FOSTER RAIL

Future of Surface Transport Research Rail

Coordination and Support Action

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Deliverable D2.6

Updated Reference Rail Business Scenarios

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1. Executive summary

FOSTERRAIL is a European funded coordination action to support the European rail research sector to explore potential European rail area futures up to 2050 and beyond. The aim of FOSTERRAIL is to gain a vision, agenda and strategy as well as to develop roadmaps for rail research and innovation. FOSTERRAIL foresees to broadly share and agree upon this vision, strategy and roadmaps among main stakeholders in European rail.

The present deliverable (D2.6) is the second outline and update of the initial FOSTERRAIL reference rail business scenario. The first reference scenario outline was developed and agreed upon in the FOSTERRAIL Futures Dialogue Forum in March 2014 in Brussels. A forward looking exercise was implemented involving a broad range of stakeholder and experts representing the European rail community: rail industry, rail operators, rail infrastructure, rail research and academia and rail related public policy and civil society actors. The scenario was taken into account when drafting and agreeing upon the roadmaps in WP4 of FOSTERRAIL.

To achieve an update of the initial reference scenario the reference rail business scenario was reframed and complemented by additional key aspects and storylines. The outcome of several other forward looking- and scenario exercises related to the rail and transport sector including a range of documents of particular rail stakeholder groups were analysed and the outcome compared to the outcome of the initial business reference scenario.

Additional storylines and key aspects were introduced into the business reference scenario. In particular the normative starting point was reframed asking the question how a European rail system of the future should look like, when post Paris a strict climate regime is implemented in Europe and globally, what means the transport sector has to be nearly fully decarbonised till 2050 and beyond. The major storylines of the updated rail business reference scenario can be summarized as follows.

At the UNFCCC climate negotiations in Paris (COP21), it was politically decided to achieve a very low carbon economy no later than 2050. Climate and environmental concerns and a common global understanding that technological and societal progress has to be taking place within planetary boundaries have succeeded the political debate. The post Paris climate regime gives a definitive impulse towards a next industrial transformation.

Under the changing framework of the post Paris climate regime, global trade has to be re-organized to achieve economic growth within planetary boundaries. This implies a paradigm shift regarding recent production, consumption and trade patterns. A major task is to achieve an energy system based on renewable energies. For mobile applications the post Paris regime is pushing towards fading out the use of conventionally fuelled vehicles for all transport modes, including rail.

The expected transformation has multiple consequences regarding economic and societal change. A high share of population is rapidly moving to growing metropolitan areas. Proactive labour market and social security policies have to tackle unemployment, and have to sustain social welfare and public health. Resilient economic and social structures

have to be developed to address the diverse economic and social change dynamics in regions and districts across Europe. The mobility and transport demand is still growing.

The expected industrial transformation has dramatic consequences for the rail sector as backbone of the European transport system. On one hand it looks that already electrified and energy efficient railway may gain a golden opportunity to be revitalized. On the other hand the expected transformation puts a heavy burden for the rail sector, because it has to comply with its role as backbone of the European transport system. Public and private household budgets are not expected to strongly increase, so new business models are wanted, although economic revenues cannot be as simply gained as in the years before.

European rail industries and operators have to expand to comply with the role as the backbone of the European transport system. Rail operating companies are converging into door-to-door mobility providers, although this implies for them to strongly diversify their business concepts, expanding for example sample to car- and bike sharing fleet operators.

Barriers regarding rail liberalisation are still challenging due to comparative market advantages of large rail operating companies. European policy level regulatory power is expected to stay related to the coordination of the rail technical system. Most rail services are expected to remain under public service obligations (PSOs). They are seen as crucial for social cohesion and regional economic development and growth.

Rail freight transport still undergoes severe competition coming from the road sector. The road sector is expected to become electrified and (semi-)automated. However, with the post Paris climate regime, fossil fuelled vehicles have to be replaced up to 2050 and beyond. Heavy duty vehicle operation, fuelled with alternatives like 2nd generation bio-fuels or synthetic fuels (e.g., power to gas, power to liquid) or with huge battery packs, is expected to be in 2050 more expensive than highly efficient electrified rail freight service operation.

Public budgets are expected to further decrease or at least not to increase in a way which would be strategically necessary to finance the requisite infrastructure transformation. Civil society opposition against financial risks of large infrastructure spending are underlining rather reluctant public investment strategies. Public private partnerships (PPP) are in several cases a favourite option, but in other cases PPPs are not operational.

An integrated rail-road strategy is crucial to achieve the post Paris climate regime. Infrastructure capacity has to increase, but it may be still not sufficient to absorb the mobility and transport demand. Public budget constraints and public enmity against new infrastructure and high infrastructure spending leads to rely on existing infrastructure capacity. With the broad extension of electrified infrastructure for all transport modes, resource scarcity, in particular for cooper and some rare metals, is expected. Costs are increasing as environmental damage in exploiting and processing these resources.

Technological progress is heading towards novel technologies, i.e. for next generation train control. Light-weight materials are adopted in railcar design. Regulatory governance is allowing more radical technological progress, in particular to improve the capacity of rail. More systems, including mainline rail lines, may, for example, become driverless.

2. Introduction and Methodological Approach

FOSTERRAIL is a European funded coordination action to support the European rail sector and rail community to explore potential European rail futures up to 2050. The aim of FOSTERRAIL is to gain a joint vision and an agenda and strategy as well as cooperatively develop roadmaps for research and innovation for European rail technologies and services, including the implementation and uptake of the expected research and innovation outcome. It is foreseen to broadly share and agree upon a joint vision, strategy and roadmaps among main stakeholders involved in the European rail sector, including public and private sector actors, and to coordinate among them.

The project's work plan foresees to enhance the coordination among major stakeholders in the "European Rail Area" and to integrate the work done so far by ERRAC and its Working Groups. Starting with the already outlined ERRAC-ROADMAP, the FOSTERRAIL project will continue to coordinate the research and innovation agenda and setting up research and innovation priorities agreed upon by all relevant stakeholders in the rail sector.

Future scenarios up to 2035 are in general based on projections like rail transport demand prognoses related to economic growth, and other forecasts. But far-horizon perspective scenarios can only to a limited extent rely on such trend extrapolations. These scenarios are based on:

- expert opinions and estimates,
- estimations and expectations regarding the trend of major factors and criteria, and
- weak signals (from a today's perspective) of potential trends and drivers.

To achieve far-horizon scenarios stakeholder and experts are jointly exploring a range of possible futures referring to differential socio-economic framework conditions and outlining within this range of potential futures a prioritised future vision as reference scenario.

FOSTERRAIL work package 2 is due to deliver a reference rail business scenario for the European rail system up to 2050. To achieve this objective methodologically sound, a foresight approach was implemented. This approach allows the reasoning about potential futures of the European rail system with a broad range of stakeholder and experts considering varying social, economic and political developments.

In a first step generic European rail future scenarios against the background of a portfolio of 4 different framework future scenarios were outlined and presented. This presentation was guiding a Futures Dialogue Forum involving a broad range of stakeholder and experts. Jointly with them the scenarios were advanced, namely fleshed-up with additional storylines. Consistent stories were sketched out and agreed upon.

In a second step, informed by the portfolio of the generic framework future scenarios, the participating stakeholders and experts in the Futures Dialogue Forum were jointly developing and agreeing upon a preferred, but still in the eyes of the stakeholder and experts "reasonable and realistic" reference rail business scenario.

The Description of Work foresees for WP2 to update this reference rail business scenario on a yearly basis. The reference scenario is used to align the road-mapping exercise in WP3 and WP4. The update will be used to align the upcoming review of the roadmaps.

To achieve the business reference scenario update additional analyses were performed to gain secondary information and input to review the first business reference scenario.

A range of other forward looking projects and actions related to the rail and transport sector were analysed. This review covered the following projects and actions:

- EU-Living RAIL and EU-SPIDER PLUS Project
- EC Transport Advisory Group (TAG) propositions
- Longer term strategies of suburban and regional passenger rail, as presented by UITP data
- ERRAC Permanent Advisory Group of Academia (PAG)'s response to Shift2Rail
- CER Challenge 2050, and
- UIC Rail Technical Strategy Europe

Most of the above mentioned projects and actions performed future studies or visioning approaches related to the future of rail. Several of them were methodological approached in a similar way than FOSTERRAIL WP2. However, in particular the mentioned EU-projects had within their duration of two to three years more opportunity to go into detail and to develop specific storylines for their rail future scenarios. Due to this reason the project outcomes are very supportive to learn and to complement the initial FOSTERRAIL rail business reference scenario. This is as well valid for the challenge analyses and vision assessments performed by EC TAG, the UITP strategy and the ERRAC PAG action.

The reference rail business scenario is outlined as visionary scenario due to its far-horizon perspective (2050 and beyond). A visionary scenario represents an informed consent among a range of stakeholders and experts, how future could/ should most reasonably look like. Trend projections can be used, but are not core in this type of scenario.

