FOSTER RAIL

Future of Surface Transport Research Rail

Coordination and Support Action

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Deliverable D4.6

Annual Summary/ Prioritisation & Recommendation report of the sector's R&D needs & priorities

WP	4	Rail Business Scenarios
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

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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.

2. Description of the Deliverable

The aim of this deliverable is to provide the European Commission with the sector's R&D needs and priorities as input for - among others - the 2016/17 – and later – Work Program for the mobility related part of Horizon 2020 and its Calls for Proposals. Its content could also be useful for the S2R Annual Programs and Calls. It is based on the work of ERRAC and and the FOSTER-RAIL project and in particular the Roadmaps for Research and Innovation as developed by the EC funded CSA project ERRAC Roadmap, following extensive discussions between the members of ERRAC within the ERRAC Steering Committee. The content of this report is also based on the input from Deliverable D5.8 which made a comparison between the FOSTER-RAIL SRRIA and the Multi Annual Action Plan of S2R. For the ease of the reader, a distinction has been made between priorities for the mainline rail and the urban rail systems.

The planning of this FOSTER-RAIL Deliverable was not directly in phase with the cyclus of the Horizon 2020 Programme but the FOSTER-RAIL partners are sure that the content of this report will prove useful in drafting future H2020 Work Programmes and Calls as well as serving as useful input to the S2R work.

3. Annual Summary/ Prioritisation & Recommendation report of the sector's R&D needs & priorities

Introduction

ERRAC has produced this document to provide guidance and input into the European Commission's process for formulating the 2017 and future Transport Work Programmes and calls of the Horizon 2020 research and innovation programme. Besides that it could also prove to be useful input to the S2R process. It is based on the priorities set by the FOSTERRAIL Roadmaps project as well as on the comparison between the FOSTER-RAIL SRRIA and the S2R MAAP as described in Deliverable 5.8.

The document covers a wide range of topics, reflecting ERRAC's view of the key underlying research and innovation gaps that are in urgent need of attention for the transport sector. Were more budget available than is currently contemplated, it could be usefully deployed.

The prioritisation and recommendations are built up in three parts. The first part closely resembles the sector's previous annual summary document (FOSTER-RAIL Deliverable D4.3) as we feel that most of the recommentaions are still very relevant. The second part has been based on a number of priority areas from each of the 10 new Roadmaps for technology and Innovations as have been prepared by the project as D4.9. The third part is based upon the FOSTER-RAIL task of making a comparission between the FOSTER-RAIL developed SRRIA and the S2R Multi Annual Action Plan.

a. Resume of the previous ERRAC Annual Summary/ Prioritisation & Recommendation report of the sector's R&D needs & priorities

As rail sector research will be mostly undertaken within the Shift2Rail JU, the focus of this part a. is rather on pan-modal transport issues: infrastructure, energy and environment, and on socio-economic and other non-technical and cross-cutting areas of research and innovation that will have a bearing on the future of railways and are envisaged in H2020.

Deploying Innovative Technologies

Specific technologies might include (but not be limited to):

- Additive material and joining processes.
- 3D printing.
- Advanced composites – for mass reduction, LCC reduction, customer benefits.
- Virtual modelling, homologation and evaluation – harnessing the increasing power of the cyber world to solve complex, multidisciplinary, design problems for transport.
- Nano technology – e.g. new materials with properties such as self sensing and self healing.

- Advanced IT - including big data processing and analytics, machine learning, image and pattern recognition, passenger information systems and wearable technology.
- The industry internet - using the 'internet of things' including sensor networks.
- Drone technologies – e.g. to inspect and maintain transport systems.
- Mechatronic applications in the transport sector.

The call could also focus on providing a better understanding of the barriers to transport technology innovation and the development of new approaches to fostering its progress.

Intelligent Transport Systems

In particular, research should look to progress the following areas:

- Shared information platforms and robust IT tools that facilitate real-time data exchange between transport modes, by using existing communication platforms and social networks.
- Innovative operational methods and tools for better public transport services, increased public transport capacity and faster recovery after incidents.
- The development of demonstrators of robotic equipment to replace simple repetitive tasks currently undertaken by maintenance teams.
- The automation of repetitive and arduous tasks will require improved management of the human/machine interface, a key safety issue. In some areas, artificially intelligent machines can already make better decisions than humans. With the advent of the 'second machine age' humans may find themselves controlling software machines that control other machines (thus MMI will become MMMI). The consequential risk and problems need to be analysed and mitigations planned.
- For freight it is urgent to specify and support the development of affordable control, command and communication systems for routes with lower density traffic with tighter margins and lower investment thresholds.

Energy and Sustainability

Specific research needs are:

- 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.
- Inductive charging for electric vehicles, including EMUs / hybrid trains.
- Lightweight materials and bonding techniques to enable lighter vehicles.
- Energy storage, including future battery technologies, graphene supercapacitors, energy harvesting, including regenerative braking.
- Alternative propulsion energy sources, including hydrogen and natural gas; the operation of public transport and heavy vehicles using 60 - 80% energy from renewable sources.

