opportunities are related to cost differential, expected to grow and features of trade that should better fit rail. Being trade for its nature international, national barriers should be more easily overcome (versus passenger segments) and the pressure of Belt & Silk is a great example of that.

Threats cannot be under evaluated as well. Unfortunately, investments and regulations are mainly oriented by policies and continuity of efforts. The intensity and pace of development are largely outside the control of the rail Industry. Also, the fragmentation of the Road transport industry and the social implication of relevant modal shift may be a barrier to an effective implementation of co-modal mobility of goods. EU countries in the East of Europe as first option they started to finance motorways constructions and road trucking.

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5.2. Tram & Metro (Light Rail + Metro ridership and infrastructure)

	STRENGTHS	WEAKNESSES
INTERNAL	• **Sustainability, energy efficiency and easier energy transition, safety differential also in future projections** • **Contribution to congestion reduction in cities** • **Cost advantages in scale economies, long distances, high co-modality potential** • **Growing industrialization benefits from exponential technologies (ICT, DSS & AI, digitalization, materials, automation & mechatronics, maintenance, ...), interoperability, modularization** • **User centric approach** • Local passenger transport solutions are fitting specific/relevant needs in self contained areas	• **Service performances not always competitive, inadequate mobility service integration in co-modal mind-set** • **Long lead time for implementing new services, investments, design/plan/build/ on new infrastructures/technologies** (versus road solutions) • Limits for new infrastructure in areas with already highly dense urbanization • Limited service segmentation not always "inclusive" for passengers • Multiple actors with inadequate collaborative approach between urban and other services • Noise, vibrations • Limited exploration of innovative use of available resources for synergies (HSR, City logistics, Postal/Express Services, ...)
	OPPORTUNITIES	**THREATS**
EXTERNAL	• **Fiscal policies favouring more sustainable modes and Rail centrality in co-modal perspective** • **Acceleration of policy developments in favour of public transport** • **Favourable cost dynamics versus Road with appropriate scale** • Growing demand patterns in future projections fitting Rail (scale economies, urbanization, ...) • Developments of light assets collaborative/ virtual integrated new business models and public/private partnership • Co-modal integration through long term more efficient time/space planning • Faster acceleration towards responsible mobility after COVID 19 crisis	• Rail is a high capital intensive business, public resources are limited • Excess of short term visioning in political priorities • Faster reaction of other modes to adopt ICT and exponential technologies and other dynamics • Dramatic evolution in urbanization (needs and habits may change very fast)

Figure 16 - *SWOT Tram & Metro – Source: New Opera (2020)*

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Rail serving urban mobility with Metro and Light Rail solutions is expected to be in good shape for increasing its role. Sustainability is the major strength. In fact, while it is a relevant issue for all mobility, it is particularly relevant in urban space where there is no alternative powered solution better than rail (walking and biking excluded). Contribution to congestion reduction and consequently air pollution in cities is important. A user centric approach is largely adopted. Cost, when scale factors are appropriate, are competitive and growing industrialization is bringing additional advantages.

Some weaknesses are a poor co-modal mind-set amongst users and planners, leading to sometimes insufficient efforts to overcome existing barriers in terms of infrastructures and businesses, limiting the integration and scope of mobility services. Coordinating actions involving multiple actors may be not easy even at local level.

The drivers of change are expected to influence the external conditions in an overall positive way for the same macro reasons of other segments even if projected in different geographies and covering different actors and stakeholders.

Specific opportunity can be considered the increasing effort in co-modal integration through long term more efficient time/space planning in coordinating mobility services in complex urban and metropolitan geographies.

Dramatic evolution in urbanization demand patterns may be a threat as needs and habits may change very quickly. This represents a challenge for the rail management for adapting the sale offerings to the new demand patterns.

The growth of unregulated drive sharing and on demand 'taxi' systems such as Uber or Lyft could act as a direct threat to rail in urban areas, diluting the critical mass of passengers for public transport especially at the off peak. Autonomous cars in such a mass system may further dissuade users to share public transport, especially if pandemic fears continue in the public psyche of the 21st century.