Visionary scenarios are, as general rule, shaped by normative principles stakeholder and experts are explicitly or implicitly agreeing upon. The normative framing of the first business reference scenario was economic driven (a "business as usual" perspective), with an underlying understanding of a future global economy and cosmopolitan society like we have in European industrialized countries and regions already today.

Given the fact that we are currently in the upstream to COP 2015 in Paris, it has been decided and will be further coordinated among the project partner to reframe the business reference scenario's normative starting position by anticipating a strong post Paris climate regime to outline a socio-economic transformation scenario.

- How would/ should the European Rail Area in 2050 look like, when at the time the European and worldwide transport sector has to be fully decarbonised?

- What role will electrified rail as backbone of the European transport system in such a framework play?
- What technologies, infrastructures and services would be necessary to achieve such a change up to 2050 in Europe? What would this imply for the FOSTERRAIL roadmaps?

3. Updated reference rail business scenario

The Work Package 2 (WP2) of FOSTERRAIL aims at defining a rail business reference scenario up to 2050 and beyond. To that aim, socio-economic and European rail area future scenarios are defined under a medium- and far-horizon perspective. Based on this a visionary scenario is developed and reviewed and updated at half time of the FOSTERRAIL project duration. Business scenarios are essential to align the road-mapping giving orientation what may be expected in a medium and far-horizon future.

The updated rail business scenario is structured and discussed in the following three sections; the scenario outline is summarized as follows:

3.1 Socio-economic framework futures

At the UNFCCC climate negotiations in Paris it was politically decided to achieve a low carbon economy no later than 2050 or two or three decades beyond. Climate and environmental concerns and a common global understanding that further technological and societal progress have to be taking place within planetary boundaries has succeeded the political debate. The post Paris climate regime negotiated at COP21 governed by UNFCCCt gives a definitive impulse towards a next industrial transformation going far beyond the current green growth paradigm.

The 21st century is proclaimed as century of global trade, but under the changing framework of the post Paris climate regime, global trade has to be re-organized to achieve economic growth within planetary boundaries. This implies a paradigm shift regarding recent production, consumption and trade patterns. A major task for example is to achieve an energy system based on renewable energies. For mobile applications the post Paris climate regime is pushing towards fading out the use of conventionally fuelled vehicles up to 2050 and beyond. This is due for all transport modes including the rail sector.

The expected transformation has multiple consequences regarding economic and societal change. The population is rapidly moving to growing metropolitan areas. Successful migration policy is expected to feed the economy with human capital, but is as well a growing aspect of humanity with increasing migration streams with severe impacts of climate change in other regions of the world. Proactive labour market and social security policies have to tackle unemployment, and have to sustain welfare and public health.

Resilient economic and social structures have to be developed to address the diverse economic and social change dynamics in regions and districts across Europe. Mobility demand is growing. However, this demand has to be covered in a sustainable way.

The expected industrial transformation has dramatic consequences for the rail sector as backbone of the European transport system. On one hand it looks that the already electrified and energy efficient railway may gain a golden opportunity to be revitalized. On the other hand the expected transformation is taking a heavy burden on the rail sector. The rail sector has to comply with its role as backbone of the European transport system, which is already today difficult to be achieved in several regions within Europe. Public and private household budgets are not expected to strongly increase, so new business models are wanted, although economic revenues cannot be as simply gained as in the golden years of strong economic and market growth.

3.2 Generic storylines regarding European rail area futures

European rail industries and operations have to expand to comply with the role as the backbone of the European transport system. Rail operating companies are converging into door-to-door mobility providers, although this implies for them to strongly diversify their business concepts, expanding for example to car- and bike sharing fleet operators.

Barriers regarding rail liberalisation are still challenging due to the comparative market advantages of large rail operating companies. European Union's regulatory power is expected to stay related to the coordination of the mainline rail technical system, while rail market deployment will be still co-coordinated at the national and regional policy level.

Most rail passenger services are expected to remain under public service obligations (PSOs), as they are seen as crucial for social cohesion and regional economic development. In particular regional and local rail passenger services are expected to remain under the governing power of national and regional authorities.

Rail freight transport still undergoes severe economic pressure and competition coming from the road sector. The road sector will become electrified and (semi-)automated. However, with the post Paris climate regime, most fossil fuelled vehicles have to be replaced up to 2050. Heavy duty vehicles fuelled with alternatives - like 2nd generation bio-fuels or PtG or PtL (power to gas, power to liquid) or with huge battery packs - may be expected to be in 2050 more expensive to operate than highly efficient electrified rail services. Rail freight, although still not as flexible as road transport, is expected to become the favourite freight transport mode for long and medium distance operation.

Public budgets are expected to further decrease or at least not to increase in a way which would be strategically necessary to finance the requisite infrastructure transformation.

Least-cost planning and cost-effective operation and investment are expected to be most significant for public budget decisions. Renovation and refurbishment of existing infra-structure and rolling stock is expected to be prioritized before investing in construction.

Civil society opposition against financial risks of large infrastructure spending are underlining rather reluctant public investment strategies. Public private partnerships (PPP) are in several cases a favourite option, in other cases PPP are not operational. Along the expected pathway of economic transformation public civic engagement is indispensable. This is as well particularly relevant for the rail sector.

3.3 Experts expectations and visions for five selected rail business areas

3.3.1 Rail business reference scenario for 2050

An integrated rail-road strategy is not alone crucial to achieve the 2011 Transport White Paper targets, but is as well in the centre of a far-horizon vision to achieve a post Paris climate regime. Although infrastructure capacity for rail is expected to increase, it may be still not sufficient to absorb the growing mobility and transport demand. Public budget constraints and public enmity against new infrastructures and high infrastructure investment may lead to rely on existing infrastructure, for example, by making them more socially compliant while at the same time increasing its capacity.

An additional critical issue is emerging with a broad extension of electrified infrastructures for all transport modes. Resource scarcity, in particular for cooper and rare metals, is expected. Costs for these resources are expected to strongly increase (competition) as environmental damage in exploiting and processing them to a much larger extent.

Technological progress is heading towards new technologies for rail traffic management. Next generation train signalling and control devices are expected to shift from fixed block to moving block technologies. New light-weight materials are adopted in railcar design. Regulatory governance is expected to be further reformed to allow more radical technological progress. Multi-constellation satellite systems (e.g. FOC of Galileo) including supporting innovative sensors in rolling stock and infrastructure are expected to become components of next generation train control systems to improve the capacity of rail. Up-to 2050 the rail (passenger) system may become driverless due to a need for increased capacity and an improved service level.

3.3.2 Long distance passenger rail

Long-distance passenger rail systems such as high-speed-rail have evolved across the world. Huge investments were made with high benefits for European rail industries and other stakeholders. The European rail industry is expected to strengthen its leading role. Large European rail operators are foreseen to drive HSR services in Europe. With rising prosperity, increasing household budget shares are expected to be spent on high and premium rail travel. A diversification of HSR train services is in progress. HSR services are e.g. increasingly used for travelling from regional metropolises to metropolitan centres.

In Europe, long distance passenger HSR networks have evolved with dedicated high speed sections and shared sections with other rail services. Due to a continuous demand for network renovation and maintenance the average speed here is lower than ideally expected. High speed passenger services today use both dedicated new routes and (at lower speeds) upgraded existing routes. On dedicated new routes, distances of up to 800km may be covered in less than 4 hours, and on mixed infrastructure in 5-6 hours.

Long-distance rail services are diversifying. Next to the premium rail segment, low-budget/ low-cost train offers are serving the needs of population with low income. A renaissance of overnight trains is from a today’s perspective uncertain, because these services are running at a deficit for rail operators. However, under a post Paris climate protection

regime the demand for such services may again increase. With rising energy costs as well as improved service concepts these trains may serve as cost-efficient alternatives to long distance overnight bus services, but as well to inner European medium distance flights.

3.3.3 Long distance freight rail

For long-distance rail freight transport, a consequent shift to rail strategy in accordance with the 2011 Transport White Paper is expected to enrol up to 2050 in particular under an intensifying climate protection regime. Long-distance freight transport chains for distances above 300 kilometres (vs. 1000 kilometres today) are expected to be shifted to a large extent to rail and waterborne. Strong rail links to the European Union's neighbour countries and Eurasian rail connections are implemented.

The capacity of rail freight is increased by longer and higher capacity trains, dedicated rail freight corridors and faster freight trains equipped with floating block applications including high speed rail freight (HSRF) lines. Cargo handling and shunting in large freight hubs – in particular in ports and bi- and trimodal hubs – is expected to be fully or at least semi-autonomous. Several new port-to-hinterland rail links are established with new sea routes and ports. Freight trains become more silent and aerodynamic properties are improved.

3.3.4 Regional and local rail freight

Regional and local logistics centres are expected to be highly self-sufficient regarding energy use, and embedded in a smart grid infrastructure. In urban areas, dispersion on the first and last mile may be organized by cyclo-logistics and specified electrified delivery fleets to achieve targets of zero emission and CO_2 neutral urban freight logistics.

