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Future of Surface Transport Research Rail

Coordination and Support Action

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Deliverable D4.4

First draft of the Technology and Innovation Roadmaps

WP	4	Technology Roadmaps, Exploitation & Implementation
Task	4.1	Technology and Innovation Roadmaps

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[1] Dissemination level: **PU** = Public, **PP** = Restricted to other programme participants (including the JU), **RE** = Restricted to a group specified by the consortium (including the JU), **CO** = Confidential, only for members of the consortium (including the JU)

[2] Nature of the deliverable: **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

Table of Content

Including draft part-Roadmaps on the following areas:

- Customer experience
- Strategy and economics
- Capacity, performance and competitiveness
- Energy and environment
- Safety (including certification) and security
- Control, command and communication
- Infrastructure
- Rolling stock
- IT and other enabling technologies
- Training and education

1. Executive Summary

The FOSTER RAIL project is addressing the challenge to strengthen and support research and innovation cooperation strategies in the European rail sector. The project's work plan foresees to enhance coordination among main stakeholders and actors in the European rail sector and rail industries and integrate the work done so far by ERRAC and its working groups. Starting with the already published ERRAC-ROADMAP, the FOSTER RAIL project will continue to coordinate the research and innovation agenda and priority setting process among the wide range of relevant stakeholders in the rail sector. The outcome of FOSTER RAIL will be a Rail Business Scenario as basis for new Strategic Rail Research and Innovation Agenda (SRRIA) and specific Rail Technology & Innovation Roadmaps aimed at 2050. The output will among others be used to advise the European Commission, Shift2Rail and other research programmes on their content.

Task 4.1 "Technology and Innovation Roadmaps" of the Work Package 4 will deliver updated and upgraded technology and innovation roadmaps in line with the SRRIA's strategic alignment and fill the gaps in the existing ERRAC Roadmaps. The new set of roadmaps (fully taking into account the work performed under the ERRAC Roadmap project) will be a plan that matches short-term and long-term goals with specific solutions to help meet those goals. The roadmaps will apply to a new product or process, or to emerging technologies. One of the aspects of this task is to summarise, cluster, prioritise and publish the sector's R&D needs. On the basis of this work, ERRAC advises the European Commission annually on the sector's R&D needs & priorities.

This deliverable D4.4 represents no more than an interim report and an initial draft of the 10 part-Roadmaps for the final Roadmap we will produce by the end of the FOSTER-RAIL project. They are very much still "under construction" as the work has not yet progressed as far as we would have liked. They cover the 10 areas which have been described as prioritary in the Strategic Rail Research & Innovation Agenda – SRRIA, using the template and build on the previous ERRAC Roadmaps and their priorities and timing and have taken into account possible gaps and recent developments in rail research as well as in the rail system as such.

The Technology & Innovation Roadmaps will describe the challenges, problems and needs of all rail stakeholders and indicate the way forward and the steps necessary to make the Vision 2050 where the European Railway System forms the backbone of the integrated European Transport System. It will provide input to European Commssion's H2020 Programme for Research and the Shift2Rail Joint Undertaking as well as their successors.

2. Description of the Deliverable

This deliverable D4.4 represents no more than an interim report, a first draft of the 10 part-Roadmaps for the final Roadmap we will produce by the end of the FOSTER-RAIL project. They are very much still "under construction" as the work has not yet progressed as far as we would have liked. The main reason for this was the delay in the preparation of the Strategic Rail Research & Innovation Agenda. Another important reason was the very limited contribution from the operational experts from the railway sector, a problem that is being dealt with in a way which will guarantee a high quality Final Technology * Innovation Roadmap within one year.

The topics of the part-roadmaps – which will all be structured in a similar way and using the same common template for easier comparison and integration have been defined by the SRRIA.

The SRRIA identified 3 main areas of focus which are:

- Attractiveness of rail and public transport
- Whole system approach
- Assets

Each of these main areas contains a number of sub-areas which are the topics of the 10 part-roadmaps. They as the following:

- Customer experience
- Strategy and economics
- Capacity, performance and competitiveness
- Energy and environment
- Safety (including certification) and security
- Control, command, communication
- Infrastructure
- Rolling stock
- IT and other enabling technologies
- Training and education

Learning from the previous ERRAC Roadmaps, it was seen as extremely important to use for the drafting of these part-roadmaps a common structure in order to be able to compare the roadmaps and their planning of activities and priorities as many of the priorities cannot be specifically included in on area and be excluded from the others. Of course many of the research priorties are part of one or two other roadmaps or are being influenced by activities contained there. Having a common structure also makes a final integration of activities and priorities into a common roadmap and planning of implementation easier.

3. Approach

The team dedicated to implement the work as described in Work Package 4 of the FOSTER-RAIL project started to discuss and develop the common structure for the roadmaps and developed a first template, which was amended and changed several times due to changing insights and depending on the presence of members at WP4 meetings and workshops. The final template was then uploaded in November 2014. Following this, further suggestions for improvement were made during a WP4 working session and the EC Project Officer was asked to 'reject' the uploaded version of D4.1 which he did. However, he gave us some comments to be integrated in the newly agreed version, which have now been incorporated in the final template which has been uploaded.

The structure of the template now reads as follows:

1. Executive Summary
2. Description of the Deliverable
3. Part Roadmap on (name the title/topic of this roadmap)

3.1 Introduction
3.2 Key issues and objectives
3.3 State of the art an ongoing research & innovation within and outside rail
3.4 The Roadmap
3.5 Implementation Plan
3.6 Visual Roadmap, Milestones and Deliverable overview4.
Conclusions

As a next step, the WP4 leader proposed a Roadmap leader and co-leader for each of the 10 part-roadmaps. However, this proposal was not accepted by most of the partners involved in this WP as their budget would not allow them to do this work. (4 of the FOSTER-RAIL partners are not at all involved in the work of WP while 13 of the partners have either 0.5 or 1 MM to spend over a period of 3 years). Practically speaking most partners would be prepared to comment but not to lead the activities which would be needed to draft a part-roadmap work.

A seemingly workable solution was found by which the three associations UIC, UNIFE and UITP would lead 8 of the roadmaps, while DB and IST would each lead another one.

The UNIFE would take the lead on the part-roadmaps "Rolling Stock", "Control, command, communication" and "IT and other enabling technologies", the UITP on "Customer Experience" and "Strategy & Econimics" while the UIC would lead "Capacity, Performance & Competitiveness", "Energy & Environment" and "Infrastructure". Besides that, DB would lead the "Safety (including certification) & Security" roadmap and IST would lead the "Traning & Education" one.

Following this, the 5 organisations who shared the leadership of the 10 part-roadmap areas went to work and went through all the previous 9 Roadmaps from the ERRA Roadmap project to attribute all the indentified research priorities to the 10 new identified priority areas as described in the new SRRIA. Then all these priorities – some which could be attributed to 2 or more areas were discussed and it was decided in which of these 10 part-roadmaps the priority would be included, but still making the link to othe roadmaps where relevent.

Subsequently, each of the part-roadmaps were ‘populated’ with these priorities, updating them where necessary, describing them more clearly or deleting them if not or no longer relevant. Where needed, gaps have been identified and added. The information related to the planned year of implementation of the priorities was retained and taken into account when drafting the first roadmap versions.

Work on the draft roadmaps proceeded but not always at the same speed. The Safety & Security part-roadmap for instance did not progress well because of the very limit possibility of involvement of its leader DB which only had 1 MM available over 3 years. Luckily Trafikverket was prepared “to go the extra mile” as well as the Energy and Environment Unit of the UIC.

4. The way forward

In the next 16 months the activities of the WP4 clearly have to be stepped up and without a possible MM shift to enable the operational partners to really get involved and contribute this will not be possible. Also, much more effort is expected from the members of the participating associations and their experts.

After decisions made on these issues, it would be necessary to nominate 10 part-roadmap leaders who will really feel responsible for the job and take the work forward in order to achive a really high-quality final Roadmap.

What will be needed now is to develop the draft roadmaps according to the common template as described in Deliverable D4.1 and to add the explanations and descriptions to the priorities as indicated sofar. At the same time a close link will be secured with the WP2 where the Rail Business Scenario will be further developed, a valuable source of input for the Roadmap work. The same holds true for the close link with WP4 where the new SRRIA – D3.2 – will be updated. Alongside this work on the Roadmapping, there will be a clear link with the work of the ERRAC Standards Recommendation & Exploitation groups “Mainline” and “Urban”.

A new WP for this WP4 has been recruited and put to work. A detailed plan has been developed for the implementation of the work needed to complete this task including a detailed timeline with Milestones, workshops, WP4 meetings and mandatory monthly feedback from all FOSTER-RAIL partners involved on their activities for this task. We aim to deliver the 10 final part-Roadmaps as intended by M32 of the project, well ahead of the finalisation of the project and if needed with the possibilities to futher improve on the results.

Attached in the Annex there are the very first drafts of the Part Roadmaps to be further developed into high quality 10 Technology and Innovation Roadmaps, based on te previous documents prepared by ERRAC and the supporting ERRAC Roadmap project, the Rail Business Scenario and the new and updated SRRIA aimed at the innovation of the European rail system and its increased role in the European transport system.

ANNEX

In this Annex you will find the very first drafts for the final Technology and Innovation Roadmaps. The common template will feature a common introduction and description followed by a more specific introduction per part-roadmap area.

1. Introduction

(This chapter is based on and gives a summary of the main issues as described in the SRRIA - Fosterrail D3.2. max 1 page)

In order to ensure that research – and especially EU-funded research – will correctly and timely address the real needs of all stakeholders, the ERRAC members had decided to put forward a structured and comprehensive approach of the sector towards such strategic activities. As a result, the ERRAC Roadmaps projects were created, thus outlining the research needs of the EU rail sector into a detailed structure – both in terms of topics to be addressed and the timeline allocated to them. These Roadmaps served as a guideline for the EC efforts in supporting rail research efforts.

This step was seen as very good, yet insufficient by the stakeholders. What was needed was to match these identified topics with a broader, more comprehensive approach of the stakeholders in order to obtain a credible and affordable plan that would make the rail sector a success story for the years to come.

Consequently the Strategic Rail Research and Innovation Agenda was prepared, outlining the future research and innovation activities that are meant to ensure a harmonious expansion of the railway sector up to 2050.

Within the SRRIA these R&D&I targets are structured around ten themes reflecting ERRAC's ambition to pursue efforts requiring extensive collaboration across the sector. Each theme has its own vision and the priorities that should be followed in order to transpose that vision into reality. However, in order to achieve these goals, it is necessary that a number of actions need to be planned and implemented over the years. That is why each of the themes has a roadmap of achieving these short-term and long-term goals.

And in order to capitalize on the efforts previously, the ERRAC members have decided to merge the structure of the SRRIA with that of the ERRAC Roadmaps, thus completing the sector's comprehensive approach and eliminating any double effort.

2. The 10 priority areas for the innovation of the rail system.

(This chapter gives the part-roadmap for each of the 10 SRRIA priority areas. These are:

Attractiveness of rail and public transport:

Customer experience (present and future customer)

- Strategy and economics
- Whole-system approach
- Safety (including certification) & security
- Capacity, performance and competitiveness
- Assets:
- Control Command, communication & signaling
- Energy and environment
- Infrastructure
- Rolling Stock
- IT and other enabling technologies
- Training and education

1. Customer Experience Roadmap

Introduction

Among the 10 themes of the SRRIA, one is the Customer Experience, and it is twinned with the Strategy and Economics roadmap. As the title shows it is a very vast topic, since almost all other themes and roadmap topics could be subsumed to it – the railways sector is meant to provide services to different customers, therefore all improvements or changes either target or influence the customer in one way or another. However, the FOSTER RAIL partners had made a split along certain criteria in order to make sure that there will be as little overlap as possible.

The identified roadmap topics that have a more technical and/or operational have been assigned to their respective subjects. However, those that have a significant direct influence on the rail customer and their perception via-à-vis the railways sectors have also been included in the "Customer Experience" roadmap.

Other topics are intrinsically vast and significantly influencing other roadmap topics – therefore they appear in their relevant roadmap, but also in the "Customer Experience" one.

Many of the topics identified under the "Strategy and Economics" Roadmap are also part of the "Customer experience", since the two roadmaps are twinned, and customers are naturally the key aspect in a company strategy and economics planning.

And, of course, there are the direct topics that pertain to customer experience – either individuals or companies that benefit from the services of the rail transport sector.

The vision outlined by the SRRIA in this case is the following:

- Passengers enjoy seamless multimodal journeys that are easy to plan, select and book. They experience a comfortable, safe and secure environment and are reassured by the availability of real-time traffic and whole-journey information about journey options should problems arise with modal connections or degraded operating conditions. Perceived nuisance factors such as noise and vibration are minimal. Rail research will take account of likely user acceptance of innovative mobility measures and services (by rail, by public transport and co-modal between public transport and individual or shared private modes)

- Business analytics facilitate more customer driven services. Data collection and improved and harmonised statistics feed convincing economic studies and traffic forecasts and the development of customer oriented business models

- Significant improvements in operational reliability, the cost of rail travel and appreciation of the security of the railway system contribute to the overall attractiveness of the system.

- The rail system is accessible and attractive to all passengers, whatever their social category, age and life characteristics and their possible physical impairment

- Integration of the databases across transport modes offers door-to-door freight transport including a rail link with fast and accurate service pricing

- Rail freight customers benefit from regularly updated Estimated Time of Arrival (ETA) using information provided via enhanced train connectivity systems

- Socio-economic studies address user responses to pricing policies, to facilitate their travel by rail and public transport through integrated charging and payment systems and to influence their modal choice and travel consumption.

Key issues and objectives

Because of the way in which the SRRIA had been designed, this roadmap is twinned with that which deals with the "customer experience", therefore there is a great overlap between the vision and priorities of the two.

The key issues and objectives identified by the SRRIA are:

- seamless multimodal journeys that are easy to plan, select and book
- Ensure the safety and security of passengers
- ensure up-to-date information about journeys
- user acceptance of innovative mobility measures and services
- ensure operational reliability, and the affordability of the cost of rail travel, delivered in close coordination with other transport modes, thus enabling seamless and sustainable mobility in all parts of Europe.
- ensure that the rail system is accessible and attractive to all passengers, whatever their social category, age and life characteristics and their possible physical impairment
- offer door-to-door freight transport including a rail link, with fast and accurate service pricing
- Understand and respond to public needs following in-depth socio-economic studies on topics such as: pricing policies, integrated charging and payment systems, passengers' modal choice(s) and travel consumption, pricing and taxation of transport infrastructure and transport means, general user behaviour, the impact of ownership or use of transport modes, etc.

State of the art and ongoing research and innovation within and outside rail

(This chapter describe the present state of the art - and outside rail – potentially useful for rail innovation – max 2 pages)

a. Shift²Rail

The Shift2Rail is a Joint Undertaking between the EC and major European rail stakeholders, with the aim of achieving a modal shift from road to rail in order to achieve a more competitive and resource-efficient European transport system.

The S2R is divided into Innovation Programmes (IPs), each addressing a major rail area, as follows:

IP1 – Rolling stock

IP2 – Traffic management and control systems

IP3 – Infrastructure

IP4 – IT solutions

IP5 – Freight-related technologies

At the moment the IP research activities have not yet started, but preparatory activities have already begun for a number of IPs.

b. FP7

c. H2020

- Planning sustainable urban areas by integrating rail freight: based on a catalogue of requirements for the optimal use of rail freight services in urban areas.
- Addressing the nexus of problems affecting urban transport (including congestion, pollution, accidents and inaccessibility) and using transport as an enabler of urban renewal.

Managing the impact of demographic trends and, in particular, the ageing population

- Effectively harnessing new transport -related ICT technology and data management opportunities
- Land-use and spatial planning around sustainable efficiences of public transport ; operate trains for 60 - 80% with energy from renewable sources ; develop common appraisal methods for cost benefits analysis of cross border business
- Impact of new integrated transport and land-use policies and measures
- Accessibility as a tool and as an objective
- Integration of ticketing and charging services - (New) charging and pricing policies strategies
- Interchanges for passenger travel and transport - Integrating interchanges, nodes of the smart city
- Integrated Urban mobility Systems and Governance -Mobility management and social networks

d. National research

e. Relevant Research & Technologies outside rail

- Advanced composites
- Nano technology
- Advanced IT - including big data processing and analytics, passenger information systems, wearable technology
- The industry internet - using the ‘internet of things’ including sensor networks
- Novel use of satellite-based services for traffic and transport solutions, made possible through technology development and the implementation of Galileo. The link with parallel developments, like smartphones, 5G and logistic solution is a key issue
- Development of demonstrators of robotic equipment to replace simple repetitive tasks currently undertaken by maintenance teams

- Smart grids - economic, legal and institutional framework for the development of smart grids for energy capture (e.g. from kinetic processes) storage and adaptive feeding to rail, road and other applications
- Alternative propulsion energy sources, including hydrogen and natural gas, operation of trains from 60 - 80% energy from renewable sources
- Strategies and objectives for the use of active and passive systems to provide constant vigilance against both daily crimes specific to the transport systems and terrorism and cyber-attacks
- Multi-senses vehicles – innovative solutions for people with mobility impairment
- Use of recycled materials and innovative cross-modal techniques for infrastructure construction

Roadmap development and improvement targets

The priority topics identified by the previous ERRAC roadmaps had been reallocated according to the new SRRIA Roadmap titles for two main reasons: to ensure both coherence between past and future work, and to create a comprehensive approach of the sector toward the R&D&I needs for the years to come.