- The reduction of negative environmental impacts from materials and processes; tools for measuring and improving overall sustainability.
- Next generation power semiconductor, with better efficiency, weight and volume and standards development for transport applications.

Climate change mitigation

Research and innovation priorities are:

- Understand, measure and identify the means to reduce further the transport industry carbon footprint.
- Integrated transport sector responses to specific weather events - building cross-modal resilience into transport planning and operations.
- Measures to improve the technical resilience of transport infrastructure and vehicles to the effects of climate change and harsh environments.
- Disaster scenario planning and the transport responses. Measuring and managing the uncertainties and risk in the transport system.

Health, Safety and Security

Research and innovation should target:

- Air pollution reduction through further focus on controls of transport emissions.
- Noise pollution reduction, particularly in urban areas and at night, through technical innovation. This should include better understanding of the generation, propagation and mitigations of aerodynamic noise and ground-borne vibration.
- New tools to identify and limit human risk within the security process – relating to planning, design, operation and maintenance.
- Automation of infrastructure maintenance to reduce the danger to transport workers.
- Alternatives to road/rail crossings and improvements in safety systems for those that remain.
- Strategies and objectives for the use of active and passive systems to provide constant vigilance against day-to-day crime affecting transport systems, terrorism and cyber-attack; systems that are capable of being used by both experienced and inexperienced staff.

Socio-economic and behavioural research

Specific research needs are:

- Demographic trends and differences and their consequences for transport system design - understanding the needs and preparing effective responses.
- Multi-sense vehicles – innovative solutions for people with mobility impairment (the blind, the deaf etc).

- Cross-modal transfer incentive structures – delivering an updated appreciation of key drivers for use in transport policy development and designing practical measures to progress modal transfer policy delivery. This should include how to improve cost transparency in transport.
- A Europe-wide education platform for all levels (young professionals, experts, senior and top management) offering tailor-made programs that cover the needs of the modern and emerging sector to improve efficiency and reduce cost.
- Assessment of the skills requirements for the future transport sector. Analysis of gaps and recommendations for remedial action plans.
- Further analysis into customer needs and behaviours and the development of accessibility assessment tools.

Competitiveness of the European transport industry in global markets

Research should focus on:

- A co-ordinated framework of good practice to reduce the cost of implementing new products and ensure their successful implementation, taking account of cultural impacts. Product/concept deployment strategies that anticipate and take account of system and human impacts, so include explanations of how best to implement the innovations working with the available people, existing knowledge and the developing culture.
- Interoperable basic components for freight vehicles - the same shape (e.g. to fit in the same place on locomotives), the same functionality (giving the same service) and the same interface (to be able to be connected directly). This is a common requirement in aviation and it should be studied to be applied in rail, enhancing competition and cost reduction.

Resource Utilisation across the transport sector

Target areas are:

- Modular "plug-and-play" infrastructure design. Using the most advanced industrial knowledge and methods to obtain similar improvements for transport infrastructure. Standardised and modular architecture will also facilitate interoperable infrastructure and operation. It should promote lean design, Improved reliability, automated maintenance and reduced LCC.
- Innovation in standardisation for infrastructure components. Designs that reduce problems with future-proofing. Use of recycled materials and innovative cross-modal techniques for infrastructure construction.
- Intermodal collaboration to provide seamless transport chains (one-stop-shop) including sustainable urban logistics solutions. This requires standardisation of information for transport planning and movement within the overall logistic chain.
- Methods to produce a competitive rolling motorway: cargo bundling, freight villages etc.

- Strengthening transhipment points as key nodes for combined transport, and increasing the efficiency of container handling within and between modes.
- Maximising infrastructure utilisation through new approaches to speed management (including operating speed compatibility for rail and other controlled systems).
- Land-use and spatial planning for sustainable and efficiency of public transport.
- Innovative concepts for decision support relating to infrastructure maintenance and renewal, taking advantage of condition data and other data across transport modes.

Urban Mobility

Key research areas are:

- The integration of transport modes for cities – including connection of all core airports to the rail network.
- Urban green logistics - 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. Smart integration of rail transport nodes into urban conglomerations - hinterland dry ports.
- Transport hubs as urban ‘’consignment stock” (sector logistics) by using existing infrastructure (stations or stations facilities in central locations) as goods distribution centres. Linked with the integration of combined transport solutions and the use of light rail for freight.
- First and last mile challenges - how to penetrate cities by combining rail trunking with urban collection/distribution of goods by electric trucks.
- Urban and suburban public transport capacity optimisation and options for managing increases in demand (what to do when public transport systems are saturated).

b. Priority areas from the 10 FOSTER-RAIL Technology & Innovation Roadmaps. These priorities are wider than only those relevant to the H2020 Transport Programme (the complete overview of all priorities and their timelines cam be found in Deliverable D4.9)

Customer Experience

- Management of degraded mode and minimising disruptions to passengers
- Addressing PRM needs – mobility for all

Strategy and Economics

- Governance models enabling the integration of traffic and travel information
- Design and operation of new generation resilient urban transport interchanges for greater integration of urban mobility networks