With the roll-out of the 2011 Transport White Paper strategy, in particular regional and local rail freight has to be revitalized. Large interregional freight hubs have to be integrated with regional hubs and urban logistics centres. High-volume bulk transport (e.g. for on-site transport) is expected to be transported under this strategy at least partly by rail again.

Regional rail freight is expected to be revitalized by public financial support of rail freight business. Private investments or public-private partnerships will start playing an increasing role in this area. Public policies such as intelligent road user charging and access regulations will support shifting in particular freight transport volumes from road to rail. However, how far this trend takes off depends on regional policy engagement and willingness at the European policy level to support, or on the contrary to block such regional strategies. Under a post-Paris regime particular regional attempts, like i.e. the 100% climate neutral region initiatives in most of the European member states are expected to be strongly facilitated by the European level.

3.3.5 Regional and local passenger rail

Regional and local area passenger rail is expected to expand its role as main transport mode in and around urban areas. Access restrictions and charging for individual car travelling is supporting this trend. An increasing number of the elderly are using rail despite all technical progress in car driver assistance systems. Many of them need support regarding access in railway stations and for ticketing. In particular regional and local

climate strategies are targeting the reduction of conventionally fuelled vehicles like proposed in the post Paris climate regime. The increase in light rail transit, tram and bus services and the requisite infrastructure is expected to be enormous with such aims. Cycling and walking are preferred options for the first and last mile and are expected to be particularly supported in urban environments. Sufficient entrainment options for bikes (bikes in trains), bicycle parking and bicycle sharing have to be provided. City walking has to be taken into account as major transport mode for inner urban areas.

3.3.6 Urban rail system

Sustainable mobility and climate action plans are foreseeing to drastically reduce CO_2 emissions by phasing out conventionally fuelled vehicles in urban areas. This presupposes shifting a substantial part of daily travelling to rail transit, metro and tram systems. Sustainable mobility is demanding alternatives to car travelling and private car ownership. Cars may be expected in the future to be parked at the cities' periphery with metro and tram access to the parking sites.

Mass transit in metropolitan areas is expected to be fully intermodal, with main shares among light rail, metro, tram, bus services and in particular cycling and walking. However, in areas where basic rail infrastructure does not yet exist, bus rapid transit systems may be given priority. All bus systems are expected to be electrified in a medium horizon future.

Building up and financing metropolitan and urban rail infrastructure in the 21st century is expected to be based on a diversity of public and private sector investments. In some regions in Europe urban transport is expected in future up to 100% funded by the public authorities and offered at low charges to local citizens to politically support a shift to public transport and rail. Due to public budget constraints, it is expected that decreasing budget shares may limit investments in new infrastructure and lead to more emphasis on the refurbishment and renovation of the existing urban rail infrastructure.

4. Review of other Rail Future Studies/ Visions

This section summarizes the information retrieved by analysing key visionary documents and projects and actions on rail futures that have taken place or been concluded recently in the European framework of railway and transport research and research agenda setting.

4.1 Challenge 2050 (CER)

(Community of European Railway and Infrastructure Companies (CER)).

Challenge 2050 is a paper of 2013 where the European rail sector's shared their perception where the rail system could be by 2050. The document first gives a brief overview of the rail sector and then sets out a shared vision for the sector. It also identifies multiple goals that are complementary to the vision and support a rail system that is responsive to the needs of Europe's citizens.

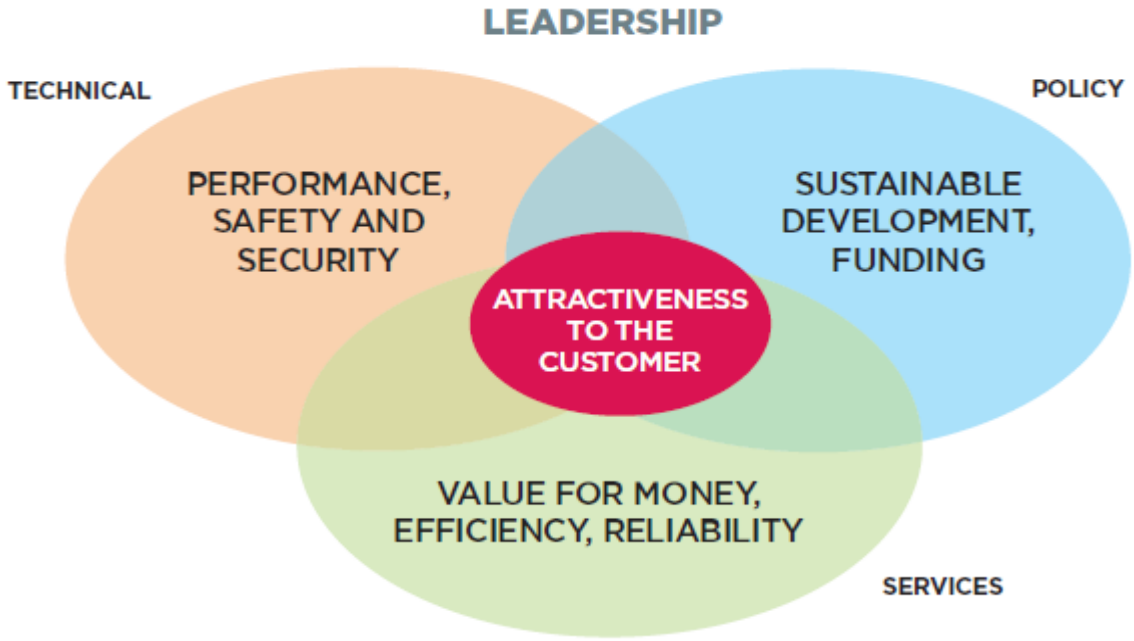

Figure 1: Attractiveness to the customer, Challenge 2050 Source: CER

The vision and goals in Challenge 2050 are all underpinned by the steps taken in the core rail policy areas (what needs to be done), technologies (developing the tools to enable it to be done) and providing services (what the user sees and receives when a customer of rail). These apply across the whole vision, overlap and come together to enhance the overall attractiveness of rail to the customer.

A summary of the strategies depicted in the Challenge 2050 is depicted as follows:

- **Value for Money**

  Rail is a competitive and viable first choice of transport mode in terms of cost and quality of service for both passenger and freight users thus supporting the economies of European member states.

- **Performance**

  Trains are on time and promised facilities for freight and passengers are available.

- **Safety and security**

  Rail is the safest mode of (land) transport.

- **Consistency**

  Passengers and freight users receive a consistently high-quality service.

- **Capacity**

  Rail capacity is maximised on a network designed to meet customer needs and mitigate congestion in other transport modes.

- **Connectivity**

  Rail is the backbone in an interconnected and seamless co-modal transport system

- **Sustainable development**

  The European railway sector provides an attractive and resource-efficient solution for sustainable mobility and transport and a significant contribution to reductions in greenhouse gas (GHG) emissions and dependency on oil.

- **People**

  The rail sector attracts personnel who are motivated and committed to providing modern, flexible and crucial mobility services.

The vision paper states the following challenges for 2050:

By 2050 the railway has developed from the best of what there is today - an absolute commitment to safety, green credentials, expertise in passenger and freight transportation, global leadership in railway research, innovation and manufacturing and, above all, its prime position as the provider of Europe's transportation needs. But the railway of 2050 is also a very different railway; one that has moved significantly forwards and one that provides the backbone of the European transport infrastructure.

To meet the challenges of climate change for mainline rail, the supply of energy and transport network congestion, rail has attracted a multi-fold increase in its share of passenger and freight markets, particularly for longer-distance travelling.

Rail has a pivotal role delivering a competitive and environmentally-friendly transport system, growing the economy, enhancing personal mobility and supporting social cohesion. The rail system has adapted and will continue to adapt, enabling further modal shift and maintaining its position as mode of choice, consistently.

Rail responds to users' needs, delivering reliable, affordable and attractive services as the core of a seamless and safe mobility network. The sector has applied its innovation skills to an assault on avoidable costs and to attracting new users, achieving significant modal shift. Rail has attracted new customers by providing high-quality services that have stimulated popular support for rail and laid the foundation for public investment.

Mobility is co-modal and the playing field between modes has been levelled up so that decision-makers can define development strategies based on comparative costs between different transport modes. An integrated transport system, with rail as backbone, continues to enable a more competitive European economy with each mode playing to its strengths.

Europe's rail sector leads the world and is at the cutting edge globally, continually growing its share of international markets as a result of investment in research and innovation and appropriate regulatory support. A strong European railway area is the key to sustainable

mobility in a low-carbon European society; it is also essential for economic growth, social cohesion and people's expectations of mobility in Europe.