The way in which these topics had been selected was already explained in this document, in chapter 3. It must also be noted that a few of the previous ERRAC roadmaps had been discarded because their approach was either too general, or was no longer reflecting the main needs of the sector.

Below is an outline of the main topics for the “Customer Experience Roadmap”, structured according to a number of sub-themes. It can be noted that many of these sub-themes are cross-sector, and there is a natural overlap between some of them. Addressing several inter-related topics within the same research effort is an added-value. The indicative timeline of these research proposals is also indicated between brackets.

T0 = topics that should be addressed as soon as possible, even in the same year that the Roadmaps are issued. ERRAC members had already proposed some topics to the EC before the mid-term of H2020.

T0 = it has been already covered.

T1 = immediate.

T2 = 2015

T3 = 2020

T4 = 2030

T5 = 2050

Noise & Vibration

- improved communication strategy (T0-T4)
- Improvement of interior acoustic comfort for passengers (T0 -T2)

Logistic services - rapid reaction to queries - response time to enquiries in terms of service availability, routes, schedules, pre and end haulage satisfying customer demands (T0)

Seamless passenger journey

- Integrated information systems handling the whole journey across modes and different mobility providers (T0-T1)

~~- Trains equipped to meet passengers' expectations (T0-T1)~~

- Adaptive interiors configuration for different types of users e.g. family activities, mobile office and group travel (T0-T1)

- Logical station layouts, good signage, location and maps and information on onward local ground transportation options (T0)

- Comfortable waiting areas, research, understand and where feasible accommodate passengers' varying priorities at different hubs (T0-T1)

PRM - Mobility for all (T0-T4)

Land use - Improving the spatial appeal to passengers of the urban environments in which transport hubs are located (T0-T1)

Customer needs and behaviour

- Customer needs and expectations including protection of privacy, and translation into functional service requirements (T0-T4)

- Mobility and location behaviour of individuals and firms (T0-T4)

- Social determinance of mobility behaviour (T0-T1)

- Measuring customer satisfaction and involving customers in service design and operation (T0-T1)

- Impact of new integrated transport and land-use policies and measures (T0-T1)

~~- Understanding and managing the impact of societal changes and of global political targets (T0-T2)~~

- Accessibility as a tool and as an objective (T1-T3)

Personal Security - Design, technological and organisational measures to improve customer and staff security (T0)

Safety and homologation - Management of degraded mode and minimising disruptions to passengers (T0)

Competitiveness and enabling technologies - Improved accessibility for specific categories (T0)

Security

- Key asset protection - Train security perception (T1)
- Key asset protection - Station security perception (T1)
- Human factors - Passengers and other users security perception (T0 - T1)
- Detection Systems - No intrusive sensors (T0 - T1)

- Detection Systems - No time spent in security check (T0 - T1)
- Procedures, Regulations and standards - Privacy and personal freedom protection (T0 - T1)

Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050)

tdb

Implementation Plan

(This chapter describes the possibilities and possible thresholds for implementation of the research and innovation priorities in this part-roadmap. Max.1.5 pages)

a. SHIFT²RAIL

b. H2020

In the case of H2020 ERRAC members consider that a 2-stage approach should be implemented.

The first stage corresponds to the first half of H2020. The topics for this first part have already been outlined in chapter 5:

- Planning sustainable urban areas by integrating rail freight: based on a catalogue of requirements for the optimal use of rail freight services in urban areas.
- Addressing the nexus of problems affecting urban transport (including congestion, pollution, accidents and inaccessibility) and using transport as an enabler of urban renewal.

Managing the impact of demographic trends and, in particular, the ageing population

- Effectively harnessing new transport -related ICT technology and data management opportunities
- Land-use and spatial planning around sustainable efficiences of public transport ; operate trains for 60 - 80% with energy from renewable sources ; develop common appraisal methods for cost benefits analysis of cross border business
- Impact of new integrated transport and land-use policies and measures
- Accessibility as a tool and as an objective
- Integration of ticketing and charging services - (New) charging and pricing policies strategies
- Interchanges for passenger travel and transport - Integrating interchanges, nodes of the smart city

- Integrated Urban mobility Systems and Governance -Mobility management and social networks

The second stage, corresponding to the second half of H2020, should address the remaining research topics that have been pinpointed for the T0 – T2 period

… (to be added)

c. Other public funding programs

The following categories of funding have been considered as public funding programmes:

1. The different EU sources of funding

2. The state (national/regional) sources of funding.

EU funding – here not taking into account either S2R or H2020 – comes through a wide array of channels and methodologies, which can be accessed directly or indirectly.

The main sources are the European Structural and Investment Funds[3]:

- the European Regional Development Fund (ERDF)[4] which aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. The ERDF focuses its investments on several key priority areas: innovation and research; the digital agenda; support for small and medium-sized enterprises (SMEs); the low-carbon economy.

- the European Social Fund (ESF)[5] invests in people, with a focus on improving employment and education opportunities across the European Union. For 2014-2020 the ESF will focus on four of the cohesion policy's thematic objectives: promoting employment and supporting labour mobility; promoting social inclusion and combating poverty; investing in education, skills and lifelong learning; enhancing institutional capacity and an efficient public administration. The ESF consequently represents a source of funding that can address the need for training and qualifications that will meet the demand of the rail sector, both today and in the years to come, thus responding to some of the topics identified under the customer experience roadmap.

- The Cohesion Fund[6], aimed at Member States with a Gross National Income (GNI) per inhabitant is less than 90 % of the EU average. It aims to reduce economic and social disparities and to promote sustainable development. A significant part can be allocated to general environmental activities: energy efficiency, developing rail transport, supporting intermodality, strengthening public transport, etc. In theory some rail stakeholders can use part of these funds for transport-related research. But this also depends both on the national legal framework and the future EU-related developments in the field of research funding.

- Alongside these funds, the EU also has the possibility to offer grants in support of projects or organisations which further the interests of the EU, or contribute to the implementation of an EU programme or policy[7]. Numerous topics covered by these grants can be subsumed to the R&D&I aims of the rail sector: competitiveness, education and training, energy, environment, sustainable development, shifting freight from road, etc.

[3] http://ec.europa.eu/regional_policy/thefunds/index_en.cfm

[4] http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm

[5] http://ec.europa.eu/regional_policy/thefunds/social/index_en.cfm

[6] http://ec.europa.eu/regional_policy/thefunds/cohesion/index_en.cfm

[7] http://ec.europa.eu/contracts_grants/grants_en.htm

The state funding comes in two major channels:

- the various national and/or regional schemes that support R&D&I development
- the involvement of foreign states (or state-owned organizations) in major research activities through: loans, grants, capital market investments, etc.

d. Private funding possibilities

The main methods to obtain private funding for rail R&D&I (in addition to those pledged by the already-involved stakeholders) are the following:

- other private companies that wish to enter the market
- public-private partnerships (PPPs) for major and expensive research topics
- loans from banks
- drawing funds from the capital markets (either from private companies or PPPs) for major projects
- private equity investors in major companies or major research projects.
- major universities, especially those with large endowment funds like those in the US

However, the rail environment is one which generally does not offer high returns of investment in a short period of time, therefore it is important that the sector – with efforts from the states, the EU and the other stakeholders – will try to become more attractive for these sources of private funding, otherwise major possible investors will continue to shun it.

In the case of customer experience the major advantage is that in some cases the rail sector, instead of doing all the research by itself, can (and should) envisage partnerships with other stakeholders and customer representatives in order to find out how to best respond to their demands.

Moreover, in some cases the rail sector does not even have to put much research effort, it only needs to be able to accommodate the solutions that the other parties are developing for the customer-experience side. In this case the railways sector needs to meet 2 key criteria: openness and continuous dialogue with the other stakeholders, and to develop/use as many open-source, adaptable technical solutions as possible, in order to enable a real “plug-and-play” solution for the widest array of developments.

Many of the current developments have been done with the help of other parties, and it is recommendable that rail stakeholders, while not completely handing over these developments, can (and sometimes should) let other actors take the lead in doing necessary research.

Part-roadmap summary and exploitation of standardisation potentials

The data from this roadmap shows that “customer experience” encompasses numerous aspects of research, including some in which rail is not the main developer, but can become one of the main beneficiaries.

In the case of the EU-funded research, the main target of this road-mapping exercise, there are two main channels, at least for the coming years: S2R and H2020

S2R deals with research that will improve the performance of railways. In this case it is the rail sector that is at the helm of research and innovation, and the plan will certainly benefit the customers, should everything go accordingly.

In the case of H2020, there are numerous research topics that can address “customer service” in the case of rail. In most of these cases the rail sector is an important partner, but does not necessarily lead the way. In other cases it is just one stakeholder among the others. However, this is a strength, not a weakness. Railway stakeholders can thus tap into the knowledge of the other stakeholders and partner with them in order to obtain results that are applicable for not only railways, but as many sectors as possible – thus strengthening the link between rail transport and other economic sectors. It is also a way to ensure that many of the rail research effort are “future-proof” – they will not quickly become obsolete in case of other technological developments from other markets. Another aspect in the H2020 research is that solutions found for one particular economic sector can be transferred to the rail sector. Therefore the rail stakeholders (and maybe the EC as well) should try and monitor the results, so as to be informed of the existing potential solutions.

Executive Summary and conclusions – A step change in rail research & innovation

(This chapter will mention the most important issues developed within this Roadmap. Max 1 page)

tbd

2. Strategy and Economics Roadmap

1. Introduction

Among the 10 themes of the SRRIA, one is the Strategy and Economics, and it is twinned with the “Customer Experience”. As the title shows it is a very vast topic, to which, in theory, almost all other themes and roadmap topics could be subsumed. However, the FOSTER RAIL partners had made a split along certain criteria in order to make sure that there will be as little overlap as possible.

All identified roadmap topics that have a more technical and/or operational have been assigned to their respective subjects. Nevertheless, there are certain subjects within these roadmaps that would require a vast amount of effort and resources to be implemented, or a significant part of a paradigm/plan to be changed. Another case refers to those topics that cannot be implemented within a short period of time, being the fruit of many years of research and implementation. These topics can therefore be found both in the Strategy and Economics Roadmap and in their subject-matter roadmap as well.

Other topics are intrinsically vast and significantly influencing other roadmap topics – therefore they appear in their relevant roadmap, but also in Strategy and Economics. In this latter case, some topics are so influential that they had been assigned only in the Strategy and Economics part.

The Strategy and Economics Roadmap also includes, obviously, all topics that are related to strategy and economics. It must also be noted that this roadmap is practically twinned with the “Customer Experience roadmap”.

Last but not least, this roadmap includes topics that are not directly attributable to the other roadmaps, despite the fact that they have a high significance for the rail sector.

The vision outlined by the SRRIA in this case is the following:

- Passengers enjoy seamless multimodal journeys that are easy to plan, select and book. They experience a comfortable, safe and secure environment and are reassured by the availability of real-time traffic and whole-journey information about journey options should problems arise with modal connections or degraded operating conditions. Perceived nuisance factors such as noise and vibration are minimal. New service offers take advantage of research on new traffic mobility management and travel information tools.

- Business analytics facilitate more customer driven services. Data collection and improved and harmonised statistics feed convincing economic studies and traffic forecasts and the development of customer oriented business models.

- Significant improvements in operational reliability, the cost of rail travel and appreciation of the security of the railway system contribute to the overall attractiveness of the system.

- The rail system is accessible and attractive to all passengers, whatever their social category, age and life characteristics and their possible physical impairment including disabled persons and persons with temporal or permanent reduced mobility.

- Reliable, affordable and attractive rail services – delivered in close coordination with other transport modes – form the core of seamless and sustainable mobility in all parts of Europe.

- The European rail manufacturing industry has technological and industrial leadership worldwide. New technologies for trains, infrastructures and ICT enable much faster, reliable and consistent services.

- Integration of the databases across transport modes offers door-to-door freight transport including a rail link with fast and accurate service pricing – essential for the attractiveness of a service which must be competitive and reliable.
- Rail freight customers benefit from regularly updated Estimated Time of Arrival (ETA) using information provided via enhanced train connectivity systems
- Rail freight competitiveness is enhanced by high train utilisation from the use of IT based space booking systems.
- Longer trains optimise the use of network capacity.
- Socio-economic studies address user responses to pricing policies, to facilitate their travel by rail and public transport through integrated charging and payment systems and to influence their modal choice and travel consumption through pricing and taxation of transport infrastructure and transport means.

2. Key issues and objectives

(This chapter will mention the most important issues developed within this Roadmap, referring to the SRRIA content specific for this part-roadmap – max. 0.5 pages)

Because of the way in which the SRRIA had been designed, this roadmap is twinned with that which deals with the "customer experience", therefore there is a great overlap between the vision and priorities of the two.

The key issues and objectives identified by the SRRIA are:

- seamless multimodal journeys that are easy to plan, select and book
- real-time traffic and whole-journey information about journey options at any time, and especially in degraded operations conditions
- noise and vibration reduction
- Better integrate information/expectation from users in order to achieve better services
- improve traffic mobility management and travel information tools
- improve business analytics facilitate more customer driven services. Data collection and improved and harmonised statistics
- ensure the rail system attractiveness through operational reliability, the cost of rail travel and enhancement of the security
- Ensure rail system accessibility for all citizens
- ensure the reliability, affordability and attractiveness of rail services
- invest in new technologies for trains, infrastructures and ICT in order to enable much faster, reliable and consistent services
- Integration of the databases across transport modes
- enhanced train connectivity systems which offer better data to customers
- enable high train utilisation from the use of IT based space booking systems
- ensure longer trains optimise the use of network capacity.

- address user responses to pricing policies, to facilitate their travel by rail and public transport through integrated charging and payment systems, and to influence their modal choice and travel consumption through pricing and taxation of transport infrastructure and transport means

3. State of the art and ongoing research and innovation within and outside rail

(This chapter describe the present state of the art - and outside rail – potentially useful for rail innovation – max 2 pages)

a. Shift²Rail

The Shift2Rail is a Joint Undertaking between the EC and major European rail stakeholders, with the aim of achieving a modal shift from road to rail in order to achieve a more competitive and resource-efficient European transport system.

The S2R is divided into Innovation Programmes (IPs), each addressing a major rail area, as follows:

IP1 – Rolling stock

IP2 – Traffic management and control systems

IP3 – Infrastructure

IP4 – IT solutions

IP5 – Freight-related technologies

At the moment the IP research activities have not yet started, but preparatory activities have already begun for a number of IPs.

b. FP7

SECUR-ED, PROTECTRAIL, MODSafe, NGTC, NODES, OSIRIS

c. H2020

Since the H2020 is only at its very beginning, and many of the rail-related topics are now covered by the Shift2Rail Joint Undertaking, the other options for rail research projects are lower than in the previous EC-funded framework programme. However, ERRAC has informed the EC of a number of research topics that the rail stakeholders would like to address in the next few years with the help of H2020.

The topics outlined by the ERRAC members are the following:

- Planning sustainable urban areas by integrating rail freight: based on a catalogue of requirements for the optimal use of rail freight services in urban areas.

- Addressing the nexus of problems affecting urban transport (including congestion, pollution, accidents and inaccessibility) and using transport as an enabler of urban renewal.