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5.3. Rail Passengers

	STRENGTHS	WEAKNESSES
INTERNAL	• **Sustainability, energy efficiency and easier energy transition, safety differential also in future projections** • **Cost advantages in scale economies, long distances, high co-modality potential** • **Growing industrialization benefits from exponential technologies (ICT, DSS & AI, digitalization, materials, automation & mechatronics, maintenance, ...), interoperability, modularization** • **Core and Extended Network drive towards EU Rail area connecting most population and all big mobility nodes** • **HSR is rejuvenating all Rail ecosystem supporting modal shift from air** • Limited de-bottlenecks to be overcome for satisfying demand and service growth • Funding of public service contracts	• **Long lead time for implementing new services, investments, design/plan/build/ on new infrastructures/technologies** • **High capital intensity** • **Service performances not always competitive, inadequate mobility service integration in co-modal mind-set** • Slow EU harmonization (liberalization & regulations, infrastructure charges, etc...) • Multiple actors with inadequate collaborative Rail ecosystem approach • Poor fare integration with co-modal services • Aging staff with unclear replacement plans • Limited service segmentation not always "inclusive" for passengers • Limited exploration of innovative use of available resources for synergies (HSR, City logistics, Postal/Express Services, ...)
	OPPORTUNITIES	**THREATS**
EXTERNAL	• **Fiscal policies favouring more sustainable modes and Rail centrality in co-modal perspective** • **Acceleration of policy developments in favour of public transport** • Growing demand patterns in future projections fitting Rail (scale economies, intercontinental exchanges, urbanization, ...) • Developments of light assets collaborative/ virtual integrated new business models and public/private partnership • Resiliency and mobility growing R&D capabilities for managing dynamics • Co-modal integration through long term more efficient time/space planning • Faster acceleration towards responsible mobility after COVID 19 crisis	• Rail is a high capital intensive business, public resources are limited • The EU Commission efforts for creating a uniform Rail space area are sometimes finding obstacles due to local interests of limited vision • Faster reaction of other modes to adopt ICT and exponential technologies and other dynamics

Figure 17 - *SWOT Passengers – Source: New Opera (2020)*

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Passenger business is a significant target of growth for rail. This statement is based on experiences of more virtuous countries allowing to identify a number of strengths to be further exploited and expanded with a true European effort. While most of the positive patterns are related to HSR innovation, lot of potential can be identified also in more traditional services both in commuting and local traffic as well as in other traffic segments. In fact, the co-modal redefinition of mobility, can attract new traffic in a number of segments of business. The technology applications - are expected to improve user friendly experience, integration with other modes and cost performances. Also, sustainability, safety and security are expected to improve while still today better than other modes.

There are still in the rail industry weaknesses to be faced. The long lead time of any innovation is unavoidable because of the complexity of a huge ecosystems implying dense structure of correlations with elements of different nature. High investment requirements are part of this complexity. The difficulties of the integration process with reference to liberalization, harmonization of regulations, infrastructural charges, etc…, are part of the picture resulting in different speeds for individual countries in participating to the European progresses.

The drivers of change are expected to influence the external conditions in an overall positive way.

Main opportunities are related to cost differential, expected to grow because of better consideration of externalities and the application of penalties to more pollutant transport means. The energy transition towards eco-friendly sources and sustainability considerations represent new opportunities. Acceleration of policy developments in favour of public transport may encourage evolutions.

Major threats are the same as anticipated for Freight and Metro/Light Rail. So, continuity of the investment's efforts in intensity and the implementation pace can be question marks.

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5.4. Rail as overall Ecosystem

	STRENGTHS	WEAKNESSES
INTERNAL	• **Sustainability, energy efficiency and easier energy transition, safety differential also in future projections** • **Cost advantages in scale economies, long distances, high co-modality potential** • **Growing industrialization benefits from exponential technologies (ICT, DSS & AI, digitalization, materials, automation & mechatronics, maintenance, ...), interoperability, modularization** • **Core and Extended Network drive towards EU Rail area connecting most population and all big mobility nodes** • **HSR is rejuvenating all Rail ecosystem** • Limited de-bottlenecks to be overcome for satisfying demand and service growth • Local passenger transport solutions are fitting specific/relevant needs in self contained areas	• **Long lead time for implementing new services, investments, design/plan/build/ on new infrastructures/technologies** • **High capital intensity** • **Service performances not always competitive, inadequate mobility service integration in co-modal mind-set** • Slow EU harmonization (liberalization & regulations, infrastructure charges, etc...) • Multiple actors with inadequate collaborative Rail ecosystem approach • Aging staff with unclear replacement plans • Inadequate internationalization and competitive patterns • Limited service segmentation not always "inclusive" for passengers • Limited exploration of innovative use of available resources for synergies (HSR, City logistics, Postal/Express Services, ...)
EXTERNAL	OPPORTUNITIES	THREATS
	• **Fiscal policies favouring more sustainable modes and Rail centrality in co-modal perspective** • **Acceleration of policy developments in favour of public transport** • Growing demand patterns in future projections fitting Rail (scale economies, intercontinental exchanges, urbanization, ...) • Developments of light assets collaborative/ virtual integrated new business models and public/private partnership • Resiliency and mobility growing R&D capabilities for managing dynamics • Co-modal integration through long term more efficient time/space planning • Faster acceleration towards responsible mobility after COVID 19 crisis	• Rail is a high capital intensive business, public resources are limited • The EU Commission efforts for creating a uniform Rail space area are sometimes finding obstacles due to local interests of limited vision • Faster reaction of other modes to adopt ICT and exponential technologies and other dynamics