4.2 Rail Technical Strategy Europe (UIC)

This document of 2014 was produced by UIC on behalf of the European Railway Operating Community. It sets the strategy to support the transformation of the railway system and to shape the future or railway in Europe. The Rail Technical Strategy Europe RTSE comprises the following central elements of the railway system:

- Control Command and Communication (CCC)
- Infrastructure
- Rolling Stock
- Energy Supply and Consumption
- Information Management
- Railway People
- Safety and Security

These elements' visions have been summarized in the following table:

Element of Railway System	Vision
Control Command and Communication (CCC)	The network is engineered for resilience and optimised by interoperable real-time traffic management that allows for intelligent, predictive, adaptable operational control of train movements, maximises system capacity and conserves energy.
Infrastructure	The rail system supports vital pan-European rail corridors and co-modal links with other continents – a practical demonstration of the technological and operational innovations that have made it a global leader. Interoperability ensures trains cross state and operational borders without delay or operational constraint, offering a smart and competitive alternative to short and medium-distance flights and water and road-borne freight flows.
Rolling Stock	Mass and energy-efficient, low whole-life cost rolling stock meets the evolving needs of its customers. Rolling stock is designed in line with the needs of the future customer and will be critical for the provision of quality, accessible and reliable rail services and for the

	competitiveness of the sector.
Energy Supply and Consumption	Rail provides an attractive and resource-efficient solution for sustainable mobility and transport and a significant contribution to reductions in greenhouse gas (GHG) emissions and dependency on oil.
Information Management	The railway has a coordinated approach to the management of the information needed to run the operational system and keep customers informed about their journey and services available. New revenue streams are based on improvements in the service to the customer, the exploitation of rail information and reduced operating costs.
Railway People	The concept of the “forever open railway” depends on organised, reliable, well trained and professional people who enable the efficient operation of the system. The railway sector is considered as one of the most attractive employers and the products and services it provides depend on skilled, committed and adaptable people delivering an efficient and customer-focused railway. The rail sector attracts personnel who are motivated and committed to providing a modern, flexible and crucial service
Safety and Security	Rail is the safest mode of land transport and intends to remain that way. Rail will actively move towards being the safest mode of all transport sectors and thereby be very attractive to the customer. Rail is the most secure mode of land transport. Customer reassurance levels are conducive to rail being an attractive mode of transport.
Railway System	The European rail sector is proud to be the global leader for rail transport because it adapts readily to technological and commercial opportunities, many of which span state and operational boundaries.

4.3 EC Transport Advisory Group

The EC Transport Advisory Group (TAG) provides valuable support to the European Commission services in the form of advice and input into the annual transport work programmes of the EU's Framework Programme for research and technological development (H2020).

The EC Transport Advisory Group TAG has identified eleven major transport research challenges:

1. Addressing the nexus of problems affecting urban transport (including congestion, pollution, accidents and inaccessibility) and using transport as an enabler of urban renewal;
2. Achieving the required level of climate change, air pollution and noise mitigation in the transport sector;
3. Managing the impact of demographic trends and, in particular, the ageing population;
4. Effectively harnessing new transport related ICT technology and data management opportunities;
5. Measuring and managing uncertainty and risk in the transport system, particularly associated with high-impact low probability events;
6. Making the transport system, and in particular infrastructure, more resilient to extreme weather;
7. Reducing the loss of life and adverse health effects associated with transport;
8. Reducing transport's dependence on fossil fuels through improvements in energy efficiency and a switch to alternative energy sources;
9. Enhancing the competitiveness of European transport manufacturers and service providers in global markets;
10. Deploying innovative technologies, materials and processes to overhaul the system of infrastructure maintenance;
11. Maximising resource utilization across the transport sector.

These challenges are considered by ERRAC when defining the vision of railway transport for Europe, respectively for the European rail area.

4.4 ERRAC Permanent Advisory Group of Academia (PAG)

The European Rail Research Advisory Council (ERRAC) is the principal contact for the European Commission regarding railway research and innovation. The ERRAC Academic Permanent Advisory Group (PAG) has been set up to advice ERRAC on academic matters and aims to contribute to the alignment of the S2R objectives with a coherent far-horizon ERRAC vision for the railway sector, being updated and under development within ERRAC FOSTERAIL Project.

The ERRAC Academic PAG supports the major challenges identified in the recently issued SRRIA and the objectives outlined in the Shift2Rail Master Plan. In particular the PAG supports the demand for an increase in reliability and punctuality and consider this to be achievable; in fact the aim should be for at least 97% system-reliability as is achieved in other industries. The PAG also agrees that a 100% increase in capacity is necessary and

possible and required if the commission's objectives regarding the role of rail in 2050 are to be achieved.

The following concepts attempt to highlight a range of low TRL, basic research topics for longer-term development linked to breakthrough technologies that should be addressed with special support from Shift2Rail:

4.4.1 Cost efficient and reliable Trains

- Structural new materials
  - Optimized structural layouts. Weight reduction.
  - Integrate functions like strength, insulation, damping, etc. in one design component.
  - Fatigue behaviour; impact resistance; durability; inspection and repair; production and joining processes; fire resistance of new materials.
  - Improved steels and coatings. Fatigue failure
  - New materials for energy absorption
  - Improved and more rapid simulation tools for these materials.
- Railway dynamics and damage processes and rolling noise creation mechanisms
- Effects or aerodynamics on vehicle operation
- Pantograph-catenary dynamics
- Systematic use of tools for coupled and multidisciplinary optimization should be promoted.
- Techniques to assess the impact of vehicle design on the deterioration of infrastructure and rolling stock components.
- New techniques for adaptive braking which are able to blend and optimise novel braking systems
- Testing methods suitable to the railway environment.
- New bogies and wheelset designs with a safe and wear-free negotiation of curves. Affordable and reliable active suspensions
- Harmonisation of specifications and rules for the appropriate design of a depot.

4.4.2 Advanced Traffic Management & Control Systems

- Solutions to improve monitoring, operating and maintaining the European rail networks.
- Regional ERTMS, Moving Block and virtual coupling based on smart technologies enhancing railway operation and maintenance for low density traffic and busy lines.
- Driverless operation is established in various fields but its application in passenger and freight transport requires a systematic and careful assessment to clearly qualify and quantify this.
- Instrumentation for new inspection technologies, remote monitoring and health assessment of tunnels, embankments and bridges. Portable on-board monitoring systems connecting infrastructure data and vehicle performance.

- Active and passive RFID technologies for train and cargo monitoring

4.4.3 Cost efficient, Sustainable Infrastructure

- Basic aspects of wheel-rail contact interaction and ever more precise knowledge and models essential to sustain and to construct other more applied concepts on track, switches and crossings, bridges, track measuring and monitoring systems, as well as maintenance strategies.
- New designs of slab track must be investigated, more resilient against deterioration, easily reparable after terrain movements or torrential down-powers, storms and floods
- Also resistance to derailments with no damage
- New track solutions to reduce rolling noise as a source
- Methods to counteract ground vibrations propagation from track to buildings, in the case of at grade railway lines.
- Numerical models helping to find new solutions to reduce ground-borne low frequency noise and induced vibrations
- New knowledge is needed in Rolling Contact fatigue and other defects in the rail head such as rail corrugations
- New switch and crossing principles, more reliable, quiet and to allow higher speeds.

4.4.4 IT Solutions for attractive railway services

- New IT solutions and functionalities based on currently leading social media as Facebook and Twitter, but also should be open and prepared for the adoption of any possible new communication solutions when they appear.
- Passenger ticketing improvements with harmonization and exchange of relevant data - unified personal ticket storage.
- Harmonised railway stations - exchange points guiding, in an intuitive and friendly manner, passengers along their journey from the entrance point to the best location on the platform for a particular wagon on a certain train and in reverse, directing them to the required exit or the other means of transport.
- Satellite positioning systems and own traffic monitoring systems for the detailed real time information including possible disruptions and accurate forecasting of the arrival time. Such systems should be integrated with relevant safety and security ensuring services.
- Proper algorithm design and distributed/parallel computation to handle such large and complex datasets. Modern platforms can provide programming and runtime support for distributed/parallel processing, but developing effective methods often requires a case-based approach, cutting across disciplinary boundaries.
- Important challenges relate to improving data analytics under polynomial running time, by exploiting sampling, randomization and approximation algorithms with quality guarantees.

4.4.5 Technologies for Sustainable and Attractive European Rail Freight

- Market research on the requirements of non-rail freight users to develop solutions that address and attract innovative market niches lost to rail freight or never gained, such as luxury goods, LDHV or temperature controlled goods.
- Intertwining progress on the rolling stock with progress on the infrastructure. These two main fields being interlinked by the overwhelming development of technology of information and communication to introduce intelligence in all processes.
- Better wagon design giving more possible payload for a global weight unchanged.
- Efficient braking system by electric assistance giving more manoeuvrability to the train for maintenance cost reduction, a better use of the available capacity and an improved commercial speed.
- Software progress on all links of the supply chain to manage the train when commercializing its transport capacity.
- Contributions for competitiveness and reliability: efficient use of all resources like network capacity, driving force, asset utilization, energy consumption, robust paths with possibility of emergency solutions.
- Identify the conditions under which the railway system will be economically profitable (demand, connection length, traffic composition, topography landscape, train frequency, aerodynamics, etc.) in order to correspondingly adapt their actions and better distribute their available resources.