- Managing the impact of demographic trends and, in particular, the ageing population

- Effectively harnessing new transport-related ICT technology and data management opportunities

- Land-use - Land-use and spatial planning around sustainable efficiencies of public transport; operate trains for 60 - 80% with energy from renewable sources ; develop common appraisal methods for cost benefits analysis of cross border business (T0)

- Customer needs and behaviour - Accessibility as a tool and as an objective

- Integration of ticketing and charging services - (New) charging and pricing policies strategies

- Interchanges for passenger travel and transport - Integrating interchanges, nodes of the smart city

- Integrated Urban mobility Systems and Governance -Mobility management and social networks

- Improving knowledge with data collection and analysis - Consistent data collection and exchange on urban mobility and development and use of harmonised models supporting data analysis, land use and transport forecasts, cost-benefit and multi-criteria economic analysis and decision-making

d. National research

e. Relevant Research & Technologies outside rail

ERRAC believes that a number of R&D&I topics that are being developed by other sectors will help rail stakeholders make significant progress in the years to come. The most relevant research areas that are seen as having the highest possible contribution for the rail sector are:

- Advanced composites & lightweight materials – for mass reduction, LCC reduction, customer benefits

- Nanotechnology

- The industry internet - using the 'internet of things' including sensor networks

- Drone technologies – e.g. to inspect and maintain transport systems

- Development of demonstrators of robotic equipment to replace simple repetitive tasks currently undertaken by maintenance teams

- Smart grids for energy capture (e.g. from kinetic processes) storage and adaptive feeding to rail, road and other applications

- Inductive charging for electric vehicles, including EMUs / Hybrid trains

- Energy storage, including future battery technologies, graphene supercapacitors; energy harvesting, including regenerative braking

- Alternative propulsion energy sources, including hydrogen and natural gas, operation of trains from 60 - 80% energy from renewable sources

- Next generation power semiconductor, with better efficiency, weight and volume and standards development for transport applications

- Use of recycled materials and innovative cross-modal techniques for infrastructure construction.

4. Roadmap development and improvement targets

The priority topics identified by the previous ERRAC roadmaps had been reallocated according to the new SRRIA Roadmap titles for two main reasons: to ensure both coherence between past and future work, and to create a comprehensive approach of the sector toward the R&D&I needs for the years to come.

The way in which these topics had been selected was already explained in this document, in chapter 3. It must also be noted that a few of the previous ERRAC roadmaps had been discarded because their approach was either too general, or was no longer reflecting the main needs of the sector.

Below is an outline of the main topics for the "Strategy and Economics Roadmap", structured according to a number of sub-themes. It can be noted that many of these sub-themes are cross-sector, and there is a natural overlap between some of them. Addressing several inter-related topics within the same research effort is an added-value. The indicative timeline of these research proposals is also indicated between brackets.

T0 = it has been already covered.

T1 = immediate.

T2 = 2015

T3 = 2020

T4 = 2030

T5 = 2050

Climate change adaptation - Adaptation of the existing railway system to the new climate conditions (T1 - T2)

Optimise environmental and sustainable impacts of the Life Cycle of subcomponents

- Design procurement, installation, maintenance, operations and disposal (T2)

- Political approach and economic assessment of feeding kinetic energy back to the public grid (T2)

General wagon issues - New transhipment technologies and operational concepts for low cost terminals (T0-T1)

Single wagons - Integrated rail freight production concept (operational, commercial and technical) for increasing the utilisation of single wagon loads (T0 + 1/2 T1)

Logistic services

- Development of transport services within single or multiple dry-ports in a Ten-T node concept (T0)
- Horizontal collaboration between shippers of the same modality (T0)

TEN-T freight network

- Freight oriented and freight dedicated network (T0-T3)
- Development of TEN-T missing cross border links with efficient green co-modal nodes (T0-T3)
- Merging TEN-T core and comprehensive network via greentype of primary, secondly and tertiary nodes (T0-T3)

Freight villages

- Spatial planning for mega hubs freight villages necessary for development of co-modality and long distance transportation, new designs and layout (T0-T1)
- Urban green logistics associated to the mega hubs and freight villages (T0-T1)

~~**European Network**~~

~~- Closing high speed gaps (T0-T3)~~

~~- Connection of all core airports to the main network (T0-T3)~~

Land-use - Land-use and spatial planning around sustainable efficiencies of public transport; operate trains for 60 - 80% with energy from renewable sources; develop common appraisal methods for cost benefits analysis of cross border business (T0)

Development and implementation of appropriate performance regimes for mobility providers and infrastructure managers (T0-T3)

Integration of urban traffic and travel information

- Integration of traffic and travel information (T0-T1)
- Definition of data quality (T0)
- Integration of information on all types of externalities (T0-T1)

- Integration of information on electromobility (T0-T1)

~~- Open interface and data enabling for the integration of the information (T0~~)

- Governance models enabling the integration of traffic and travel information (T0-T2)

~~- Security and privacy framework for the provision of transport data and information (T0-T1)~~

- Interoperability for customers through common multi-application processes on a single media: create a Pilot operation in a number of Member States in preparation for wider roll-out (T0)

~~- Develop a Common EU portal and Common Product Templates supporting an extension of the "IFM Brand" (T0-T1)~~

- Create a common EU-IFM application (T1)

- Develop a commercial and technical framework for the sales and settlement of EU-IFM Products (T1)

- Extend functionalities to facilitate inter-modality and Demand Management (T1)

- Engage and merge with existing IFM Systems and other ITS services and transport modes (T0-T2)

~~- Security and privacy framework for contactless payment (T0 - T1)~~

- (New) charging and pricing policies strategies (T0)

Interchanges for passenger travel and transport

- Design and operation of new generation of urban transport interchanges for greater integration of urban mobility networks (T0)

- Financing and business models (T0-T1)

- Integrating interchanges with urban policies (Land use planning, economic development, etc.) (T0-T2)

- Building resilient interchanges (T0)

- Integrating interchanges, nodes of the smart city (T0-T1)

New city logistics concepts and interfaces for a more efficient freight delivery

- Framework for stakeholders involvement in greater exchange of information on urban freight delivery (T0

- Definition of a platform & tools for the exchange of information on urban freight delivery by stakeholders, compatible with e-Freight, and relying on the provision of relevant data (T0-T1)

- New city logistics concepts, taking into account the impact of societal changes on commercial behaviour and goods delivery in urban areas (T0-T2)

Integrating urban mobility management

- Network management strategies, integrated with sustainable urban mobility plans (T0-T1)

- Governance for the coordination of the network management tools (T0-T3)

~~- Interaction between private cooperative network management and public network managers (T0-T2)~~

~~- Algorithms for network management (T0-T1)~~

- Short term forecasting models (T0-T2)
- ~~New intelligent decision support systems for network management (T0-T2)~~
- Strategies and models to face serious network disruption, network management for climate resilience (T1)
- ~~Optimization of PT operations through network (including traffic) management tools (T0)~~
- Evaluation of models efficiency and network management tools and policies (T0-T4)
- ~~Integration of freight movement in network management (T0-T1)~~
- Integration of a all modes and mobility options, and of a greater variety of network management tools, in network management systems (T0-T1)

Integrated Urban mobility Systems and Governance

- Actions influencing modal choice and travel behaviour: mobility demand management (T0)
- New mobility services (transport supply), including tailored services for different modes, social groups, territories and periods of time (T0-T1)
- More sustainable land development: new activities settlement and transport services (T1-T2)
- Mobility management and social networks (T1-T2)

I**mproving knowledge with data collection and analysis** - consistent data collection and exchange on urban mobility and development and use of harmonised models supporting data analysis, land use and transport forecasts, cost-benefit and multi-criteria economic analysis and decision-making (T0-T4)

Cooperation between stakeholders:

- Training needs and programmes (T0-T4)
- Promote cooperation for sustainable urban mobility (understanding, awareness, incentives, etc.) (T0-T4)

- ~~Standardisation beyond benchmarking in a global competition (T0-T4)~~
- Developing the robustness and resilience of transport systems (facing and recovering from incidents and disasters) (T0-T4)
- Improving local integration of land-use, transport and environment (T0-T4)
- Interregional and/or European approach of urban mobility (T0-T4)
- Improving market up-take of EU research (T0-T4)
- ~~Tackling together and worldwide the global challenges (T0-T4)~~

Data and models

- Collect and share appropriate urban mobility data (T0-T4)
- Develop and use the appropriate models supporting data analysis, forecasts, cost benefits and multi criteria analysis and decision making (T0-T4)

Energy and Environment

- Streamlining the infrastructure for more efficient land-use (T0)

- Use of environmental friendly materials (T3-T5)

Infrastructure - tools and measures for better economic management of railways (T1-T5)

Benchmarking - Benchmarking inside Rail sector and between transport sectors International cooperation for more efficient transport systems and technical harmonization (T1-T5)

Safety
- Extreme Climate events & resilience (T2 - T3)
- European level crossings risks ranking (T1 - T2)

Security
- Procedures, Regulations and standards - PPP (T0 - T1)
- Procedures, Regulations and standards - International Security Organisations (T0 - T1)

Economics - Delivering whole life asset performance (T0-T1)

5. Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050

tbd

6. Implementation Plan

a. SHIFT²RAIL

b. H2020

In the case of H2020 ERRAC members consider that a 2-stage approach should be implemented.

The first stage corresponds to the first half of H2020. The topics for this first part have already been outlined in chapter 5:

- Land-use and spatial planning around sustainable efficiencies of public transport; operate trains for 60 - 80% with energy from renewable sources ; develop common appraisal methods for cost benefits analysis of cross border business
- Integration of ticketing and charging services - (New) charging and pricing policies strategies

- Interchanges for passenger travel and transport - Integrating interchanges, nodes of the smart city

- Integrated Urban mobility Systems and Governance -Mobility management and social networks

- Improving knowledge with data collection and analysis - Consistent data collection and exchange on urban mobility and development and use of harmonised models supporting data analysis, land use and transport forecasts, cost-benefit and multi-criteria economic analysis and decision-making

- Planning sustainable urban areas by integrating rail freight: based on a catalogue of requirements for the optimal use of rail freight services in urban areas

- Addressing the nexus of problems affecting urban transport (including congestion, pollution, accidents and inaccessibility) and using transport as an enabler of urban renewal

- Effectively harnessing new transport -related ICT technology and data management opportunities

The second stage, corresponding to the second half of H2020, should address the remaining research topics that have been pinpointed for the T0 – T2 period:

c. Other public funding programs

The following categories of funding have been considered as public funding programmes:

1. The different EU sources of funding

2. The state (national/regional) sources of funding.

EU funding – here not taking into account either S2R or H2020 – comes through a wide array of channels and methodologies, which can be accessed directly or indirectly.

The main sources are the European Structural and Investment Funds[8]:

- the European Regional Development Fund (ERDF)[9] which aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. The ERDF focuses its investments on several key priority areas: innovation and research; the digital agenda; support for small and medium-sized enterprises (SMEs); the low-carbon economy.

- the European Social Fund (ESF)[10] invests in people, with a focus on improving employment and education opportunities across the European Union. For 2014-2020 the ESF will focus on four of the cohesion policy's thematic objectives: promoting employment and supporting labour mobility; promoting social inclusion and combating poverty; investing in education, skills and lifelong learning; enhancing institutional capacity and an efficient public administration. The ESF consequently represents a source of funding that can address the need for training and qualifications that will meet the demand of the rail sector, both today and in the years to come.

- The Cohesion Fund[11], aimed at Member States with a Gross National Income (GNI) per inhabitant is less than 90 % of the EU average. It aims to reduce economic and social disparities and to promote sustainable development. A significant part can be allocated to

[8] http://ec.europa.eu/regional_policy/thefunds/index_en.cfm

[9] http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm

[10] http://ec.europa.eu/regional_policy/thefunds/social/index_en.cfm

[11] http://ec.europa.eu/regional_policy/thefunds/cohesion/index_en.cfm

general environmental activities: energy efficiency, developing rail transport, supporting intermodality, strengthening public transport, etc. In theory some rail stakeholders can use part of these funds for transport-related research. But this also depends both on the national legal framework and the future EU-related developments in the field of research funding.

- Alongside these funds, the EU also has the possibility to offer grants in support of projects or organisations which further the interests of the EU, or contribute to the implementation of an EU programme or policy[12]. Numerous topics covered by these grants can be subsumed to the R&D&I aims of the rail sector: competitiveness, education and training, energy, environment, sustainable development, shifting freight from road, etc.

The state funding comes in two major channels:

- the various national and/or regional schemes that support R&D&I development

- the involvement of foreign states (or state-owned organizations) in major research activities through: loans, grants, capital market investments, etc.

d. Private funding possibilities

The main methods to obtain private funding for rail R&D&I (in addition to those pledged by the already-involved stakeholders) are the following:

- other private companies that wish to enter the market

- public-private partnerships (PPPs) for major and expensive research topics

- loans from banks

- drawing funds from the capital markets (either from private companies or PPPs) for major projects

- private equity investors in major companies or major research projects.

- major universities, especially those with large endowment funds like those in the US

However, the rail environment is one which generally does not offer high returns of investment in a short period of time, therefore it is important that the sector – with efforts from the states, the EU and the other stakeholders – will try to become more attractive for these sources of private funding, otherwise major possible investors will continue to shun it.

7. Part-roadmap summary and exploitation of standardisation potentials

The roadmap outline and analysis has shown the fact that the potential and opportunities for research in the coming years are tremendous. There is a vast number of rail research topics to be addressed in the short and medium term, and there is a large number of potential channels through which they can be addressed.

The main channel is still the traditional one, namely the EU-funded research projects. In this category we find both the S2R JU and the regular EC research framework programmes (today H2020). The EU-related research continues to be the main manner in

[12] http://ec.europa.eu/contracts_grants/grants_en.htm

which rail research will be conducted at the EU level, since it is the only way in which all stakeholders can come together around the same table and try to reach a common understanding. And while it is true that S2R will significantly change this landscape, the new situation does have a certain advantages:

- the S2R JU will ensure that a significant amount of funding (approx €1 billion) will go into rail-related research, benefitting a large number of stakeholders. It will pave the way not just for increased cooperation, a more coordinated research and better rail solutions, but also to a wider standardisation process within the rail sector, which should increase the overall benefits.

- the H2020 programme (as well as the future framework programmes) have indeed lost many of the specific rail research topics in favour to S2R. However, this leaves a clear way to other rail-related research topics. Unlike in the S2R case, when rail will be almost the excluding topic of research, the H2020 programme will enable stakeholders to link the railways sector with other social-economic activities. This aspect is crucial, since a harmonious and organic development of a European competitive economy cannot be done in separated clusters, with no cross-sector influence and synergies. Such efforts under H2020 can also lead to standardisation activities, also ensuring that the products can be used by multiple stakeholders not just in the field of railways, but also in other economic arenas.

Consequently, S2R and H2020 offer rail stakeholders complementary approaches to rail research and innovation.

And while the target for this road-mapping exercise is to match the sector's research needs with the available EU research funds, it is clear that more resources need to be allocated for certain topics. Therefore the roadmaps have outlined a number of other sources of funding – national allocations, private alternatives – in order to fill in any gaps. These alternatives can be considered both for the EU-level cooperation and for the national rail research done by the stakeholders.

8. Executive Summary and conclusions – A step change in rail research & innovation

(This chapter will mention the most important issues developed within this Roadmap. Max 1 page)

3. Capacity, Performance & Competitiveness Roadmap

Introduction

→Seizing on the opportunity for a huge modal shift to rail, the rail sector will have to adapt continuously to new market demands by focusing on the customer experience, new operating plans, co-operative alliances and its technology deriving requirements. To remain competitive and meet the challenge projected by the European Commission of rail being the backbone of transport in Europe, the whole European rail sector should join its efforts towards that goal of being closer to end customer's expectations for rail services.

→To attract new customers, rail must capitalise on its strengths: for example its absolute commitment to safety, its green credentials, its global leadership in high speed land services, its traffic management systems technology and telematics. As a main facilitator of mobility and a fundamental part of the transport system, rail also offers reliable and efficient services for the benefit of multi-modal and seamless door to door journeys.

Key issues and objectives

Aiming to develop organisational arrangements maximising capacity on busy corridors and improved system utilisation, the priorities are the following:

- More reliable system components, leading to a highly reliable system which is a prerequisite for the development of track capacity; improved system utilisation, yield management and organisational arrangements, which maximise capacity on busy corridors; business continuity, optimised by real-time traffic management, maximising capacity, conserving energy and minimising inconvenience to the passenger and the freight user; reduction of in-service failure.
- Reduced overall life cycle exploitation costs for all rail sub-systems, the minimisation of the effects of obsolescence and the effective migration of emerging technological innovation. Innovation shall allow for highly automated rail both technically and operationally and for monitoring vehicle and infrastructure condition and maintenance, hereby enhancing system resilience, reliability and cost efficiency, improved customer service.
- Continued improvement of every aspect of the passenger's trip (obtaining information, purchasing tickets, enjoying station services and travelling in local, regional, intercity and high speed trains, etc.), or of the rail freight transport along the supply chain,.
- All these major developments must at the same time lead to win-win solutions for rail freight, which faces fierce competition from other modes.