Figure 18 - *SWOT Overall Rail ecosystem – Source: New Opera (2020)*

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The strengths of the overall Rail Ecosystems are the summarized consequences of its major sub systems with the additional impact of their overall synergetic relationships.

In the last decades, rail has continued to build capabilities despite limited traffic gains but creating the conditions for accelerating the growth in the near future. The successful experiences of more virtuous countries and the demonstrated continuity of efforts allow to identify a number of strengths to be further exploited and expanded with true European efforts.

Sustainability is a major strength as well as cost competitiveness. These are going to increase rail service penetration after technology applications. Technology is expected to improve all performances including safety and security and substantially supporting seamless customer experiences. In fact, the co-modal redefinition of mobility, can attract new traffic in a number of business segments. Infrastructure has significant free capacity, to be exploited with relative limited investments (notably HW & SW together with selected infrastructure and other assets) for "quick" additional capacity.

About Freight, not only long-distance transport, traditional target for rail still shows a potential for growth, but also medium and even short distances, with the co-modal approach, can unveil new substantial demand aspects.

Metro and Light Rail solutions are expected to be in good shape for increasing their role. In particular in urban space there are no better alternative solutions (walking and biking excluded). Sustainability is a major strength.

Passenger business is a natural space for growth. While most of the positive patterns are related to HSR innovation, lot of potential can be identified also in more traditional services both in serving commuting and local traffic and in serving other traffic segments. Being the investments planned according to new co-modal thinking, they are usually beneficial to the entire rail system, including freight and metropolitan needs.

There are still in the Rail industry weaknesses to face. The long lead time of any innovation is unavoidable because of the complexity of a huge ecosystems with dense structure of correlations. High investment requirements are part of this complexity. Service performances can be a weakness, unless new service policies enabled by the upgrading of operational capabilities, new processes of communicating and customer relationship management allow to turn this weakness into a strength. The difficulties of the integration process with reference to liberalization, harmonization of regulations, infrastructural charges, etc… are part of the picture resulting in many different speeds of individual countries in participating to the European progresses.

The drivers of change are expected to influence the external conditions in an overall positive way.

Main opportunities are related to cost differential, expected to grow because of better consideration of externalities and the application of penalties to more pollutant transport means.

Threats cannot be under evaluated as well. Unfortunately, investments and regulations are mainly oriented by policies and continuity of efforts. The intensity and pace of development are largely outside the control of the rail Industry. Also, the fragmentation of the Road transport industry and the social implication of relevant modal shift may be a barrier to an effective implementation of

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co-modal mobility of goods. EU countries in the East of Europe as first option they started to finance motorways constructions and road trucking.

Major threats are in any case related to the continuity of the investment's efforts both in intensity and in the implementation pace.

One has to appreciate that the "Rail as an Opportunity to EU Society" has much greater development potential beyond the "Declared Opportunities". In fact, the "Weaknesses" which have been existing in rail services for many years are partially self-generated inside the system itself. If one was to imagine that indeed EU Institutions together with the member States would undertake actions for achieving uniformity of intents/objectives and modular organization in all aspects such as operations and communication in order to overcome the 27 different approaches, the weaknesses would transform themselves in positive elements with enormous benefits to EU Society far beyond the declared ones. Also unexpected critical events (as COVID 19) while modifying the market demand, may accelerate the transition towards smarter/responsible mobility due to increased environmental and safety/security awareness.

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Impact 1	Impact 2	Innowag
Living rail	Marathon	M2O (ongoing)
Mobility4EU	Near 2050	Planet (ongoing)
REFINET Score	Setris	Skillful
Score	Smarte	Spectrum
Spider Plus	Tiger	Tiger Demo
USEMOBILITY	VEL-WAGON	ViWas

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