4.4.6 Cross cutting themes

Long term needs and socio economic research

- Long term trends in society and technology will influence mobility patterns and the need for consistent ways in appraising the costs and benefits of alternative modes
- Changes in lifestyle, urbanisation, developments in information technology and demographics will influence the demand for alternative modes
- The impact of technological developments in competing modes
- Research into the organisational and regulatory environment necessary to encourage the adoption of innovations and the step change in cost and quality of service necessary to achieve the Commission’s ambitions

Smart materials and processes

- Fundamental studies on the impact of certain new technologies linked to nano-particles
- Eddy current brakes have the potential to significantly reduce noise at average speeds
- New photovoltaic materials enabling sourcing of energy on the wagons for all type of purposes including transmitting by low consumption technologies information on the wagon status to the ground or the driver
- New components able to enhance computer processing speeds should have a fundamental impact on the management of ‘big data’

System integration, safety and interoperability

- Methodologies allowing the correlation between the cost which is required for the application of preventive and mitigation measures dealing with accidents and the improvement of the level of safety as a result from their implementation.
- A specific issue for the TSIs that concerns all the subsystems is the safety critical "interface cases" (selection of horizontal alignment curve radii, selection of overhead clearance for the civil engineering structures, selection of the wheel profile (Equivalent conicity), routing of tilting trains).

Energy and sustainability

- At low technology readiness levels railway auxiliary and propulsion power devices have efficiencies that are limited by the fundamental efficiencies of the individual components that are used in the construction of the devices.
- Improvements in materials, semi-conductors, and magnetic materials, all have a potential to improve the performance of devices and machines used by the railway.
- System design, operation and optimization for a particular duty cycle.
- Train design needs to optimize the running resistance, and design for a low mass in order to reduce the energy used by the vehicle.
- Regenerative braking systems are common in modern railways, and there is a trend of increasing braking power available for train braking
- Electric railways across the EU use a wide range of both AC and DC power. There are many tools available to model these systems, and to undertake optimization. These tools should be used with a whole system approach, especially when these tools are used to deliver other objectives set out in the Shift2Rail master plan (advanced traffic management and train control for example).

4.4.7 Roadmap to training and education

The purpose of training and education is to contribute to the implementation of the European surface transport research program and to the enhancement of the rail sector by fostering a better match between the human resource needs to make railways a more competitive and innovative sector and the offer of skills coming out of the different research based education and training institutions across Europe.

Knowledge transfer from other sectors is an important aspect of the future of rail transport's cross-sector approach: even though partnerships may be assigned to a specific sector, they often work across different business sectors.

The following key actions are identified under this:

- Forecasts of the skills that railways will need and analysis of gaps in skills. Identify new skills resulting from emerging technologies and new services and business models in the railway sector.
- Identify research based education content resulting from the outcomes of finished projects.
- Enhance and expand educational access to railway courses.
- Enhance educational quality in the railway area (academic, stakeholders)

- Create mechanisms to put forward courses not offered by existing institutions
- Develop e-learning based courses and promote the production of course materials
- Promote Joint PhDs using bilateral and multilateral programs
- Promote joint international MSc programs in different rail related areas
- Develop and deliver short training courses (STC).

4.5 Summary of longer term strategies of suburban and regional passenger rail provider

In order to clarify the topic of this subchapter, it is necessary that the definition of this market segment is give, as agreed by the sector representatives – the Regional and Suburban Railway Committee of UITP discussed, and proposed the (updated) definition of this market segment on October 2014:

Regional and Suburban Railways (RSR) are passenger services in and around conurbations and regions. Such services are mostly organized along Public Service Obligation (PSO) arrangements, generally contracted by an infra-national government level (Region, Land, Province, Canton, Voivodeship, etc.);

The services typically feature the following characteristics:

- Average distance between stations : 1-25 km ;
- Commercial speed : 40-60 km/h ;
- Typical one-way passenger trip time : <1 hour;
- A high proportion of unmanned stations : >50%;
- Regional railways can run (partially) on single track.

It is true that unfortunately this definition is not always perfectly matching with the legal/operational definitions from several operators/European states, which makes any study in this field have a small margin for the figures given.

One of the project tasks has been to research the available RSR figures in order to show what the current statistical situation at the EU level is. This RSR (passenger) market oriented research undergone by UITP is actually an update of an earlier one (2005, also done by UITP on behalf of ERRAC). At the time of finalizing this deliverable the RSR statistics had been collected and the data analysed, thus being able to provide a clear input on the current situation, the general trend and the foreseen evolutions. The main outcomes are presented here in a clear and concise manner.

A main finding has been that the European available statistics through e.g. Eurostat do generally little justice to the specific segment of regional and suburban railways: they cover mainline railways and large national companies. This report will nevertheless provide a clearer and more detailed depiction of this fragmented market of regional railways

This research provides an overview of the information on the main features of the “suburban and regional railway” market. This rail market segment is:

- the most important from the business perspective for the operators, due to the volumes of passengers at stake;

- one of the most promising in terms of potential development and alternative to private car and buses (in line with EC Transport White Paper[3] perspective) for trips of the daily life between suburban areas and city centres (commuter and regional travel);
- one of the most fragile in terms of financial sustainability due to its high dependence on public funding: these services are operated under public service contracts following public service requirements, and they are often replaced by coach or bus services even if such services are less sustainable than rail services; this issue shall become even more challenging in the near future with the wider opening of coach services in EU;
- perhaps the most challenging from a technological point of view: a lot of upgrades and changes will be witnessed in this segment, as a result not only of the innovative technologies and passengers' demands for modern services, but also due to the fact that this is the overlapping point between the mainline and urban rail domains.
- And, last but not least, one of the most fragmented which does not facilitate the data collection with a view towards technical harmonization of the characteristics of such rail systems.

The study comprises 26 Member States (excl. Malta and Cyprus which do not have railways) and 2 EFTA countries (Norway and Switzerland). Contrary to the previous study, no feedback from candidate countries was available and the decision was taken to concentrate the efforts without them. Nevertheless, meaningful comparisons with 2005 results were possible, as the study had been presented with 4 clusters of countries (EU-15, new Member States, EFTA and EU candidates). The main methodological challenge was to be able to find the most objective set of criteria to make a distinction among general business data of those representing the segment of regional and suburban railways. In most cases passenger railway business is not singled out in reports. In some case even, there is no distinction between passenger and freight information.

It not only added to the difficulty of the survey, but it also shows that the RSR segment is not always seen as a key market, even though all figures prove the contrary.

While the document outlining the findings is a standing FOSTER RAIL/ERRAC public deliverable, and can be freely consulted either from the ERRAC or UITP resources, it is important to recall here the main findings:

- There are currently 217 passenger railway companies in the 28 European countries surveyed (26 Member States, excl. Malta and Cyprus, and EFTA countries Norway and Switzerland). Most of them are incumbent operators. This reflects a stable situation since the previous 2005 study (220).
- As a dominating pattern in most countries, nearly all regional trains run exclusively under public service contract
- European operators produce collectively approx. 2576 million train-kilometres per year for services qualified as suburban and regional. Unsurprisingly, the largest countries, Germany, the UK, France and Italy have the highest train

[3] EC White paper 2011: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system.

performances of the 28 surveyed countries (more than half of the total train kilometre). These four countries account for more than half (55%) of all train-km production of Europe.

- The total number of Regional and Suburban Rail passengers carried in 2006 was more than 6800 million. In nearly 10 years, demand has increased by 31% to reach 8,9 billion journeys. This figure comes from robust growth in most countries (France +15%, Germany +23%, Belgium +44% and very remarkably UK +98%). Southern countries on the other hand are affected by the economic downturn and the sharp increase of unemployment: Spain -15%; Portugal-12%. This confirms -if needed- one of the primary function of this railway segment: to bring commuter to work and back home. The passengers on regional or suburban trips represented by far the biggest part of all rail trips in Europe: they accounted for about 89% out of the total number of rail passengers and 50% of the total number of passenger kilometres per year[4].
- This figure of 8 900 million yearly passengers is the **equivalent** of patronage on all 45 European **metro** networks in 2013[5]. In 2013, the total number of passengers travelling by Light Rail and trams in the European Union was 7 688 million. In 2013, the total number of passengers travelling by air in the European Union could be established at 842 million[6], i.e. **regional and suburban railways carry 10 times more passengers than airlines** in Europe.
- Comparisons with official Eurostat's private motorisation rate (# cars per 1000 inhabitants) provide no clear and obvious correlation between popularity of railways and car ownership. On the contrary, countries with the lowest motorisation rates (<400 cars per 1 000 inhab.) are also among those with low railway usage: Romania (224 cars), Bulgaria (385 cars), Slovakia (337 cars) and Latvia (305 cars). In reverse, countries with above average/high car ownership (> 500 cars per 1000 inhab.) also scores among the most frequent train users: Switzerland (529 cars), Luxemburg (621 cars), Germany (539 cars), Austria (542 cars).
- The total number of annual passenger kilometres in Europe in is about 220 600 million, i.e. a 13,7% increase compared to the 2006 study.
  This represents 50 % of the total 444 500 million passenger km in Europe (EU28 + EFTA); It is worth noting that with 109 800 million passenger km, High Speed Trains represents 25% of performance expressed in passenger km whilst it is only a small percentage of the passenger numbers
- The average percentage of electrification on railways in the surveyed countries is 53%. Interestingly enough, this proportion also matches the proportion of single track from the total network length. Although it cannot be assumed that all single track lines are non-electrified, it is believed that single track lines would be dominantly non-electrified.