State of the art and ongoing research and innovation within and outside rail

(This chapter describe the present state of the art - including global level - from in- and outside rail – even from a global level, potentially useful for rail innovation – max 2 pages)

tbd

Roadmap development and improvement targets

Traffic Flow Management - Holistic Approach towards traffic “fluidification” (T2)
Traffic Flow Management - Specification of interfaces/ communication between IM and RU (T2)
Traffic Flow Management - Real time traffic optimisation (T2)
General wagon issues - Cost effective methods for assembling and managing longer trains (T
General wagon issues - New transhipment technologies and operational concepts for low cost - Also in RM8 and RM2
Single wagons - Integrated rail freight production concept (operational, commercial and techn increasing the utilisation of single wagon loads (T0 + 1/2 T1) - Also in RM2
Seamless passenger journey - Integrated information systems handling the whole journey acc different mobility providers (T0-T1) - Also in RM1
ERTMS fully implemented on core axis (TEN-T) - Development and implementation of process for time tabling and operational traffic management (T0-T3) - Also in RM6 and RM9
Management of degraded modes - Resilience augmented through "centralised" crisis manage
Management of degraded modes - Global resilience in transport systems in case of disruption capacity in 1 or 2 modes to compensate for difficulties in another one (T0-T1)
Management System - Optimisation tools widely used (T0-T1)
Competitiveness and enabling technologies - Innovative design of services/Timetable (T1-T3)
Competitiveness and enabling technologies - Innovative operation methods and tools for bett increased capacity and faster recovery after incidents (T0)
Competitiveness and enabling technologies - Innovative tools and techniques for improved op
Optimise operations at freight traffic nodes (T1-T5)
Interoperability - Interface harmonisation (T0)
Interoperability - Removal of barriers to interoperability and intermodality - link with TSIs (T0-T
Operations - Capcaity optimisation & options for managing increases in demand (T0-T2)
Infrastructure interaction vehicles - Innovative Maintenance Technologies (T0 - T4)
Infrastructure interaction vehicles - Non damaging vehicle track interaction (T0 - T3)
Economics - Decision support tools for asset management (T0 - T2) - Also in RM9

Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050)*

Implementation Plan

(This chapter describes the possibilities and possible thresholds for implementation of the research and innovation priorities in this part-roadmap. Max.1.5 pages)

a. SHIFT²RAIL

b. H2020

c. Other public funding programs

d. Private funding possibilities

Part-roadmap summary and exploitation of standardisation potentials

(This chapter gives a short summary of the most important findings from this part-roadmap – max 0.5 page)

tbd

Executive Summary and conclusions – A step change in rail research & innovation

(This chapter will mention the most important issues developed within this Roadmap. Max 1 page)

tbd

4. Energy & Environment Roadmap

Introduction

Transport plays a key role within the economy and society: transport systems are of crucial importance for the competitiveness of any nation or regional economy as well as for the mobility of its citizens. However, while they bring significant benefits to society there are also substantial costs. The current growth of the transport sector is far from being sustainable. In Europe it is the only sector with uninterrupted and rapidly growing energy consumption and CO_2 emissions, and is now responsible for around 23% of total EU greenhouse gas emissions.
The current transport system is a heavy burden for the environment and the health of citizens, and continues to move in the wrong direction. In this context, rail has the capability to play a key role in any sustainable transport system by offering efficient transport with low environmental impact, and these strengths need to be articulated in the political decision-making process.. Rail already has a strong focus on how to continuously improve its sustainability performance. But of course rail is not the only transport mode working on new solutions to reduce its 'whole-life' environmental impact from construction, through to operations and end-of-life. Other modes continue to seek improvements to their environmental performance, and rail manufacturers, infrastructure managers, and operators all have to put strong emphasis on working together and improving performance in order to remain the least polluting major mode of transport. Thus, a long term strategic approach is needed: one that forms an efficient answer to the challenges of the future and that allows a solid base on which to build. This strategy is based on a long-term vision and has two main target points in time: 2030 and 2050. At a first glance this time frame seems to be long. But the railway sector has very long life cycles; today's "new technology" is likely still to be in operation towards year 2050. Furthermore, new strategies for reducing greenhouse gas emissions are being developed that foresee 2050 as the target date. For typical train sets the time from idea to production, operation until end of life are in the range of 30-50 years. Even though this structure might also change in the decades to come in order to improve rail performance and competitiveness, it is not too early to think, plan and act now for the performance of railways in 2050.

Vision & Priorities

Rail will continue to play a key role in reducing the environmental impact of transport. By offering increasingly efficient transport which lowers environmental impacts, rail helps create a more sustainable approach to transport. Modal shift to rail, away from more polluting modes, in particular aviation and road freight, can further reduce the transport environmental footprint, benefitting society. To meet the challenges of climate change, energy supply and transport network congestion, rail has attracted a multi-fold increase in its share of passenger and freight markets, particularly for longer-distance trips. The European railway sector will seek to supply its customers and society with attractive,

carbon-free and resource-efficient solutions for sustainable mobility and transport. Moreover the rail sector will have to face a changing climate with and an intensification of extreme weather events. It will be fundamental to deliver to society, for the benefit of its economy and its citizens a climate resilient infrastructure system. to be able to ensure a resilient economy and will adapt is system in due time, including upgrading its infrastructures, services or transporting the system To maintain and enhance its leading sustainability performance, based on responsible business leadership, the European rail sector will engage in research in the following main areas: ... tbd

Key issues and objectives

- Energy supply is a critical function in the rail system both for traction power and for heating, comfort, lighting and other operational needs. Rail will become a system that relies much less on the consumption of fossil-sourced energies. This may come about through more and sustainably-sourced electrification of the system or by of the use of alternative sources of renewable energy.

- The rail sector will look at new combustion technologies, efficient transmission systems and exhaust after treatment that will ensure that rail diesel traction will remain more environmentally friendly in the future. Again electrification of remaining lines is also one of the many approaches that may be taken, although rail diesel propulsion is still expected to play an indispensable role for the European transport system in the coming years.

- The European rail sector has long recognised that noise from rail activity needs to be further reduced. The sector will aim to ensure that noise and vibrations will no longer being considered a problem for the railways in the future – meaning that noise levels will be socially and economically acceptable and allow for 24-hour passenger and goods operations.

- The management of the rail system for minimum energy use and better traffic management based on the development of new technologies will enable energy savings and better overall railway system efficiency.

- Rail will also pay particular when addressing in energy used in non traction activities. Stations, terminals and other railway installations and trains will use their own renewable and environmentally-friendly energy sources wherever this is feasible.

- The development and deployment of resilient and efficient energy distribution schemes will involve smart grid solutions, energy harvesting devices and improved energy self-sufficiency.

- Railways will develop a climate resilient transport mode dealing with climate change threats, with research into the effects and management of weather, water, heat impacts on infrastructure.

The promotion of environmentally friendly and efficient rail transport of passengers and goods is a key objective in Europe. Public authorities must improve societal understanding of the environmental advantages offered by the railway system in comparison with competing modes of transport.

State of the art, ongoing research and innovation within and outside rail

Shift to Rail (coming soon)

Shift to Rail represents an unprecedented research investment in rail for improving the quality and cost effectiveness of the railway system as a whole. By aiming to strengthen the attractiveness of rail to end users, this project will accelerate the integration of customer-led requirements and technologies as innovative business solutions. Shift to Rail will pave the way towards a sustainable transport system for future generations in while reinforcing European leadership in designing, constructing, operating and maintaining the railway system. Shift to Rail has been conceived for closing the gap between operational needs, research & innovation efforts and industrialisation processes

Energy and Sustainability is one of the cross cutting themes that will be covered by all Innovative Programs included in Shift to Rail.

FP7

Cleaner-D (2010-2013) was a partly European Commission funded project that aimed to develop, improve and integrate emissions reduction technologies for diesel locomotives and rail vehicles. Its target was to achieve emission levels below the limits established by the new European Directive 2004/26/EX and to evaluate innovative and hybrid solutions for the best possible contribution to reductions in CO_2 emissions.

MERLIN. (2012-2015)

MERLIN's main aim and purpose is to investigate and demonstrate the viability of an integrated management system to achieve a more sustainable and optimized energy usage in European electric mainline railway systems. MERLIN will provide an integrated and optimized approach to support operational decisions leading to a cost-effective intelligent management of energy and resources through:

- Improved design of railway distribution networks and electrical systems and their interfaces
- Better understanding of the influence of railway operations and procedures on energy demand
- Identification of energy usage optimizing technologies
- Improved traction energy supply
- Understanding of the cross-dependencies between technological solutions

- Improving cost effectiveness of the overall railway system
- Contribution to European standardisation (TecRec)

Where MERLIN's results are being implemented, an overall reduction of the energy consumption of 10% is expected.

RIVAS (2011-2013)

RIVAS aimed at reducing the environmental impact of ground-borne vibration while safeguarding the commercial competitiveness of the railway sector. For several areas of concern vibration should be reduced to near or even below the threshold of perception. The project's goal was to provide the tools to solve vibration problems for surface lines by 2013. The project aimed to contribute to relevant and world leading technologies for efficient control of people's exposure to vibration and vibration-induced noise caused by rail traffic. RIVAS focused on low frequency vibration from open lines but its results will be eventually implemented to suburban, regional and high-speed operations. RIVAS delivered:

- Assessment of the benefits of mitigation measures in terms of human response and agreed protocol for the evaluation of annoyance and exposure to vibration.
- Agreed measurement protocols to assess and monitor the performance of anti-vibration measures.
- Agreed protocol to characterize vibration response properties of soils
- Guidelines for track and vehicle maintenance geared towards low vibration
- Mitigation measures for ballasted and slab track.
- Guidelines for the design of transmission mitigation measures under the track.
- Guidelines for the design of low vibration vehicles

UIC PROJECTS

ARISCC

The UIC project ARISCC (Adaptation of Railway Infrastructure to Climate Change) explored in detail the strategies of European railways on natural hazard management, and found out which of them were developing strategies for climate change adaptation. The project produced a wide number of good practice case studies in the management of a wide range of weather and climate related natural hazards such as flooding, severe storms, landslides, rock fall and avalanches. Using this as a basis, ARISCC produced a guidance document on how to integrate long-term climate forecasts into natural hazard management. All the results of ARISCC, including a case study database, are available on UCI website.

ENERGY AND EMISSION REDUCTION DRIVERS FOR EUROPEAN RAILWAYS

In the framework of the "Analysis of UIC/CER EES Strategy Energy&CO2 Targets", UIC has prepared the report on energy consumption and CO2 emission reduction drivers for European railways.

The goals of the work were the following:

1. Examine the progress towards the 2020-2030 targets for energy consumption and CO2 emissions set by UIC and CER, and whether those targets should in any way be adjusted;

2. Evaluate in what measure green electricity instruments such as Guarantees of Origin (GO) and Renewable Electricity Certificates (REC) contribute to the evolution towards the emissions targets, and explore whether there are any differences if those instruments are not taken into account (i.e. the electricity production mix is used);

3. Determine which railway companies have contributed the most to the progress towards the environmental objectives fixed for 2020 and 2030;

4. Investigate which drivers have contributed to the decrease of specific energy consumption and CO_2 emissions in the past years and in what measure;

5. Identify the drivers which will influence the evolution of specific energy consumption and CO_2 emissions in future years.

ADD PROJECT ABOUT NOISE

HORIZON2020

UIC will lead a project in the H2020 bid " Smart governance, network resilience and streamlined delivery of infrastructure innovation". Aim of the project is to enable transparent, risk based optimisation of investments within and across transport modes and particularly for railway. A parallel consideration will be the resilience of modes to current and future hazards. This project aim to overcome the specific challenge faced by transport infrastructure owners and operators across Europe where there is a lack of a common framework of governance, management and finance of transport infrastructure projects.

National PROJECTs

TRaCCA

TRaCCA – *Tomorrow's Railway and Climate Change Adaptation* – is a project which will enhance and augment knowledge of climate change impacts on the GB railway. The work is funded by RSSB and Network Rail through the FutureRailway programme, as part of the undertaking, commissioning and managing of research and innovation programmes to provide knowledge for decision making now and for the future, and promoting step changes to deliver the Rail Technical Strategy.

Roadmap development and improvement targets.

Climate Change adaptation (Challenge)

According to the 5th Assessment Report of the IPCC, higher frequencies and intensities of extreme weather events are expected in the future. Climate Change events like increases in average temperature, sea level rise and changes in precipitation patterns will seriously

affect the railway sector. Higher temperatures and higher frequencies of heat waves are likely to have a direct effect on the rail buckles. Extreme weather events can cause floods or landslides that can lead to a diversified range of consequences from delays to human fatalities….()
As smooth and effective operations of the railway system heavily rely on heavy infrastructure such as bridges, tunnels and embankments, adapting it to new climate conditions require a substantial economical effort from national authorities. Those assets are in fact designed to last around a century or more and initial investments have usually a very long return rate. Therefore an anticipatory planning that considers future climate conditions is now necessary in order to maintain costs for adaptation acceptable.
Without an integrated adaptation strategy and adaptive action, the present resilience of railways could proof to be insufficient in the near and midterm future. Therefore European railways will work to develop a proactive adaptation strategy and systematically build up adaptive capacity. The strategy should comprise short term as well as mid-term and long term adaptation goals and measures and has to take into account affordability. The guiding principle of the integrated strategy should be the three R:

- Readiness - To be well prepared for extreme weather events
- Resilience - To systematically increase the resilience of the whole system
- Recovery - To have contingency plans allowing for fast and full recovery

Climate Change adaptation (Action)

- Railways will develop a climate resilient transport mode dealing with climate change threats, with research into the effects and management of weather, water, heat impacts on infrastructure.

The future role of UIC in strengthening and improving the adaptation of railway infrastructure to climate change will include the following measures and actions:

- Facilitate and coordinate knowledge sharing e.g. by running research projects or hosting best practice workshops and supporting common methodologies
- Facilitate the development of appropriate metrics for impact and vulnerability assessment
- Support the development of appropriate governance approaches for adaptation

Energy (Challenge)

Europe needs to reduce its import dependence for all fossil fuels. By using electricity, which can draw its power from a range of sources, rail is the only major transport mode not entirely dependent on fossil fuels.

The total amount of annual traction energy cost within Europe lies between 5 and 10 billion euro

In 2010 UIC and CER developed the Sustainable Mobility Strategy – “Moving towards Sustainable Mobility: Rail Sector Strategy 2030 and beyond – Europe“. The Goal was to adopt a unified Strategy of the rail sector in Europe that was endorsed by European

members of UIC, CER, EIM and UNIFE to strengthen coordination, speed and direction of actions and ensure the widest possible acceptance within the rail industry.

Energy Efficiency Targets

Short Term: by 2030 the European railways will reduce their specific final energy consumption from train operation by 30% compared to the base year 1990; measured per passenger-km (passenger service) and gross tonne-km (freight service)

Medium Term: the European railways will strive towards halving their specific final energy consumption from train operation by 2050 compared to the base year 1990; measured per passenger-km (passenger service) and grosse tonne-km (freight service)

So far specific energy consumption has been reduced by 16.5% in the passenger sector and by 23% in the freight sector in the period 1990 – 2012. Therefore the specific energy consumption of the European railway sector for passenger and freight is in line with the targets set for 2030 as with this pace of energy reduction the target will be achieved

There have been various factors contributing to the reduction in the CO2 emissions and energy consumption of rail in recent years: these include the increased energy efficiency of railway services, further electrification of lines, and a reduction in carbon intensity of the electricity production by the power supply sector. Exhaust emissions and noise, in contrast, have largely relied on technical innovation within the sector, so change has been more challenging due to the long lifespan of many technical systems

There are huge perspectives for the growth of the energy meters market, as most of the responding railway are integrating (or planning to integrate) energy meters in virtually all their trains. The development of energy metering systems (due to the development of energy bills adapted to the real consumption of energy by the consumers, Railway Undertakings, Stations, etc) confirms that there are ways for a more efficient use of energy.
In the decades to come, these trends will play a crucial part in enhancing the environmental performance of rail further:

- More railway operators will actively demand green energy and shift to CO2-free energy sources, as European and national regulation facilitates more renewable and carbon-free electricity coming onto the market.

- Energy efficiency will continue to increase through improved technology and service efficiency (occupation rates and load factors).

- Further electrification will occur, and new low carbon propulsion technologies will replace diesel traction by electric traction or other less carbon-intensive propulsion concepts.