[4] Comparison with UIC statistics (metro and light rail not included)

[5] UITP, statistics brief – world metro figures, October 2014

6 http://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_transport_statistics#Air_passengers

- There are 27 693 stations or stops in Europe, translating in an average distance between stations/stops of 8.2 km. This reflects well the local character of most railway infrastructure (dedicated high speed lines were removed from the survey). There is a slight difference between EU-27 (25 303 stations/stops and 8,7 km) and EFTA (2 390 stations/stops and 3,6 km, resulting from the extremely dense station network in Switzerland)

Having taken all the data into consideration it can clearly be said that the RSR segment is a critically important market, accounting for 90% of total railway passengers in Europe and 50% of passenger-kilometres.

Furthermore, it is currently an opening market in several European countries and the current final discussions around the political pillar of the 4th Railway Package will largely determine the course of evolution for the coming decade. Last but not least, it is also a challenging public transport market, notably for ensuring sustainable urban mobility, encouraging modal shift from car and decongesting transport corridors providing access to major European cities and notably the "nodes" of the Trans-European Networks (TEN-T).

4.6 SPIDER PLUS & LIVING RAIL

Spider Plus and Living Rail are two EC 7th Framework funded projects which aim is to develop a passenger and freight mobility vision for 2050, encompassing seamless travel and transportation chains in which electrified rail play a key role.

Spider Plus analyses the gap existing between the expected futures, based on 'business as usual' scenario, and the desired future based on the 2011 Transport White Paper.

The interdisciplinary consortium of Spider Plus is formed by:

Duss, Hacon, European Aeronautic Defence And Space Company France, Newopera, Kombiconsult, Rapp Trans, Nuovo Trasporto Viaggiatori, Tecnicas Territoriales Y Urbanas, Universita Commerciale 'Luigi Bocconi', Consorzio Ib Innovation, Center For Future Studies, Siemens and Gruppo Clas

They have elaborated a roadmap to sustainable mobility 2050 considering four guiding principles, it is shown below:

Figure 2: Roadmap of Spider Plus. Source: Rail towards 2050 – Vision and Roadmap for Sustainable Mobility, LivingRail and SPIDER PLUS (2015)

LivingRail project explore the strategic measures through which transport policy, special planning and the rail sector can maximize the market share of electrified rail.

This project develops visions of the future role of electrified rail in 2050 in two parallel streams.

- Railway evolution
- Spatial and urban policies

This encompasses the mobility of people and goods with the evolving of demographic and economic structures, the environmental challenges, the energy issues, the social and cultural values, the living spaces and the advances in technology.

The working process has been based on:

- Literature review
- Analysis of framework conditions and best practice cases
- Appliance of visioning and road mapping techniques
- Extensive stakeholder and expert involvement

The partners: *Fraunhofer ISI, Allianz pro Schiene, Mcrit, rtca, Savez za Željeznicu, Siemens: Mobility and Logistics, TRT Trasporti e Territorio, and University of Birmingham* have produced a "Railmap" shown in the next exhibit.

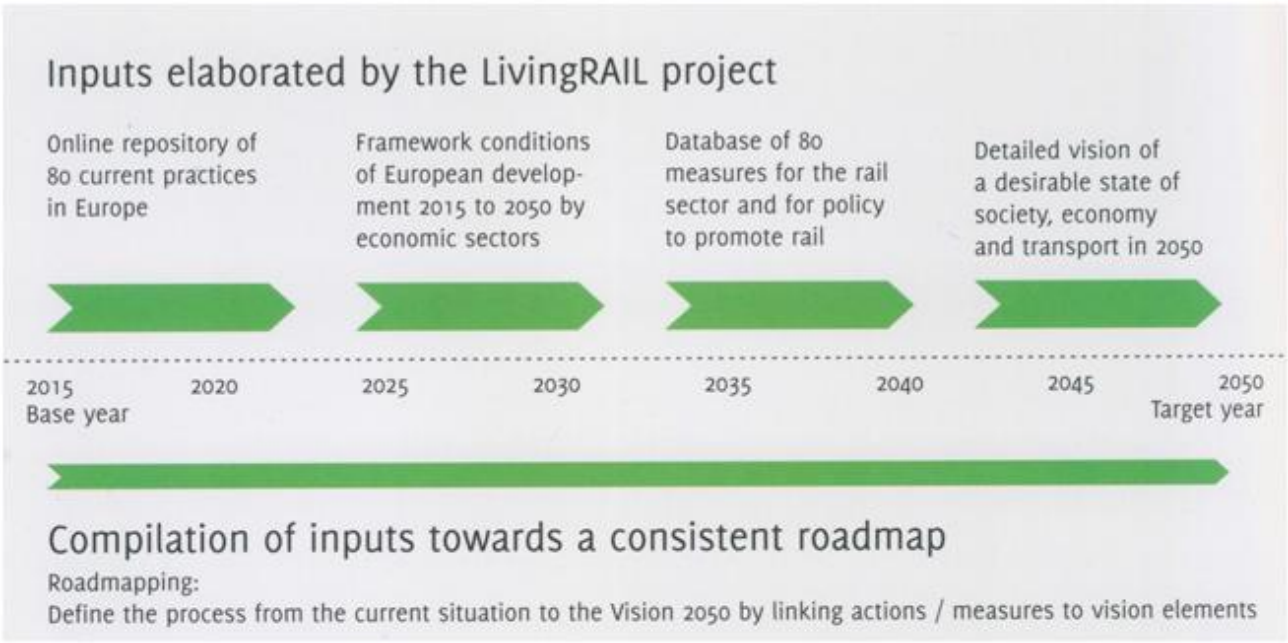

Figure 3: Railmap of LivingRAIL. Source: Rail towards 2050 – Vision and Roadmap for Sustainable Mobility, LivingRail and SPIDER PLUS (2015)

The results of the project point out a set of roadmaps and action plans for achieving the vision of a European society served by electrified rail. These can be expressed in keywords can be put on tables for a quick view.

Roadmaps for the rail sector	
Infrastructure	• EU network development • Interoperability & modular design • Predictive maintenance • Safety & security • Environment & sustainability • Stations and nodes
Rolling Stock	• Hybrid locomotives & train sets • Automatic coupling, electric wire & new braking technologies • New light weight wagon design
Technology	• Rolling stock design and materials • Automation in movements / transfers • Comprehensive ICT based management
Governance	• Network governance • Transport industrialisation • Legal framework, policy measures
Market Update	• Collaboration and offer driven business model • Permanent education and training

Figure 4: Roadmaps for the rail sector. Source: Rail towards 2050 – Vision and Roadmap for Sustainable Mobility, LivingRail and SPIDER PLUS (2015)

Roadmaps for spatial concepts and policy	
Norms, Values and Lifestyles	• Actively address social norms and values • Stimulate green behaviour • Green and transit friendly cities • Transit oriented development • Transport mobility and accessibility plans • Fostering the shift of mobility

Sustainable and powerful regions	• Strengthen the power of local communities • Revitalise small and medium-sized rail stations
Regional Freight Solutions	• Analyse the reasons for failure of regional and urban logistic centres • Provide financial incentives or funding • Containerisation and standardization
Integrated and Open European Transport Planning	• Common European vision and roadmap • Coordinating European and national investment plans • Actively involving the railway sector
Foster Multi-Modality	• Rail stations to become intermodal hubs • Reliable multimodal European booking & information platforms • Rail connections to major European gateways • Support regional mobility associations
Reforming Railways	• Customer orientation • Binding performance targets
Funding the Mobility Shift	• Fair taxation and pricing • Multimodal and cross-regional funds • Involve private investments • Expand public service obligations

Figure 5: Roadmaps for special concepts and policy. Source: Rail towards 2050 – Vision and Roadmap for Sustainable Mobility, LivingRail and SPIDER PLUS (2015)

As a conclusion both projects send joint key messages to the public administration, to the infrastructure managers and to the railway industry, they are summarized as follows.