Energy (Action)

- The management of the rail system for minimum energy use and better traffic management based on the development of new technologies will enable energy savings and better overall railway system efficiency

Efforts should concentrates on different parallel lanes according to their technology readiness level

Lane 1: Rolling Stock

- Lighter Trains
- Hybrid traction
- EE Auxiliaries

Lane 2: Infrastructure
Smart Grids
Advanced Traction Energy Supply

- Increasing the traction power supply voltage
- Braking Energy Recovery
- Energy utilization in AC traction power supply system by introducing Power conditioning

Lane 3: Operation and management

- Traffic Flow Management
- Implementation a communication between Traffic Management Systems and Driving Advisory System that include real time changes in Time Table in order to reach the optimal solution for detected conflicts.

Lane 4 : Support and communication

- UIC will monitor the progress towards the targets guaranties transparency and accountability, towards competitors, stakeholders and decision makers. To ensure that all objectives are met, the Environment Strategy Reporting System has been started. It is an integrated management system, officially used from September 2012. Through support and communication (training activities, further studies) UIC will collect and share implemented energy efficiency actions implemented in the European railway community.

Adaptation of the existing railway sytem to the new climate conditions
Safety - Climate & environmental safety related issues (T0 - T1)
Safety - Extreme climate system resilience (T2 - T3) - also in RM2

Noise

Keeping the acoustic performance of the system (train and infrastructure) throughout its whole life (T1 - T2)
A new breakthrough in noise reduction - minus 5-10 dB or more (T4)
Rolling noise revisited (T0 - T3)
Target annoying noise, tonal noise - Further reduction for traction noise / equipment noise / screech / squeal (T0 - T1)
A system approach for noise reduction (T0 - T3)
Innovative vibration mitigation technologies (T2 - T3)
Standards for the assessments of vibration (T1)
Keeping the acoustic performance of the system (train and infrastructure) throughout its whole life (T1 - T2)
Rolling noise revisited (T0 - T3)
Indicators beyond the dB (A) level (T0 - T1)
A system approach for noise reduction (T0 - T3)
Ground borne vibration and vibration induced noise: From better understanding of the phenomena to efficient vibration control (T1 - T2)
Better understanding of the generation noise & vibration mechanisms (T0 - T2)

ENERGY

Smart Grids and the multiplication of energy sources - Development of techniques based on an economical potential (T4)

Smart Grids and the multiplication of energy sources - Improvement of efficiency, weight, volume among others (T4)

Smart Grids and the multiplication of energy sources - Standardisation (request from the railway sector to the semi-conductor industry) (T4)

Monitoring System - Provision of detailed informa-tion about energy consumptionin the railway system (by service type) (T2)

Re-use of kinetic energy - Improvement of technologies with basic systems being available (T2)

Re-use of kinetic energy - Link to smart grids (T2)

Re-use of kinetic energy - Reliability to be proven (T2)

Pollution

Identification of components with special concerns in REACH - investigate alternatives with same life duration (T2)

Land use

Land-use - Land-use and spatial planning around sustainable efficiences of public transport ; operate trains for 60 - 80% with energy from renewable sources ; develop common appraisal methods for cost benefits analysis of cross border business (T0) - Also in RM2

Safety - Vegetal clearance and animal trespasses (T2 - T3)

Others (to be linked or erased)

Cost effectiveness of solutions for an implementation in commercial and operational solutions (T0 - T1)

Monitoring and maintenance of the system vehicle and infrastructure from a maintenance point of view (T0 - T1)

Setting clear responsibilities (T1)

Improved communication strategy (several actions - also in RM1 (T0 - T4))

Cost effectiveness of solutions for an implementation in commercial and operational solutions (T0 - T1)

Monitoring and maintenance of the system vehicle and infrastructure from a maintenance point of view (T0 - T1)

Improved communication strategy (several actions - also in RM1 (T0 - T4))

Demonstrator: Green Silent European Train & Track - Real train and track where green solutions are implemented and tested in operation (T0 - T4)

Climate change adaptation - Adaptation of the existing railway system to the new climate conditions
Identification of components with special concerns in REACH - investigate alternatives with sam
Keeping the acoustic performance of the system (train and infrastructure) throughout its whol
Cost effectiveness of solutions for an implementation in commercial and operational solutions
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Demonstrator: Green Silent European Train & Track - Real train and track where green solutio
Ground borne vibration and vibration induced noise: From better understanding of the phenor
Better understanding of the generation noise & vibration mechanisms (T0 - T2)
Modelling (T1 - T2)
Innovative vibration mitigation technologies (T2 - T3)
Standards for the assessments of vibration (T1)
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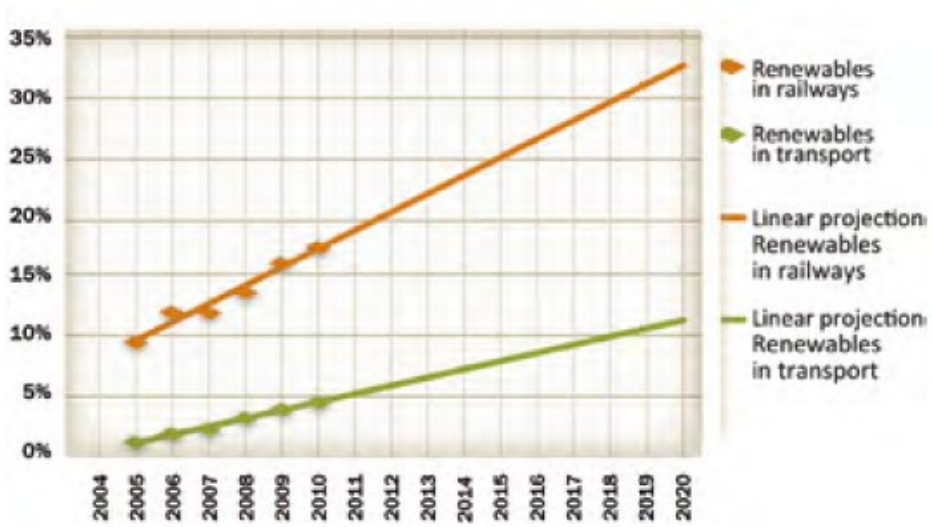
Re-use of kinetic energy - Reliability to be proven (T2)
Land-use - Land-use and spatial planning around sustainable efficiences of public transport ; sources ; develop common appraisal methods for cost benefits analysis of cross border busi
Energy and Environment - Streamlining the infrastructure for more efficient land-use (T0) - Als
Safety - Climate & environmental safety related issues (T0 - T1)
Safety - Extreme climate system resilience (T2 - T3) - also in RM2
Safety - Vegetal clearance and animal trespasses (T2 - T3)
Safety - Environment system resilience (T2 - T3)

~~For instance rail electric traction in EU27 increased its share from 2005 to 2011 reaching 86% of train-km for freight and 81% for passenger service. Moreover the use of diesel energy decreased by 31% in European railways between 1990 and 2011, while the use of electric energy increased by 14%. European Railways are increasing their share of renewable at a faster pace that all transport sector.~~



Source: Elaboration by Susdef in UIC/IEA, *Railway Handbook 2013: Energy Consumption and CO_2 Emissions*

If the energy sources used by railways continue to follow the trends of past years, EU railways will use almost 35% renewables by 2020 (they were already at 18% in 2010). The fuel mix of the whole transport sector is now 5% renewables and is set to reach 12% in 2020.

5. Safety (including certification) & Security Roadmap

Introduction

The series of standards EN 50126, EN 50128 and EN 50129 should address security topics if relevant to RAM and Safety targets.

Security topics have been established in the last years because of coming up changes in signaling box development. Thus it is necessary to address security within an own standard.

The scope of series of EN 50126 will be applicable for the whole railway system. Thus the need to establish the security topic in relationship to RAMS standards is necessary not only for signalling but also for rolling stock and fixed installation.

Because of the needs of ETCS in future it will be more important to establish security standards for common use for signalling and rolling stock.

At the moment within the railway sector there are no standards established to ensure the high level of safety that may be influenced by modern IT network structures.

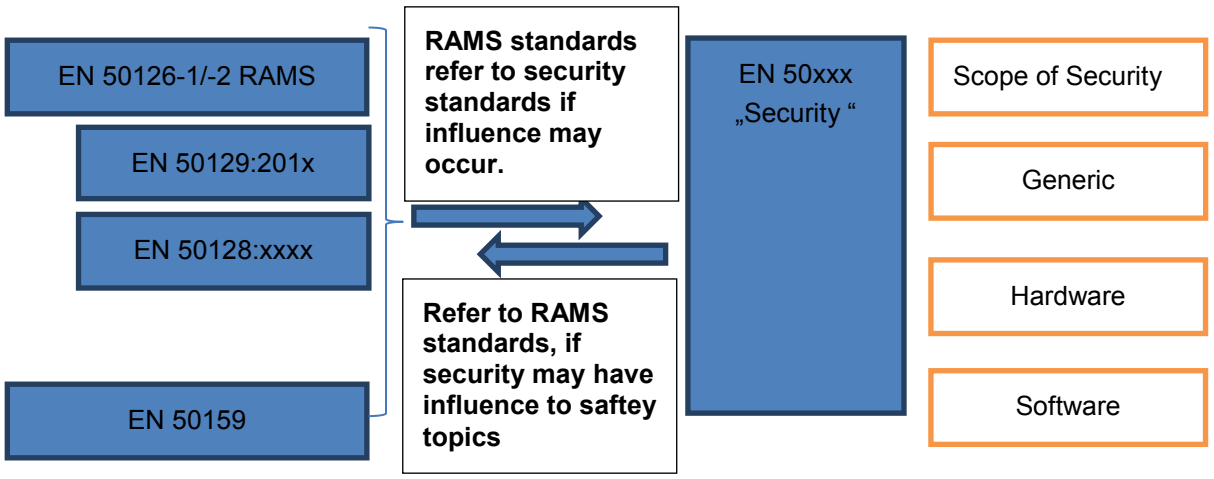
The target is to establish guidance and roles for applying security within the field of rolling stock and infrastructure including signaling (CCS).

The need will enlarge due to the situation that more systems are based on IT-network technology.

The economic situation will force the operators of critical networks on trackside as well as on trains by using public networks as well. Therefore it is necessary to develop measures for those types of networks.

RAMS
(Reliability, Availability,
Maintainability and Safety)

Safety



The need to establish different technology requirements for RAMS and Security is because of

- Safety requirements will follow a long-term lifecycle.
- Security requirements have a short lifecycles as typically for IT development.

Key issues and objectives

(This chapter will mention the most important issues developed within this Roadmap, referring to the SRRIA content specific for this part-roadmap – max. 0.5 pages)

tbd

3. State of the art and ongoing research and innovation within and outside rail

(This chapter describe the present state of the art - and outside rail – potentially useful for rail innovation – max 2 pages)

tbd

4. Roadmap development and improvement targets

(This chapter will include the recommendations for R&I activities and planning to deployment. This should be based on the priority topics identified in the ERRAC Roadmap and re-distributed to the new part-Roadmap titles as described in the SRRIA. Describe per priority area, including a simple timeline picture – max 5 - 6 pages)

tbd

5. Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050

2015: Identification

- Methods used in user industries
- Identification of security requirement for safety-related IT networks

2016: Improve the requirements for railway sector systems

- Analysis of railway specific requirements and demonstration of the need.
- Analysis of existing methods within the European railway system

2017 - 2021: Establish generic state of the art documents and CENELEC a/o IEC standards

- Start the work at Cenelec a/o IEC
- Establish working group(s)

2030: Maintenance of established technical rules and standards

2040 – 2050: Established cross sector best practice methods and further development of the state of the art

6. Implementation Plan

(This chapter describes the possibilities and possible thresholds for implementation of the research and innovation priorities in this part-roadmap. Max.1.5 pages)

tbd

7. Part-roadmap summary and exploitation of standardisation potentials

The main target should be to establish the security requirements as standards. This will ensure a high acceptance by manufactures, operators and the national safety authorities. To establish standards will avoid a mixture between the legal frame work and standardisation work. A need to publish directives or regulations by European Commission or other agencies will be reduced to the identification of the need. This will be a clear guide for innovation.

8. Executive Summary and conclusions – A step change in rail research & innovation

Good base for innovation within the IT related products dealing with CCS and rolling stock. *Closing the leak in IT security issues and possible unauthorized access to IT networks (wireless and LAN based).* *No limitation for manufacturers and operators due to established open state of the art methods and strategies.*

6. Control, Command and Communication Roadmap

Introduction

Among the 10 themes of the SRRIA, one is control, command and communication, which is linked to two other themes, rolling stock, safety (ensuring safety communication between signals and train drivers) and also capacity, performance and competitiveness, since this is a major part of the holistic, system-wide approach to rail research.

This is a very specific subject. The control, command and communication systems are pivotal to increasing the efficiency and safety of transport networks and operations.

The vision outlined by the SRRIA in this case is the following:

The railway operates under a flexible, real-time intelligent traffic management system, maintaining the high level of safety. Trains run at very close headways, thanks to the use of moving block and convoy train operation.

Rail is equipped at a system level with the integration of the latest train traffic management and train control systems. Customer information and communication technology provide seamless transition between transport modes for passengers and ensure the provision of a modern multimodal freight distribution system.

Networks are engineered for resilience and optimised by interoperable real-time traffic management that allows for intelligent, predictive and adaptable operational control of train movements. This increases system capacity, conserves energy and reduces life cycle costs.

Priorities for development are:

- Real time traffic management capabilities for increased capacity, energy efficiency and sustainability.
- Robust and cost effective standard design, test, installation and maintenance of signalling infrastructures.
- Future generation of train control systems focusing on: autonomy, convoying, enhanced train location knowledge and its impact in capacity, environmental gains and operational costs.

Key issues and objectives

The key issues and objectives identified by the SRRIA are:

- Increase capacity through real-time intelligent traffic management systems
- Reduce energy consumption
- Reduce life cycle costs through cost effective standard design, test, installation and maintenance of signalling infrastructure

• Improve the level of safety in the rail network
• Improve customer quality for both passengers and freight companies in the transition between transport modes
• Improve performance in terms of reliability and punctuality
• Enhance interoperability

State of the art and ongoing research and innovation within and outside rail

5.1 Shift²Rail

The Shift2Rail Joint Undertaking is a public-private partnership between the EC and major European rail stakeholders, with the aim of bringing about a modal shift from road to rail in order to achieve a more competitive and resource-efficient European transport system.

The S2R is divided into five Innovation Programmes (IPs), each addressing a major rail area, as follows:

IP1 – Cost-efficient and reliable trains, including high capacity trains and high speed trains

IP2 – Advanced Traffic Management & Control Systems

IP3 – Cost Efficient and Reliable High Capacity Infrastructure

IP4 – IT Solutions for Attractive Railway Service

IP5 – Technologies for Sustainable and Attractive European Rail Freight

IP2 is directly linked to this theme of control, command and communication, and focuses on activities to support the rapid and broad deployment of advanced traffic management and control systems, by offering improved functionalities and standardised interfaces, based on common operational concepts, facilitating the migration from legacy systems, decreasing overall costs, adapting it to the needs of the different rail segments as well as to the needs of a multimodal smart mobility system.

In order to achieve these objectives, an indicative list of priority research and innovation activities has been produced focused on:

- Smart, fail-safe communications and positioning systems: develop a fail-safe, multi-sensors train positioning system, boosting the quality of train localisation.

- Traffic management evolution: advanced traffic management systems should be automated, interoperable and inter-connected, and they should be combined with Driver Advisory Systems (DAS) and automation functionality to allow for predictive and dynamic traffic management.

- Automation

- Moving block (MB) and train integrity

- Smart procurement and testing: develop an approach for zero on-site testing using simulation tools and demonstrators in a laboratory.

- Virtual coupling

- Cyber security

5.2 FP7

• INESS (2008-2012) aimed at defining and developing specifications for a new generation of interlocking systems.

• EATS (2012-2016) aims at providing a model of the complete on-board ERTMS system behaviour to eliminate interpretation differences, leading to reduced laboratory and field-testing certification process time and cost.

• NGTC (2013-2016) aims at developing the next generation of train control systems, paving the way for standardized train control systems for mainline and urban domains which provide complete ATP (Automatic Train Protection), ATO (Automatic Train Operation), and ATS (Automatic Train Supervision) functionality. The main scope of the NGTC project is to analyse the similarities / differences of the required functionality of ETCS and CBTC systems, and to determine the achievable commonality level of architecture, hardware platforms and system design.

5.3 H2020

The call “Mobility for Growth” invited proposals against the topic “New generation of rail vehicles” (MG.2.3-2014). The following topic relevant for this theme is covered under this call:

- Traction, command-control and cabin environment applications (e.g. new materials, smart power and wireless technologies)

The call “Mobility for Growth” also invited proposals against the topic “I²I – Intelligent Infrastructure” (MG.2.1-2014). This includes proposals supporting an integrated approach to the optimisation of railway architecture and operational systems at network, route and individual train level, and particular emphasis is given to real-time data collection and analytics from trains and infrastructure for the purposes of goal-oriented predictive and adaptive control of the traffic, including full compatibility with ERTMS.

5.4 National research

To be completed by Member States representatives and Academia Advisory Groups

5.5 Relevant Research & Technologies outside rail

- GNSS (Galileo): satellite-based services as a cost-efficient way for Train Control Systems

Roadmap development and improvement targets

The priority topics identified by the previous ERRAC roadmaps had been reallocated according to the new SRRIA Roadmap titles.

Below is an outline of the main topics for the “Control, command, communication Roadmap”, structured according to a number of sub-themes. In the case of control, command and communication some overlaps exist, especially with the “IT and other enabling technologies” roadmap as well as with “Energy and environment” and “Safety”.

The indicative timeline of these research proposals is also indicated between brackets.

T0 = it has been already covered.

T1 = immediate.

T2 = 2015

T3 = 2020

T4 = 2030

T5 = 2050

Freight

- Intelligent traffic management - Introduction of new intelligent management systems capable of optimizing the use of the existing infrastructure (T0)

- Intelligent traffic management - ERTMS level 2 and 3 - implementation of low cost compatible solutions for freight trains (T0-T3)

Passenger

- ERTMS fully implemented on core axis (TEN-T) - Development and implementation of processes and ICT tools for time tabling and operational traffic management (T0-T3)

Urban Mobility

- Integrated Urban Mobility Systems and Governance - Intelligent integrated transport network management

Urban, Suburban and Regional Rail

- Competitiveness and enabling technologies - High capacity urban rail systems through new control command and signalling concepts (T0-T1)

- On-board way side CBTC interface (T0)

Improving Safety and Security

- Safety - Control Command system compatibility (T1 - T2)
- Safety - ERTMS integration (T1 - T2)
- Safety - Control command systems integration (T0 - T1)
- Safety - ETCS new generation (T1 - T2)
- Safety - ETCS Optimal cost operation (T2 - T4)
- Safety - Control command systems failure prevention (T1 - T2)

Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050. The visual/pictorial overview template is provided in annex of this document) - tbd

Implementation Plan

(This chapter describes the possibilities and possible thresholds for implementation of the research and innovation priorities in this part-roadmap. Max.1.5 pages) - tbd

- *SHIFT²RAIL*
- *H2020*
- *Other public funding programs*
- *Private funding possibilities*

Roadmap conclusion

(This chapter gives a short summary of the most important findings from this part-roadmap – max 0.5 page)

ANNEX

tbd

7. Infrastructure Roadmap

Vision & priorities

→Europe has an integrated transport infrastructure, enabling a single European rail area. This integrated transport infrastructure system for the 21st century would be advanced, affordable and acceptable to Europe's citizens.

→The system will be optimised in terms of performance, and would adequately enable and support the advancements in other systems, processes and technologies involved with the seamless movement of people and freight through the modes[13].

→Operation and maintenance of network infrastructure are reliable, supportive of customer needs, cost effective, sustainable, adaptable to future requirements, automated and resilient to hazards by bringing together innovative technologies and concepts.

→The infrastructure is interoperable, enabling trains to operate across borders without delay or operational constraint, offering a real alternative to short and medium-distance flights and water and road-borne freight flows. As fundamental interfaces within the transport system, stations and terminals are designed to meet the needs of the future customer and are the cornerstone for the provision of quality, accessible and reliable rail services and sector competitiveness.

→Rail system infrastructure is designed to be intelligent and self-learning. It should adopt relevant infrastructure technologies from other sectors.

Intelligent infrastructure will be fatigue and wear resistant; system components will be monitored autonomously in real time. The use of new operational and track engineering techniques across the network will reduce the need for intrusive maintenance and greatly improve the train/infrastructure interaction at conventional and high speeds, such as the wheel/rail interface. A focus on intelligence provided by the system (remote condition monitoring), will enable the establishment of what, when and where maintenance is needed. This will ensure that there is low impact through system interruption and maximisation of product availability to the customer.

→Freight customers will have easy access to terminals. Terminals will manage throughput and loading and unloading throughputs swiftly. Optimising processes for train preparation will reduce the noise and vibration and so social nuisance from terminal operations and increase efficiency.

Key issues and objectives

- Increased track resilience and cost efficiency through improved design and materials
- Reduced costs and maximise track availability by non-disruptive inspection and targeted timely maintenance interventions
- New infrastructure technologies. This will include new track forms, switches and crossings, and their potential for commercial development.

[13] "*TOWARDS A PERFORMING INFRASTRUCTURE",* Roadmap for Cross-modal transport infrastructure innovation

- Modelling tools to analyse whole-life whole-system energy and carbon impacts. The application of new materials and construction techniques, modularisation for fast change components, pre-fabricated modules can offer significant improvements in performance and reductions in investment and operational costs
- Development of intelligent infrastructure maintenance and inspection and defect detection technologies carried out at commercial speeds.

State of the art and ongoing research and innovation within and outside rail

(This chapter describe the present state of the art – including global level - from in- and outside rail – even from a global level, potentially useful for rail innovation – max 2 pages)

tbd

Roadmap development and improvement targets

(This chapter will include the recommendations for R&I activities and planning to deployment. This should be based on the priority topics identified in the ERRAC Roadmap and re-distributed to the new part-Roadmap titles as described in the SRRIA. Describe per priority area, including a simple timeline picture – max 5 - 6 pages)

Creosote or wooden sleeper alternatives - Composite sleepers or Alternative substructure (T0 - T
Energy Storage in the infrastructure (T2)
Railway lines with~~out~~ discontinuous caternary operated with particular adapted rolling stock (traction e supply by pantograph and energy storage on board) (T5)
Advanced Traction Energy Supply - ~~Increase of line voltage to decrease the losses~~ (T1)
Advanced Traction Energy Supply - New catenary materials (T1)
Sector Smart Grids - Development of techniques based on an economical potential assessment (T3
Advanced Traction Energy Supply - Assessment of existing catenary materials and components – analysis for optimisation (T1)
Innovative infrastructure - Mobility management and social networks (T1)
Innovative infrastructure - Improved management of existing infrastructure (T0)
Innovative infrastructure - Improved maintenance of existing infrastructure (T0-T1)
Innovative infrastructure - Social acceptance of new infrastructure procurement and legal issu
Innovative infrastructure - New infrastructure concepts including lines and loads (T1)
Innovative infrastructure - New infrastructure construction methods reducing LCC (T1)
Innovative infrastructure - New sustainable funding of infrastructure (T0-T1)
Energy and Environment - Fully modular construction enabling easier upgrade (T1-T2) - Also i
Energy and Environment - Use of environmental friendly materials (T3-T5) - Also in RM2 and R
Safety and homologation - Intelligent infrastructure improving inspection and maintenance (T1
Safety and homologation - Improve station design for better safety (T1-T2)
Competitiveness and enabling technologies - innovative constituents increasing RAMS whilst LCC (T1-T2) - Also in RM8

Competitiveness and enabling technologies - Innovative design, devices and constituents (T1-
Improve stations and interchanges design (T0)
New generation of interlocking systems (T0-T1)
New cost-efficient control technologies (T1-T5)
Safety - Infrastructure safety improvement (T0 - T1)
Safety - Infrastructure inspection (T1 - T2)
Safety - Safe level crossing (T0)
Safety - Rail Road accident preventive platform (T2 - T3)
Infrastructure interaction vehicles - Innovative infrastructure (T0 - T4)

Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050)*

tbd

Implementation Plan

(This chapter describes the possibilities and possible thresholds for implementation of the research and innovation priorities in this part-roadmap. Max.1.5 pages)

a. SHIFT²RAIL b. H2020 c. Other public funding programs d. Private funding possibilities

Part-roadmap summary and exploitation of standardisation potentials

(This chapter gives a short summary of the most important findings from this part-roadmap – max 0.5 page)

tbd

Executive Summary and conclusions – A step change in rail research & innovation

(This chapter will mention the most important issues developed within this Roadmap. Max 1 page)

tbd

*). ANNEX: template

8. Rolling Stock Roadmap

Introduction

Among the 10 themes of the SRRIA, one is Rolling Stock, which is a very technical and specific subject. The design and development of rolling stock able to meet increasing technological demands and comply with changing regulations for interoperability, technical harmonisation and standardisation is a key roadmap topic.

This topic clearly connects with others such as safety (including certification) & security, capacity, performance and competitiveness, control command, communication and energy and environment.

As noted in the SRRIA, high-capacity modular rolling stock with efficient new generation braking and bogie designs, use of lightweight materials and information systems to improve customer services and reduce life-cycle cost, are examples with a strong potential for innovation.

The vision outlined by the SRRIA in this case is the following:

- Energy and mass-efficient, high capacity and optimised LCC rolling stock meet the evolving needs of rail customers. Rolling stock is critical for the provision of quality, accessible and reliable rail services as well as for the competitiveness of the sector.
- New generation trains are lighter and more energy efficient, are able to reduce previous travelling times, cause less track damage and less impact on the environment, thereby delivering a lower whole life cost. The environmental impact of noise and vibration is mitigated by innovative processes and technologies.
- At the same time, the operational reliability of trains benefits from targeted technical development, so there is less travel disruption, passengers arrive at their destinations on time and the overall better service enhancing rail's attractiveness for passengers.
- For freight traffic, faster, flexible freight trains with improved performance enable rail to deliver the reliability and cost-competitiveness that are key to exploiting market segments until now largely untapped by rail. IT systems enable buying and selling of capacity in wagons, reliable door to door track and trace services for loads and real time information on actual and forecast train position. These services add to the attractiveness of rail for the freight customer.
- Vehicle performance has improved. Power trains consume much less energy, components have become lighter, regenerative braking has become standard and the use of regenerated kinetic energy in the grid has significantly increased.

The priorities are:

• Promoting the increase of capacity by creating more space for passengers and reducing the weight of vehicles through smaller and lighter sub-systems and components.

• Improving vehicle performance through enhanced braking and flexible coupling and by addressing technologies for better accessibility in order to reduce dwell times. Increased operational reliability, mentioned below, will also have the effect of increasing track capacity.

• Increasing vehicle operational reliability by the combination of new, more reliable components and technologies together with fundamentally more reliable architectures for key sub-systems.

• Reducing vehicle life cycle costs through the combined effect of simpler architectures, less energy consumption and cheaper and more agile certification processes.

• Extending the benefits of LCC reduction to the infrastructure through the development of track-friendly rolling stock technologies.

• Developments that reduce vehicle energy consumption by the combination of more energy efficient equipment and lighter vehicles, which is achieved both by employing incipient technologies and materials and by simplifying system architectures.

• Technical standardisation of high-level architectures and interfaces between train sub-systems for cost effective procurement and retrofitting.

• Environmentally friendly rolling stock with special emphasis in the reduction of the emission of noise and vibrations.

• New paradigms for cost efficient freight rolling stock designs with improved capacity and optimised weight and suitable functionalities for different types of freight.

Key issues and objectives

The key issues and objectives identified by the SRRIA are:

• Increase capacity by reducing the weight of vehicles

• Increase operational reliability and track capacity through new, more reliable architectures for key sub-systems

• Reduce vehicle life cycle costs and extend its benefits to the infrastructure

• Reduce vehicle energy consumption

• Improve the technical standardisation of high-level architectures for cost effective procurement

• Reduce noise and vibrations

• Improve cost efficient freight rolling stock designs

State of the art and ongoing research and innovation within and outside rail

(This chapter will describe the present state of the art – including global level - from in- and outside rail – even from a global level, potentially useful for rail innovation – max 2 pages)

5.1 Shift²Rail

The Shift2Rail Joint Undertaking is a public-private partnership between the EC and major European rail stakeholders, with the aim of bringing about a modal shift from road to rail in order to achieve a more competitive and resource-efficient European transport system.

The S2R is divided into five Innovation Programmes (IPs), each addressing a major rail area, as follows:

IP1 – Cost-efficient and reliable trains, including high capacity trains and high speed trains

IP2 – Advanced Traffic Management & Control Systems

IP3 – Cost Efficient and Reliable High Capacity Infrastructure

IP4 – IT Solutions for Attractive Railway Service

IP5 – Technologies for Sustainable and Attractive European Rail Freight

IP1 is directly linked to rolling stock, and focuses on the design of reliable, comfortable, affordable and accessible trains, in order to attract more passengers in the future while reducing system costs and enhancing interoperability.

In order to achieve these objectives, an indicative list of priority research and innovation activities has been produced, focused on:

- Train interiors: enhance passenger comfort by addressing accesibility issues, noise and vibrations.

- Doors and intelligent access systems

- Traction: new tools to reduce weight, noise and energy consumption

- Brakes: safer and better performing brake systems with lower life cycle costs and noise levels.

- Train Control and Monitoring System (TCMS): reducing the number of components, optimising the architecture and integrating safety critical functions.

- Carbodyshell: Lighter and aerodynamic carbodyshell structures, reduced life-cycle costs.

- Running gear: reduced infrastructure/wheel wear and damage as well as energy loss.

IP5 is also linked to rolling stock, on wagon design and including new bogie solutions, running gear for higher speed, lower noise, running stability, lower wear and tear, intelligent safety sensors, disc brakes, power-pack and generator aiming at reduced overall costs/high safety.

5.2 FP7

• CLEANER-D (2009-2013) aimed to develop, improve and integrate emissions reduction technologies for diesel locomotives and rail vehicles. The main goals of the project were to demonstrate the feasibility and the reliability in service of railway rolling stock powered with diesel engines compliant to the requirements of stage III-B of the Non-Road Mobile Machinery (NRMM) European Directive.

• EURAXLES (2010-2013) aimed to bring the risk of failure of railway axles to such a minimum level that it will no longer be considered as a significant threat to the safe operation of the European interoperable railway system.

• MARATHON (2011-2014) investigated the integration of rolling stock technologies combined with innovative operating patterns in order to provide freight services based on longer heavier and faster trains.

• TRIOTRAIN (2009-2013) was a cluster of integrated research projects which aimed at further promoting interoperability by increasing virtual certification, i.e. replacing testing by simulation and proposing a simplification of the authorisation processes through an optimised mix of field testing, mock-up testing and simulation.

• RIVAS (2011-2013) aimed to reduce the environmental impact of ground-borne vibration.

• SUSTRAIL (2011-2015) aims to contribute to a new era in increased competitiveness of the rail freight sector by adopting a holistic approach, implementing a clear methodology and viable procedures for a combined improvement in both freight vehicles and track components.

• ACOUTRAIN (2011-2014) aimed at simplifying and improving the acoustic authorization of new rolling stock by introducing virtual certification procedure, in particular relating to the TSI Noise.

• EUREMCO (2011-2014) aimed to harmonise and reduce the certification process of rail vehicles against Electromagnetic Compatibility (EMC).

• OSIRIS (2012-2015) aims to develop Optimal Strategies to Innovate and Reduce energy consumption In urban rail Systems (OSIRIS) by implementing technological and operational solutions and tools, while testing/demonstrating/assessing their individual and combined benefits in real case scenarios.

• ECUC (2012-2016) aims to prove that linear eddy-current brake (ECB) is an effective solution for increasing the braking capacity of new high speed trains.

• REFRESCO (2013-2016) aims to reduce energy consumption of railway rolling stock through new materials such as composites and light metallic alloys, which will consume less energy and help reduce the emissions of rail transport.

5.3 H2020

The call “Mobility for Growth” invited proposals against the topic “New generation of rail vehicles” (MG.2.3-2014), aiming to deliver a reduction of up to 40% in life cycle costs of rolling stock products, an increase in passenger train capacity up to 15%, reductions of downtime by increased reliability (up to 50%), a reduction of energy consumption (up to 30%) and an improvement in environmental performance, whilst delivering superior performance in terms of overall service quality, safety and customer experience in rail transport.

The following topics are covered:

- Development and integration of higher-performance technologies for critical structural components

- Traction, command-control and cabin environment applications (e.g. new materials, smart power and wireless technologies)

- Design and production solutions (e.g. modular, "commercial off-the-shelf" or adaptive concepts)

- Innovative solutions to extend vehicle lifetime

- Technologies to ensure interoperability through better Electro-Magnetic Compatibility (EMC) between the railway vehicles and the electrical installations of the network.

- Development of innovative, modular and customisable solutions for comfortable and attractive train interiors.

5.4 National research

To be completed by Member States representatives and Academia Advisory Groups

France

The research project “Mimosa” focused on the development of new aero-acoustic methods for high-speed train noise prediction.