Joint key messages to...	
...policy and public administrations	• Agree on common vision for rail • Policy across sectors (transport, energy urban and regional development) • Standardise railway regulations (more ERA)[7] • More funds for railway system
...infrastructure managers	• Complete national HS networks • High capacity freight corridors • Remove bottlenecks at borders • ETCS[8]
...railway industry	• Replace outdated equipment • Introduce IT-based technologies

Figure 6: Joint key messages. Source: Rail towards 2050 – Vision and Roadmap for Sustainable Mobility, LivingRail and SPIDER PLUS (2015)

[7] Applicable only for the mainline rail domains, and not for the urban rail ones.

[8] And CBTC in the case of urban rail

5. FOSTERRAIL Future Dialogue Forum

The concept of FOSTERAIL WP 2 proposed a specific methodology to achieve a reference rail business scenario. An exploratory forward-looking methodology (foresight) was taken up and implemented in a robust multi-stakeholder dialogue process; a futures dialogue forum was organized. This Forum took place in March 2014 in Brussels. It was attended by more than 40 stakeholders and experts of the European rail sector. An initial rail business reference scenario was jointly outlined and agreed upon by the participants.

The methodology applied is referring to an actual European Commissions concept linking science and research to society. This concept is called responsible research and innovation (RRI) and foresees the inclusion of a wide range of stakeholders and experts, including civil society, into research and innovation agenda and priority setting. Furthermore, the methodology refers to the state of debate regarding the renewed principles for the European Technology Platforms (ETP) to serve as multi-stakeholder platforms to agree upon strategies and roadmaps for research and innovation and to commit to joint research and innovation actions in the European Research Area.

Figure 7: Participants of FOSTERRAIL Futures Dialogue Forum (2014)

5.1 Four socio-economic scenarios

In the morning session of the forum a portfolio of four different scenarios of potential socio-economic and European rail system futures were discussed and further developed to gain an informed consent among the participating stakeholder and experts. The four socio-economic and rail future scenarios were structured with the STEEP concept, namely social, technological, economic, environmental and political trends, i.e. to make the four scenarios comparable.

In the socio-economic and rail future scenarios a wide range of storylines were clustered. This was allowing, for example, to vary the scenarios regarding different trend prognoses for economic and transport demand and other long-term projections.

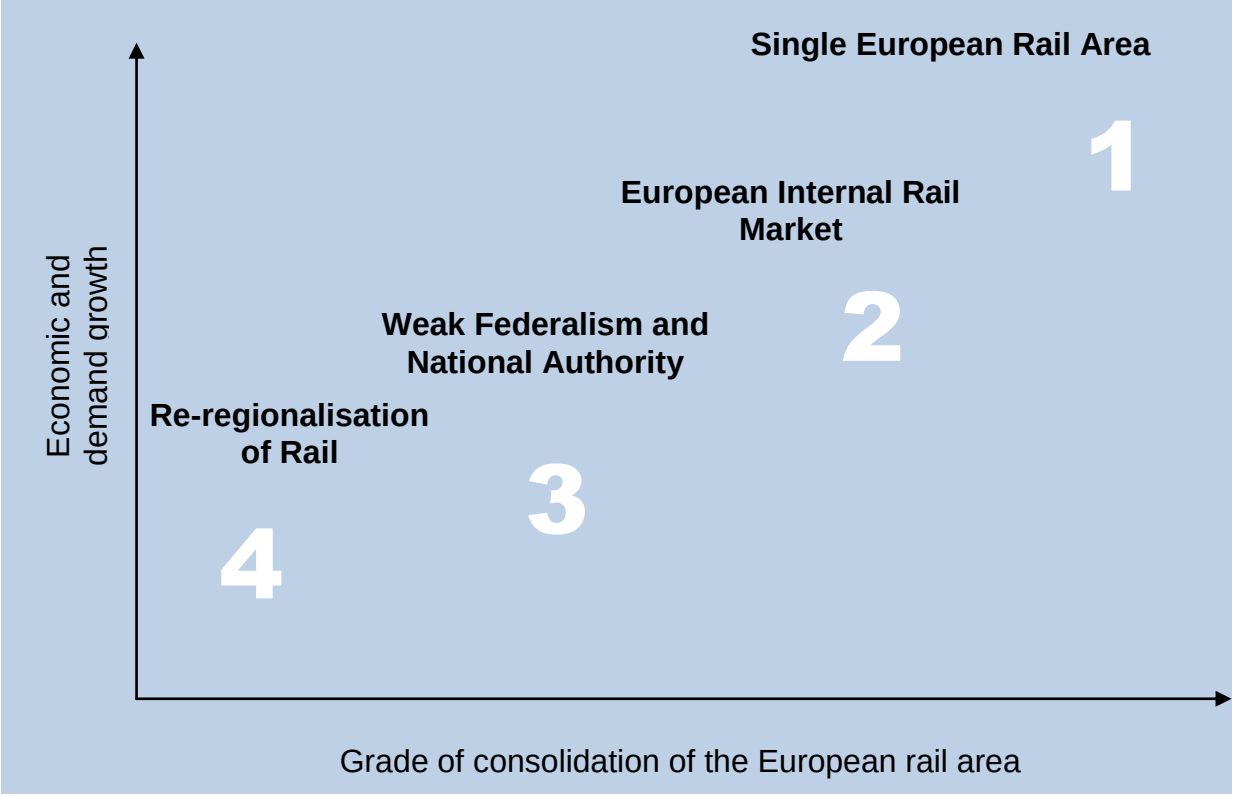

Figure 8: Classification of four socio-economic and rail future scenarios in FOSTERRAIL

The **first scenario** outlines a socio-economic framework scenario of high economic and transport demand growth and increase of prosperity and with this "prosperity narrative" significant political framing conditions towards the horizontal integration idea of a "Single European Rail Area".

The **second scenario** focuses on European rail market integration with advanced coordination mechanisms, but a trend towards vertical integration and large consolidated rail operation and infrastructure service providers. In this scenario economic growth is more moderate.

A **third scenario** points at the European Union as weak federalist system and a re-shift of rail policy authority to the national and regional policy level. Main investment in rail is taken at the national and regional level. Only small budget shares will be available for European co-funding for some main corridors.

A **fourth socio-economic scenario** is finally sketching out the European Union drifting apart and shrinking budgets at the European level. Re-regionalisation of production and consumption implies less travelling and transport.

These scenarios represent potential futures of the rail system in Europe against the background of different socio-economic framework futures. Varying socio-economic trends and policy drivers, e.g. the successful implementation of the railway packages into practice and the accomplishment of challenges set up in the 2011 Transport White Paper were taken up to differentiate the four framework scenarios. In the Forum these scenarios were discussed and fleshed up with additional storylines. This exercise resulted in improving and agreeing upon the scenarios. The final scenarios are outlined in Deliverable 2.4.

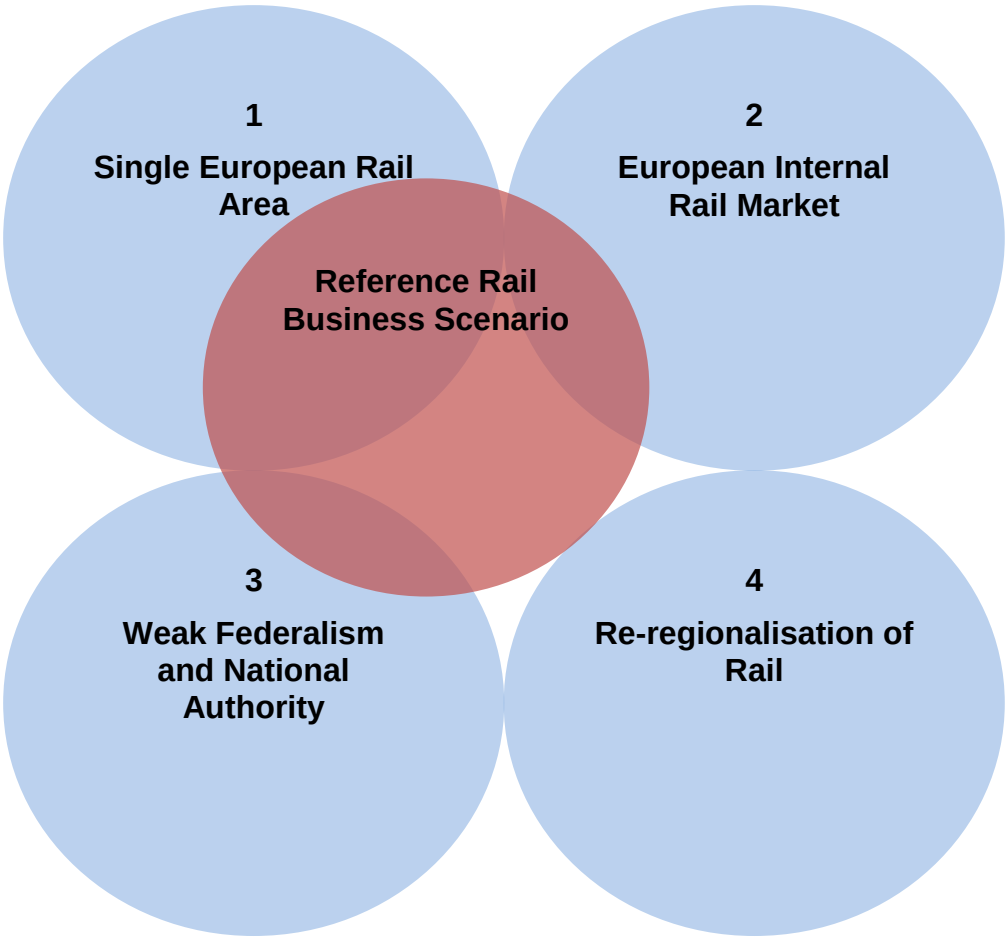

Figure 9: Rail business scenario on the four socio-economic and rail future scenarios of FOSTERRAIL Futures Dialogue Forum