5.5 Relevant Research & Technologies outside rail

- Use of composite materials, already common in the aeronautic and the wind power sectors.
- Nanotechnologies
- Alternative propulsion energy sources, including hydrogen and natural gas
- Multi-senses vehicles – innovative solutions for people with mobility impairment

Roadmap development and improvement targets

(This chapter will include the recommendations for R&I activities and planning to deployment. This should be based on the priority topics identified in the ERRAC Roadmap and re-distributed to the new part-Roadmap titles as described in the SRRIA. Describe per priority area, including a simple timeline picture – max 5 - 6 pages)

The priority topics identified by the previous ERRAC roadmaps had been reallocated according to the new SRRIA Roadmap titles.

Below is an outline of the main topics for the “Rolling Stock Roadmap”, structured according to a number of sub-themes. In the case of rolling stock some overlaps exist, especially with the “Customer experience” roadmap as well as with the “Energy and environment”, “Safety” and “Strategy and economics”.

The indicative timeline of these research proposals is also indicated between brackets.

T0 = it has been already covered.

T1 = immediate

T2 = 2015

T3 = 2020

T4 = 2030

T5 = 2050

Sustainable design and procurement

- Eco-design label for rolling stock - Based on key criteria covering significant environmental aspects: Energy-CO2, Materials, Noise (T1 - T2)

Noise and vibration

- More research on aerodynamic noise, generation, propagation and control - Improved prediction methods and design solutions for aero acoustics of high speed trains (T0 - T1)
- Improvement of interior acoustic comfort for passengers (T0 -T2)

Energy

- Lighter Trains - Assessment of the technology transfer potentials from the aeronautic and automotive sector to the railway sector (T1)
- Lighter Trains - Weight reduction for the suburban and urban passenger services (T2); design methodologies to be re-evaluated (T2)
- Lighter train - design with impact on in due consideration of standardisation & regulation issues e.g. crash worthiness (T2)
- Hybrid Traction - Multiple power sources for traction (T2)
- Hybrid Traction - Development of prototypes (T2)
- Hybrid Traction - Energy storage on-board (T2)
- Hybrid Traction - Engine stop at stations (T2)
- EE Auxiliaries - Optimisation and development of intelligent management auxiliaries (T2)
- Next generation of power semi-conductor - Improvement of efficiency, weight, volume among others (T2)
- Next generation of power semi-conductor - Standardisation (common expressed request by the railway sector to the semi-conductor industry) (T2)
- Innovative Propulsion - Implementation of hydrogen fuel cell of RAMS/LCC incl. the aspect of hydrogen production & storage (T5)

Freight

- General wagon issues - Modern wagon concepts with low noise, track friendly bogies. Increased speed capability with no increased track attrition. Incentivisation of track friendly equipment (T0-T1)
- General wagon issues - Cost effective methods for assembling and managing longer trains (T0-T1)
- General wagon issues - New transhipment technologies and operational concepts for low cost terminals (T0-T1)
- General wagon issues - Modern wagon fleet adapted to business needs and societal requirements. Innovative faster flexible freight trains performing like passenger trains with low infrastructure wear and tear properties that address lighter more valuable good segments (T0-T3)
- Single wagons - Automatic coupling and decoupling, improved braking (T0-T2)

Passenger

- Adaptive interiors configuration for different types of users, e.g. family activities, mobile office and group travel (T0-T1)

Urban Mobility

- Freight and Urban Mobility: Interfaces and complementaries: New techniques and vehicles for urban freight delivery (T1 - T2)

Urban, Suburban and Regional Rail

- Energy and Environment - Reducing RS weight while reducing noise and vibration (T1-T2)
- Energy and Environment - Eco-procurement specifications and harmonisation (T1-T2)
- Energy and Environment - Fully modular construction enabling easier upgrade (T1-T2)
- Energy and Environment - HVAC (heating, ventilation and air conditioning) interfaces (T3-T5)
- Energy and Environment - Use of environmental friendly materials (T3-T5)
- Competitiveness and enabling technologies - innovative constituents uncreasing RAMS whilst decreasing LCC (T1-T2)
- Competitiveness and enabling technologies - Tram-train (T1-T5)
- Competitiveness and enabling technologies - Innovative design, devices and constituents (T1-T5)

Improving Safety and Security

- Safety - Train collisions preventions and effects mitigation (active and passive safety) (T0 - T2)
- Safety - European Rolling Stock safety platform (T1 - T2)
- Safety - Wheel sets and axles failure prevention (T1 - T2)
- Safety - Vehicle preventive maintenance (T1 - T2)

Strengthening competitiveness

- Economics - Global competitive rolling stock (T0 - T2)
- Infrastructure interaction vehicles - Innovative and future proof vehicles (T0-T2)

Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050. The visual/pictorial overview template is provided in annex of this document)

Implementation Plan

(This chapter describes the possibilities and possible thresholds for implementation of the research and innovation priorities in this part-roadmap. Max.1.5 pages)

8.1SHIFT²RAIL
8.2H2020
8.3Other public funding programs
8.4Private funding possibilities

Roadmap conclusion

(This chapter gives a short summary of the most important findings from this part-roadmap – max 0.5 page)

ANNEX

Please see next page the visual/pictorial overview template of the main research priority Rolling Stock against an indicative time-line.

tbd

9. IT and other enabling technologies Roadmap

Introduction

Among the 10 themes of the SRRIA, one is IT and other enabling technologies, which is closely linked to the cluster on the attractiveness of rail and public transport, since one of its key goals is to improve the quality of the passengers' door-to-door journey. It is also linked, to a lesser extent, to control, command and communications, when it comes to ensuring reliability and punctuality.

The vision outlined by the SRRIA in this case is the following:

• Rail embraces all technologies that enable new forms of information and communication. It encourages the design and use of standard systems architectures and the integration of information systems throughout Europe. This helps to manage large volumes of data over the life of assets.

• The railway has a co-ordinated approach to the management of the information needed to run the operational system. The web of transportation things connects all the assets, allowing much better monitoring of the rail system, with preventive maintenance and flexible adaptation of the different components. Freight is traced and tracked in real-time through all stages of transit, whatever the mode.

• Passengers enjoy a seamless door-to-door journey, thanks to new services addressing all aspects of the travel whatever the mode of transport. Fragmentation of different services (shopping, booking, ticketing, validation, etc.) and between different modes has been removed. Moreover, the availability of real-time traffic and whole-journey information keeps the passenger abreast of the varying alternatives, including inter-connection with other modes, should journey problems arise.

The priorities are:

- New architectures to allow the easy adoption of new technologies with stable rules for functional requirement layers.
- IT technologies which allow interoperable services whilst limiting impacts on existing systems, without prerequisites for further standardisation.
- User-centric services, adapted to the mobility of the citizen, which put the passenger at the heart of innovative solutions: easy accessible business services on mobile applications, personalised journey information and whole journey integration and information in conjunction with other transport modes.
- Technologies to manage the transmission, capture, storage and communication from new sources such as sensors, video cameras, tablets and other hand held devices.
- High performance systems for train control.

Key issues and objectives

The key issues and objectives identified by the SRRIA are:

• Use IT technologies that allow service interoperability, even with other transport modes, without further standardisation

• Improve customer experience through the implementation of new services addressing all aspects of the travel whatever the mode of transport.

• Enhance the data management and communication technologies used in hand held devices.

• Use a reliable live tracking system for freight, including inter-connection with other modes.

State of the art and ongoing research and innovation within and outside rail

(This chapter describe the present state of the art – including global level - from in- and outside rail – even from a global level, potentially useful for rail innovation – max 2 pages)

5.1 Shift²Rail

The Shift2Rail Joint Undertaking is a public-private partnership between the EC and major European rail stakeholders, with the aim of bringing about a modal shift from road to rail in order to achieve a more competitive and resource-efficient European transport system.

The S2R is divided into five Innovation Programmes (IPs), each addressing a major rail area, as follows:

IP1 – Cost-efficient and reliable trains, including high capacity trains and high speed trains

IP2 – Advanced Traffic Management & Control Systems

IP3 – Cost Efficient and Reliable High Capacity Infrastructure

IP4 – IT Solutions for Attractive Railway Service

IP5 – Technologies for Sustainable and Attractive European Rail Freight

IP4 is directly linked to this theme of IT and other enabling technologies, and focuses on the need to achieve a full seamless multimodal travel experience, where the customers must be able to easily plan and purchase door-to-door journeys through ticketless and multi-application solutions that guarantee interconnectivity no matter where the traveller roams.

The innovation activities proposed by this IP are based in three broad topics:

- Customer experience applications: develop secured customer experience applications including customer preferences, itineraries, preselected payment means, and giving access to additional services such as en-route assistance, guidance to PRMs or passenger right information, etc.

- Technical framework: identify, formalise and document requirements and solution engineering specifications for interoperability using unambiguous semantic web technologies and open architecture and standard service interfaces.

- Multimodal travel services: develop one-stop-shop solutions and applications for multi-modal shopping and ticketing enabling integrated door-to-door, multi-modal itineraries.

5.2 FP7

• IFM (2008-2010) aimed to make public transport more user-friendly by facilitating seamless accessibility to different public transport networks, providing travellers with common styles of contact-less cards which can be used for multiple transport products in different European geographic areas and for sustainable modal switching.

• INTERCONNECT (2009-2011) aimed at reducing the environmental impact of passenger transport by encouragement of integration, co-operation and, where appropriate, competition in the provision of local connections, paying attention to land, air and maritime modes. The range and applicability of specified solutions, which were tested in the project case studies, made use of policy measures like integrated pricing and ticketing, improved links and interchanges, infrastructure pricing, strategic planning, information and marketing.

• SECUR-ED (2011-2014) aimed at providing a set of tools to improve urban transport security by integrating a consistent, interoperable mix of technologies and processes from risk assessment to complete training packages.

5.3 H2020

The call “Mobility for Growth” invited proposals against the topic “Smart Rail Services” (MG.2.2-2014), aimed at conceiving and prototyping an on-line, mobile, suite of integrated facilities providing a whole new traveller experience throughout the journey. The following topics relevant to this theme are covered:

- Planning and reservation of user-friendly multimodal trips and services

- IT solutions for persons with reduced mobility

- Measuring the environmental impact of user choices

- Easily accessible entitlements, validation and control for all transport modes, en-route assistance including re-accommodation.

The call “Mobility for Growth” also invited proposals against the topic “I²I – Intelligent Infrastructure” (MG.2.1-2014). This includes proposals that reconcile business and operational requirements (namely customer service, capacity, speed, timekeeping, energy, asset management) with real-time field and asset condition monitoring and intelligent traffic planning (including cross-border), to deliver normal or near-normal services during all but the most exceptional circumstances, with a view to ensuring a minimum impact on services delivered.

5.4 National research

To be completed by Member States representatives and Academia Advisory Groups

5.5 Relevant Research & Technologies outside rail

- GNSS (Galileo): satellite-based services as a cost-efficient way for Train Control Systems
- Advanced IT: big data processing and analytics
- Innovative solutions for people with mobility impairment

Roadmap development and improvement targets

The priority topics identified by the previous ERRAC roadmaps had been reallocated according to the new SRRIA Roadmap titles.

Below is an outline of the main topics for the "IT and other enabling technologies Roadmap", structured according to a number of sub-themes. In the case of this theme some overlaps exist, especially with the "Control, command, communication" roadmap as well as with the "Customer experience" and "Strategy and economics".

The indicative timeline of these research proposals is also indicated between brackets.

T0 = it has been already covered.

T1 = immediate.

T2 = 2015

T3 = 2020

T4 = 2030

T5 = 2050

Freight

- Intelligent traffic management - Introduction of new intelligent management systems capable of optimizing the use of the existing infrastructure (T0)
- Intelligent traffic management - ERTMS level 2 and 3 - implementation of low cost compatible solutions for freight trains (T0-T3)
- Single wagons - Tagging standardisation (RFID) of wagons (T0 + 1/2 T1)
- Logistic services - Rapid reaction to queries - response time to enquiries in terms of service availability, routes, schedules, pre and end haulage satisfying customer demands (T0)
- Fleet Management - Reduction of empty running and repositioning of equipments (T0)
- Fleet Management - Open standard rail freight management of ICT packages compatible with other operators - enabler of train planning and collaborative approach (T0-T2)

Passenger

- Seamless travel -Ticketless journeys (EU level) compatible with local transport fare management systems; standardisation of ticketing procedure and ticket information (T0-T1)
- ERTMS fully implemented on core axis (TEN-T) - Development and implementation of processes and ICT tools for time tabling and operational traffic management (T0-T3)

Urban Mobility

- Freight and Urban Mobility: Interfaces and complementaries - New city-logistic concepts (T0 - T2)
- Integrated Urban Mobility Systems and Governance - Interoperable integrated ticketing (T0)
- Integrated Urban Mobility Systems and Governance - Integration of traffic and travel information (T0)
- Innovative technologies, tools and products - Interchangeable and/or interoperable innovative technologies, tools and products, for traffic and travel information (T0 - T2)
- Integration of ticketing and charging services - Interoperability for customers through common multi-application processes on a single media: create a Pilot operation in a number of Member States in preparation for wider roll-out (T0)
- Integration of ticketing and charging services - Develop a Common EU portal and Common Product Templates supporting an extension of the “IFM Brand” (T0-T1)
- Integration of ticketing and charging services - Create a common EU-IFM application (T1)
- Integration of ticketing and charging services - Develop a commercial and technical framework for the sales and settlement of EU-IFM Products (T1)
- Integration of ticketing and charging services - Extend functionalities to facilitate inter-modality and Demand Management (T1)
- Integration of ticketing and charging services -Engage and merge with existing IFM Systems and other ITS services and transport modes (T0-T2)
- Integration of ticketing and charging services - Engage with applications for electromobility related services (T1)
- Integration of ticketing and charging services - Security and privacy framework for contactless payment (T0 - T1)
- Integration of ticketing and charging services - (New) charging and pricing policies strategies (T0)

Urban, Suburban and Regional Rail

- Competitiveness and enabling technologies - Innovative ITS for operation management (T1-T5)
- Personal Safety/security - ITS for passenger security and safety (T0)
- Competitiveness and enabling technologies - Information management (databases, dynamic control of information) (T0)

Improving Safety and Security

- Security - Procedures, Regulations and standards - Privacy and personal freedom protection (T0 - T1)
- Security - Detection Systems - No hindering sensors (T0 - T1)
- Security - Detection Systems – CCTV (T0 - T1)

Strengthening competitiveness

- Economics - Decision support tools for asset management (T0 - T2)

Visual Roadmap of the planning of milestones and deliverables

(This chapter gives a visual/pictorial overview of the main research priorities against a time-line to 2050. The visual/pictorial overview template is provided in annex of this document)

1. IT and other enabling technologies - Implementation Plan

(This chapter describes the possibilities and possible thresholds for implementation of the research and innovation priorities in this part-roadmap. Max.1.5 pages)

8.5SHIFT²RAIL
8.6H2020
8.7Other public funding programs
8.8Private funding possibilities

2. IT and other enabling technologies – Roadmap conclusion

(This chapter gives a short summary of the most important findings from this part-roadmap – max 0.5 page) - tbd

IT and other enabling technologies – ANNEX

tbd

10.Training an Education

Introduction

The Railway sector is presently a rapidly developing and changing sector in its various market segments (High Speed rail; Regional Rail; Suburban Rail; Light Rail; Metro; Freight ...). The railways and their staff are facing crucial changes that will determine the future of this important sector. These changes occur in numerous areas, such as the technological, demographic, structural, legal and regulatory domains.

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 resources 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. Europe needs rail and rail needs research, development and innovation, which in turn require skilled and motivated staff as agents of change in an increasingly complex, multidisciplinary and transdisciplinary environment.

A partnership for innovation, skills development and jobs is envisaged to mobilize support and help the different players work together to spread ownership and excellence.

The sector is getting increasingly impacted by new processes and technological changes, and complex simulation tools and ICT applications are getting more and more important. These trends will play an important role in regard to future skills.

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

Training and skills development is a necessary pre-condition for the success of both the European Research challenges and the everyday needs that the railway sector is facing. Training and education initiatives offer an effective way to nurture collaboration across the sector by:

- Providing access to industrial expertise and promote knowledge transfer processes from academia and research institutions through specific actions and research based training and education initiatives.
- Fostering collaboration and joined-up thinking by facilitating sustainable partnerships involving the sector, SMEs, academia and R&D institutions.
- Facilitating cross-fertilization from other sectors aiming to intermodal integration by cooperating with ETPs and other stakeholders from the transport sector.

Key issues and objectives

The transport industry in general and the rail sector in particular demand a mix of competencies from present and future transport researchers. This demand is changing, reflecting the current and future needs (environmental protection, new materials, new technology, new energy sources, etc.). Presently, the educational programs being offered at transport courses do not in general meet in a systematic manner these requirements.

Several sources of competences gaps are identified:

- Gap between the competences that the employees need and the actual competences of the students (i.e. to what extend are the student's competences actually useful in their working daily activities?).

- Gap between the knowledge the companies need and the actual competences of the employees (i.e. to what extend do the employees' competences actually fit in their companies' competences requirements).
- Gap between the knowledge the universities generate and the actual competences of the students (is the knowledge generated in the research transferred in the courses?).
- Gap between the know-how the companies need and the knowledge the universities have (i.e. are the universities' research and teaching activities of relevance for the companies).
- Closer cooperation between academic institutions and end-users is needed in order to inform and train appropriate personnel for transport research and offer them competitive work conditions.

Key objectives in training and education activities are:

- Forecasts of the skills that the railway sector will need and analysis of gaps in skills;
- 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);
- Facilitate sustainable partnerships involving the sector, SMEs, academia and R&D institutions envisaging knowledge transfer and fostering innovation processes.

State of the art and ongoing training and education activities within and outside rail

Skills and jobs are of vital importance for the future of the European economy and have recently gained increasing attention, both at national and EU level.

The transport sector is one of the most important sectors for the European economy. Its importance stems not only from its size (which is estimated to be € 803 billion or 6.6% of European GDP in 2007), but also from the fact that it plays a crucial role in connecting other economic actors with each other.

The transport sector is characterized by a great diversity and different transport modes that come with different technologies, regulations, challenges and know-how and skills requirements. Rail transport (passenger and freight) includes subway, metro and tram systems, regional services, intercity and cross border operations of which high-speed trains become a new passenger travel paradigm.

The employment structure and work organization in the transport sector is dominated by large (and often monopolistic) companies (such as air and rail transport). In the important freight transport by road segment small companies predominate. The transport sector has a gender issue when it comes to employment and recruitment, and a paramount source of future labor shortage in the transport sector will be retirement. [1]

Partnerships for innovation, skills and jobs, in connection with technology platforms, industrial high level groups, as well as lead market and cluster initiatives are being promoted at both European and national level.

Existing partnerships for innovation, skills and jobs generally show a number of characteristics, which include:

- Involvement of all relevant actors, ranging from companies, research organisations, education and training institutes to public administration and others;
- Cross-sectorial approach: even though partnerships may be assigned to a specific sector, they often work across different business sectors. This may be the case of rail freight where successful business involve in a cooperative manner technology, services, logistics, operators and shipping agencies;
- Cross-thematic approach, i.e. linking innovation, skills and jobs;
- Inclusion of general human needs into the partnership strategy: human needs, such as housing, health or mobility can be part of the formulated partnership vision or strategy;
- Long term commitment of actors (members);
- Joint problem solving, i.e. working on problems that cannot be met by one member alone.
- European dimension, i.e. being established at the European level in order to challenge non-European competitors.

Major underlying drivers are now identified as they may lead to the development of new skills copping with emerging job profiles: globalization and world trade, natural resources availability and prices, technology developments (ICT and technology for planning, surveying and monitoring and innovative rail products), demand for clean and safe transport, regulations, safety policies and vehicle legislation, etc..

A number of strategic options may involve different measures at different levels of the training, education and skills development chain:

- Recruiting staff with appropriate levels of education with specific majors offered in Higher education institutions;
- Training employed workers and tailoring their skills, design and offer new courses either in-house or outsourced;
- Improve the image of the sector and the attractiveness of pursuing careers in the different railway sub-sectors, and promote a stronger cooperation with industry (internships, visits and.
- Exploitation of the Marie Curie instruments in cooperation with industry is an illustrative example with a potential strategic impact at European dimension.

During the past 15 years a number of initiatives and policies have been taken at European level to promote education and training activities in general (unfortunately not specifically for the field of Transport). The most notable of these are the following [5]:

2000 – Initiation of the concept of the European Research Area (ERA);

2007 – EU's Green paper aiming to deepen and widen the ERA, by i)removing the institutional and national barriers hampering free movement of researchers and ii) improving their working conditions and widening their career prospects;

2012 – EU Communication: "A Reinforced European Research Area Partnership for Excellence and Growth", aiming at deepening and re-ensuring the removal of barriers to researcher mobility, training and attractive careers for an open labor market for researchers;

2000 – 2013: Several other initiatives and actions by a number of relevant organisations such as the COST programme, initiatives by NoEs-VCEs (e.g. HUMANIST, EURNEX, NEARCTIS), initiatives by research associations such as ECTRI, Erasmus, Erasmus Mundus, etc.

At the level of the EU, the transport research education and training issues are addressed collectively within the overall education and training activities of the "Excellent Science" pillar of the Horizon 2020 programme of the Union. These are primarily carried out through the well-known Marie Skłodowska-Curie (or simply Marie Curie) programme. This programme is considered by the academic and research communities as successful.

In the ETRA report is worth mentioning that the training activities that take place with the support of the Marie Curie programme should be complemented by relevant actions that could be supported by the rest of the H2020 activities, most notably through the process of funding and implementation of collaborative research in general. In this respect it is proposed that the main collaborative research pillar of the "societal challenges" research of the H2020 programme could include some funding for actions (through projects) in the following areas:

- Instituting web-training and short courses as well as training workshops in various subjects related to the specific subject of the research carried out according to the Descriptions of Work of the specific research projects;
- Activities within research projects that provide training materials, short training courses and / or publishing textbooks. Such activities could be given some sort of priority in funding especially when this is done with involvement of leading international academic organizations;
- Projects doing solely the above could also be funded in specific sectors that are considered as particularly important;
- Concerted attempts and suggestions at benchmarking (for Transport courses and training material and curricula) have been made over the past decade mainly through EU funded research projects in the FP6, FP7, and now in the H2020 programme. Two of them merit special mention here: the DETRA project (Developing the European Transport Research Alliance)11, and the MORE and MORE2 projects (MObility patterns and career paths of REsearchers).

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Roadmap development and improvement targets

1. Characterisation of skills and competence needs

Together with ERRAC and partners as members of EURNEX, UNIFE, UIC, ERA and European universities and other relevant research institutions, the future topics on training and education in the rail sector will be identified as:

- State-of-art and current trends in the development of technically and operationally inter-dependent systems, production methods and industry structure, value added and changes in volume trends, employment trends;
- Trade globalization and internal competition between modes (and even within mode sectors), which give a new dimension to skills development and changing trends in staff requirements while the legal and regulatory environment is becoming also more relevant requiring specific skills and knowledge in specific issues e.g. those in the safety domain;
- Technical competences associated with: professional intervention across different railway assets; appraisal of the level of intervention in technical careers; new emerging technology products and services such as Galileo, GSM, IT, environmental efficiency; systems engineering, man-machine interfaces and human factors, signaling systems, innovative and modular RS, modern infrastructure maintenance, sensor technologies and asset management methods;
- Competences in the legal domain: interoperability directives, safety rules, certification of rail staff, environmental policies, working conditions, etc.;
- Competences in market areas: competition, social objectives, customer demands, cross border operations, liberalization, low fare airlines, globalization, freight logistics and related passenger and freight services.

2. Higher education offer

Based on the results of the SKILLRAIL and NEAR2 projects, update and develop a comprehensive inventory of current railway higher education programs and activities in the E.U. and the rest of the world, and determine the demand for railway higher education by the industry, both quantitatively and qualitatively. Establish a web-based railway education forum as a tool for stakeholders to provide input and suggestions.

Appraisal of current educational offers and definition of major guidelines at BSc and MSc levels bridging the gaps between knowledge production in Higher Education institutions and required know-how in the different industrial environments.

Establishment of training and education for top management in the sector. The main features of such programs include:

- running an efficient and safe rail system while respecting the rules of competition;

- focus on strategic directions, needs and aspirations of customers;
- forward strategies ensuring rail as the backbone of a sustainable European transport system;
- legal and institutional contexts,;
- features of the future rail passenger and freight services, standardisation and interfaces.

3. Advanced Training courses

Universities and research centres working together with railway manufacturers,railway operators and infrastructure managers at international (EU projects) or national (national programmes) levels, have developed methods, tools, instruments, test specifications and sometimes test facilities as well as any kind of scientific activity tailored for the railway sector.

Several times and in several national or international projects a know-how transfer from other industrial sectors or other transport modes have been used and specified for the railway sector introducing new technologies or new techniques in technological and in the economic and legislation areas. This opportunity and the outcomes of projects are often not well disseminated and exploited while they can be suitably introduced in high level training courses and related tools and instruments.

Short training for high skilled jobs can be targeted to all kind of railway stakeholders in order to develop competences standardized or recognized at international level, enabling to comply with EU and international requirements and legislation, and also with the high-tech innovations under development/implementation in railway services.

The creation and development of a portfolio of short training courses for high skilled jobs constitutes a benchmark for the rail training system which mainly answers to the following needs:

- To create professional profiles able to operate in the technological changes provided recently by the signalling, communication, IT systems introduced in the railway sector;
- To create professional profiles in the international legislation and market liberalization under implementation in the railway sector;.
- EU universities and research centres must continue to develop a Knowledge Management System (KMS) in order to analyse and to compare the existing competences, tools and facilities for railway education and research. The EURNEX pole of excellence “Education & Training” created the EURAIL Virtual University which is providing a centralized Learning Management System;
- Explore advanced training courses in different settings according to the industry needs and taking into consideration the target audiences: in-house tailored courses for specific companies; summer courses for university students, open advanced courses targeted to larger groups of industry specialists and PhD students;
- Lifelong learning actions aimed to address emerging technologies and recover current staff to new organisational and emerging skill needs;
- Learning programmes fully exploiting current virtual learning environments, and e-learning technologies to explore networking of specialists and expose novices and specialists to real operational situations. E-learning classes can be provided to suit needs and timescale in the current climate travel and tight training budgets. To help still meet training needs the e-learning courses can be developed to complement the live class. The e-learning courses may run over different class periods or may

allow students to be exposed to recorded classes in after work periods and weekends. E-learning classes are ideal for companies with a group of engineers requiring training.

4. EURAIL – The European Railway University

The SKILLRAIL project has launched the EURAIL “European University of Railway”. As a corporate service of EURNEX, its main mission is associated with the creation, dissemination and transfer of knowledge within the railway sector. By addressing the needs of the sector the European University of Railway- EURail will provide the conditions to disseminate the social and industrial benefits of training and education in the railway sector and to develop, at European level, high quality training and education activities for the railway community of tomorrow.

Based on knowledge, experience and people from "real" universities in Europe, EURail is virtual in nature and aspires to foster, at European level, excellence by gathering and networking the different relevant organizations and institutions around an educational project suitable to the needs of the European Rail sector. EURail’s unique feature is this concentration of high-level knowledge and expertise in one single sector/problem-oriented institution. It is expected that EURail will form a coherent community able to define lines of actions and conduct sustainable business in close liaison with the Network of Excellence EURNEX.

The first objective is to unite the efforts of the different railway stakeholders seeking to share information and training. EURAIL must be supported to periodically collect the research results and educational options provided by the associated EURNEX institutions (universities and research centres) and all other universities in Europe.

5. Meeting expectations of end users

- Create innovative programs for “proficiency” through innovation, bringing together teaching, research and knowledge development by academicians, practitioners and students.
- Promote higher flexibility, tailored contents, operational and practical subjects for educational courses in the rail sector, and also in the more general Transport domain.
- Promote and / or reinforce the interaction between educational establishments and industry, through:
    - “trusting partnerships” between academia and practitioners to develop regular problem solving workshops and research projects and Strategic alliances for on job coaching of practitioners (e.g. “seed planting” approach).
    - Promote full and unhindered mobility of students, professors / teaching staff, and industry professionals

6. Harmonised European Transport/Rail PhD

A relevant major recommendation of the project DETRA (http://detra.fehrl.org/) was the need for a commonly defined “European Doctorate (PhD) in Transport” and the need to define specific guidelines for such a PhD format.

A commonly features, the defined “European Doctorate (PhD) in Transport” would provide, among other, acquisition of:

- knowledge from basic disciplines (e.g. mathematics, statistics) in order to enable analysis and management of complex systems;
- specific and high-level knowledge related to the various transport disciplines;
- experience in project management with development of leadership, mediation and communication skills.

Stakeholders that should take the initiative for the design and implementation of such a EU PhD transport/rail are:

- Universities in charge of PhD programs;
- Research centres hosting PhD students;
- Networks of Excellence (NoEs) that encourage training and mobility activities;
- Industries capitalising on researchers' know-how and abilities, and of course
- The relevant governmental bodies.

Visual Roadmap of the planning of milestones and deliverables

May not be applicable as most of the activities due to their nature have a continuous uninterrupted nature

Implementation Plan

To carry out all the proposed road mapping activities several lines of financial support must be sought in the framework oh SHIFT2RAIL, H2020, Member States funds, Structural Funds, other public funding and self-sustained business oriented activities with funding private support.

Part-roadmap summary and exploitation of standardisation potentials

Due to the internationalisation in the train transport sector and the need for technical unification of the existing network it will be necessary to constantly adapt the knowledge and skills of the employees. To ensure international standards as well as the required mobility of labour a European recognition of skills and a corresponding adaptation of national initial vocational training is recommended for train drivers and stewards of the sector. The European Qualification Framework can provide a common basis for the European transport sector to pursue this aim. Social partner organisations, the European Commission and companies and training providers should adopt the European-wide validation system for the sector and develop a special certification system.

This would also support trans-national mobility within in the sector and enhance a common rail transport market.

From reference [1]

Executive Summary and conclusions – A step change in rail research & innovation

Training and Education aim to contribute to the enhancement of the railway sector by fostering a better match between the human resources 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. In this context the proposed activities do not aim to develop new research but simply develop a matching function that is to bring the existing knowledge near the existing needs for a successful synergy.

The proposed activities also contribute to disseminate the social, economic and industrial benefits of education and research in the railway sector, and promote the idea that society needs advanced technologies and further education as applied to a highly innovative and technological developed sector.

In line with the ETRA paper on Training and Education issues, the following final recommendations are offered:

- Create new innovative research based “postgraduate” programs through bringing together: teaching, research and industrial needs by enhancing cooperation of academicians, practitioners and researchers;
- Create new or complement existing transport educational “offers”, through:
    - New courses and programs (more flexible and not focusing on fundamental disciplines only);
    - Specialization courses offering higher flexibility, tailored contents, operational and practical subjects; and through offerings well designed and coordinated at European level;
    - Courses for top management in transports and railway addressed to high level managers in the transport sector, including manufacturers, technology providers, operators, logistics, authorities;
    - Lifelong Learning and Vocational Training courses.
- Continue to support and strengthening the EURNEX – EURAIL and similar agencies and institutions in the preparation and organization of short training courses and other collaborative initiatives at European level;
- Establish a web-based portal associated with EURAIL including portfolios of course offers, industry and academic specialists engaged in T&E activities, course materials;
- Reinforce University-Industry Interaction, through:
    - Partnerships between academia and practitioners to develop programmes and problem solving content;
    - Creating strategic alliances for on-job coaching of practitioners;
    - Promoting mobility of students, teachers and industry professionals further and above all in a coordinated and fully transparent way.
- Improve the Marie-Curie programme through:
    - providing funding for supervisory activities in hosting institutions, i.e. for tutoring or academic supervision of the hosted researchers;
    - increasing the allowable percentage of commercial work that a Marie Curie programme supported researcher can undertake for the institution he/she is placed with. This will give the individual researcher some commercial experience and skills that are necessary to a researcher, and will help

manage the hosts' institutional costs especially for organisations with no Government funding;
    - increasing the incentives to encourage stronger and more commercially oriented research institutions to provide highly skilled researchers as "stagers" to lesser developed or developing research organizations;
    - supporting the creation of a pan-European database of researchers per sector (in our case for the railway sector). Such database would be useful for more efficient and widespread transport research mobility all around.
- Promote transport education and specialization within the university students and graduates;
- Promote networking of young transport professionals in order to strengthen "specialism" and also get them to know more about other specialists and be open to collaboration with them;
- "Educate" the transport employers on the need to facilitate and promote the further lifelong education and training of their employees.
- Finally, work towards establishing some harmonized and well specified transport degrees, starting with the "European Transport /Rail PhD.

NB: all these draft Roadmaps are still under development and in various stage of completion. They have been introduced into this deliverable 'as is" in their state of development when the D4.4 was due.