The four generic socio-economic and rail area future scenarios were paving the ground to develop a first visionary scenario up to 2050 and beyond as a reference rail business scenario. For this scenario five types of rail operations were addressed, namely:

- the European high speed rail area,
- the long-distance rail freight area,
- the regional and urban freight area,
- the regional and local passenger rail area, as well as

- the urban rail operations.

The exploratory exercise developing and discussing in a first round a portfolio of generic scenarios was crucial to keep the visionary scenario based on reasonable expectations and estimates, rather than promises and blue sky ideas of stakeholders and experts. This type of informed visioning and scenario building process resulted in a sound and robust reference rail business scenario sketching out a preferred, but still reasonable European rail system up to 2050. The first business reference scenario as final outcome of the forward looking exercise in the futures dialogue forum is presented in Deliverable 2.5.

6. Conclusion and updated rail business reference scenario

To up-date the reference rail business reference scenario after halfway through the FOSTERRAIL project gave the opportunity to complement as well as to reframe the initial rail business reference scenario and to gain a second reference rail business scenario. The scenario was reframed to challenge the rail sector as backbone of the European transport system under a strict post Paris climate regime. In the scenario conventionally fuelled vehicles have to be replaced by alternatives up to 2050. The overall energy and transport system and the economy has to be nearly fully decarbonised – near zero carbon emissions till 2050.

Working out roadmaps involves agreeing upon what public and private sector investments have to be taken in order to successfully address a vision or in this case a reference scenario. The updated reference rail business scenario is expected to serve to align the road-mapping exercise. Conversely, by drafting and agreeing upon the FOSTERRAIL roadmaps this may bring up further input to be fed back into the reference scenario. The feedback will be taken up and implemented into the actual scenario outline.

The first portfolio of scenarios to guide the FOSTERRAIL Futures Dialogue Forum was already prepared by analysing economic and societal trend curves including transport demand prognoses and other forecasts as well as qualitative trend and driver analyses. An overview was given on other relevant visioning-, scenario development or road-mapping exercises related to the rail and transport sector. This task was further preceded by preparing deliverable 2.6. A range of additional projects and supporting actions were analysed, mainly EU funded projects and actions which were already ongoing or had just started at the time when drafting deliverable 2.3. Most trends indentified as outcome of these projects and actions are similar than the trends analysed in WP2, for example:

- Most scenarios and trend analyses share the issue of ageing of European population and the migration challenge.
- Regarding technology trends in most analyses and scenarios new (light) materials for rolling stock, electric engines, ICT, hybrid engine technologies, braking technologies and noise reduction solutions are emphasized.

Less addressed aspects are, for example, security related issues in public transport, which, added to the safety issues, represent a grand challenge already under a short and medium horizon perspective. A major challenge in the rail sector – both mainline and

urban rail – is caused by daily crime, which actually produces high losses with operators, for example, graffiti, metal theft, staff assault, etc. Other challenges have to be taken up, especially when it comes to cyber security issues.

Regarding market deployment trends, all scenarios are showing an important (ascending) trend regarding RSR (Regional and Suburban Railway). In the case of urban rail statistical figures are also showing an ascending trend. Policy-makers, public authorities, operators and industry are requested to take up strategic measures to respond to this challenge.

The ERRAC Permanent Advisory Group of Academia describes a range of very concrete and feasible actions and topics for research and innovation including challenges to be addressed These topics are strongly referring to the storylines already summed up in the first reference rail business scenario. In addition to this it is very important to mention the ERRAC/ PAG roadmap for training and education.

The table below is summarizing main areas and concepts addressed by the up-dated reference scenario. This concluding summary in deliverable 2.6 will support the transfer of key aspects to further align the road-mapping exercise – to provide guidance and structure for the review and up-date of the FOSTER-RAIL roadmaps in WP3 and WP4.

Area	***Concepts***
Technology	• **Hybrid, electric, lighter rolling stock with nearly-zero emission** • **Automation of operations, unmanned terminals/stations, industrialisation of transport** • **Technical innovations towards more energy and resource efficient as well as quieter railway systems** • **More resilient infrastructure; less maintenance costs and innovative rehabilitation methods** • **Integrated and harmonized services for ticketing, traveller information and guidance** • **Multimodal (seamless) travelling/transport for passenger and freight, using the advantages of the rail wherever possible**
Societal	• **Lifestyle changes, ageing of population and migration challenges: young people use more public transport, more innovative transport concepts** • **Transport freight growth mostly shifted to rail; intermodal freight transport chains** • **Accessible and frequent public transport not only in inner cities** • **Major focus on training and education in railway**

Policy	• **European Union as a federalist system based on a multilateral treaty or a constitution** • **Policy authority regarding rail regulation and standardization fully at the European level for mainline rail** • **Member states' rail networks are interconnected and interoperable.** • **Safety and security in transportation related to new technologies, e.g. internet** • **R&I policies at EU level by then strongly driven to strengthen the European rail industries in competing with rail markets worldwide and to encourage shift2rail strategies**

7. References

- *4th Railway Package (European Commission, 2013)*
- *A sustainable transport vision for Germany (FHG ISI, 2011)*
- *A Vision for Railways in 2050 (OECD ITF, 2010)*
- *Challenge 2050 – The Rail Sector Vision (CER, EIM, UC, 2012)*
- *DETRA D5.2 Optimized Pan-European Transport Research Work Programme (2012)*
- *Employment in the EU Transport Sector (European Commission, 2013)*
- *ERRAC Permanent Advisory Group – Academia Academic Response to the SHIFT2RAIL Master Plan: The ERRAC Challenges*
- *ERRAC Roadmap Rail Business Scenarios (ERRAC Roadmap Consortium, 2012)*
- *Europe 2020 - A strategy for smart, sustainable and inclusive growth COM(2010) 2020 final (European Commission, 2010)*
- *European Foresight Platform ´´Smart Mobility 2050´´ Workshop paper Brussels June 2012*
- *FORESEC D2.3 Global Trends and Actors Shaping European Security (2008)*
- *FOSTERRAIL D2.3 – Report on Business Scenarios, May 2014*
- *FOSTERRAIL European Futures 2050*
- *Future Scenarios for the European Airline Industries (HHL, 2010)*
- *Krisen an Europas Grenzen (Hanns-Seidl-Stiftung, 2013)*
- *Living Rail Project www.livingrail.eu*
- *Proposal for a Regulation of the European Parliament and of the Council on Union guidelines for the development of the trans-European transport network. COM/2011/0650 final/2 - 2011/0294 (COD) (European Commission, 2012)*
- *Rail Business Scenarios and Dialogue Forum Agenda (Working paper), March 2014*
- *Rail Route 2050 – The sustainable backbone of the Single European Transport Area (ERRAC, 2012)*
- *Rail Technical Strategy Europe (UIC, 2014)*
- *Report on Transport Scenarios with a 20 and 40 Year Horizon (Tetraplan A/S, ITS University of Leeds et. al., 2009)*
- *Roadmap to a Single European Transport Area Towards a Competitive and Resource Efficient Transport System COM(2011) 144 final (European Commission, 2011)*

- *Spider Plus Project, www.spiderplus-project.eu*
- *Strategic Transport Infrastructure Needs to 2030 (OECD, 2011)*
- *The Academic Response to the Rail Technical Strategy 2012, Nov 2013*
- *The optimal setup of a rail system – Lessons learned from outside Europe (Roland Berger, 2012)*
- *Think Railways Jose Viegas OECD ITF May 2014*
- *Transforum Project http://www.transforum-project.eu/*
- *Transport development in Asian Megacities (Morichi 2013)*
- *UITP PTx2 (UITP, 2009)*
- *UITP RSR (passenger) market oriented research*
- *Unife World Rail Market Study (Roland Berger, 2012)*
- *We make it fly (Airbus Group, 2014)*
- *White Paper 2011 - Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system (European Commission, 2011)*

8. List of figures