Energy and Environment

- Renewable energy production
- Deployment of more efficient fleets (10-20%)

Safety

- Best practice screening for discovering potential innovative safety procedures and methods
- Develop methods to reduce unjustified barriers to innovation by using tools for big data and data analytics

Security

- Perceived security – incl. the interaction and/or collaboration with social media
- Response time and capability regarding limitation of the consequences of an attack

Control, Command and communication

- New radio-based control systems that allow for less signal failures
- Cost-effective standard design, test, installation and maintenance of signalling infrastructure and on-board equipment: New generation of CBTC (2.0) for automated urban lines (GoA 3 or 4). Research allowing for interchangeability development of sub-systems and components

Infrastructure

- Decision support tools for sustainable design and energy efficiency
- Optimise structure repair and life extension techniques

Rolling stock

- EE Auxiliaries- Optimisation and development of intelligent management auxiliaries
- Competitiveness and enabling technologies - Tram-train

IT & other enabling technologies

- Privacy and security aspects
- Enhance multimodal traveller experience

Training and Education

- skills development and changing trends in staff requirements
- Bridging the gaps between knowledge production in Higher Education institutions and required know-how in the different industrial environments

c. Priority areas and recommendations based upon a comparison between the FOSTER-RAIL SRRIA and the S2R Multi Annual Action Plan

The FOSTER-RAIL project has compared the newly developed ERRAC Strategic Rail research and Innovation Agenda – SRRIA – and the S2R Multi Annual Action Plan – MAAP - and has reported on the findings in Deliverable 5.8. As there is no specific funding for rail research contained in the H2020 Transport Programme, the rail sector depends on the content of the S2R MAAP for the implementation of its specific rail related – modal – research priorities. Below the reader will find a summary of the areas which the SRRIA has confirmed as being important for the innovation of the rail system and which have not been included in the S2R Action Plans. Some of these identified areas might be considered in the near future with S2R and follow-up program and/or within the present H2020 Transport programme and calls or within the research programming from 2020.

Following the S2R structure, the following topics have been identified as **not** covered by S2R and that should be supported by H2020 and the follow-up research programming:

- Rolling Stock:
  The S2R IP1 is rather comprehensive as it covers all major sub-systems of a (mainline) train. Therefore, some topics have been identified as challenging for the long-term future of the Rail business and not covered by the S2R activities.
  - Hybrid Traction Energy: Light rail in some cities is already operating with on-board Energy Storage System (ESS) to avoid visual pollution of overhead power supply. The development of enabling technology of ESS must be followed very closely by the Rail Sector for main lines applications, keeping in mind that "one size won't fit all needs"
  - Innovative Propulsion Traction, e.g. based on hydrogen energy, that will require constant investment over a long period to make it a reliable and cost-effective operational traction system.
  - More efficient and smarter auxiliary equipment, e.g. HVAC: the sector must follow closely development made in other sectors to adapt them to the rail environment.
  - Enabling Technology: the future generation of power electronics materials i.e. diamond
  - The specific needs of the urban rail sector in terms of rolling stock – metro, trams, tram-trains – should benefit from dedicated R&I actions as they are not fully covered by S2R: HVAC improvements; IT platform(s) for Tram and Light Rail; new generations of Rolling Stock for urban rail segments; improved rolling stock maintenance technologies and procedures, etc.
- Control Command and Communication:
  The S2R IP2 agenda is quite comprehensive combining pragmatic TDs that will deliver solutions by the end of the Program and other that are more exploratory. No R&D topic has been identified to be supported by H2020 outside S2R activities for mainline rail. In the case of urban rail, there is a strong need for R&I activities on CBTC systems, such as the standardization of interfaces (on-board and wayside) or performance improvements. Another topic which ought to receive H2020 support is the bandwidth allocation for urban rail (e.g. the SUG initiative of both urban rail and industrial partners).
- Infrastructure:
  The S2R IP3 is covering all major sub-systems of the mainline rail infrastructure with, for some of them, a medium-term perspective fitting within the S2R life span but also a longer term perspective e.g. Switching & Crosses and Tracks. Except the security issue of the rail infrastructure which is mainly an unattended asset, most of the topics are covered by S2R. However, some elements would benefit from being supported by H2020:
    - Smart removal strategies for outdated polluting existing infrastructure being historical legacy
    - Smart strategies to reduce pollution from infrastructure sources
    - The specific topics of urban rail should also benefit from targeted R&I opportunities within future H2020 calls; urban intermodal stations of the future; connecting airports with urban rail systems in order to improve urban public transport use and services for air passengers; research on

technical and economic factors for prioritizing investments in urban rail – how to choose between tram & light rail/metro and suburban/regional connections (and extensions); how to better connect major EU cities through regional and suburban railways to the TEN-T networks; measures to reduce the LCC of infrastructure and facilitate its maintenance by taking into account the specific requirements of each market segment, etc.

- IT Solutions:
  It is the first time that within an EU Program, this topic is comprehensively tackled. The S2R activities that gathered rail expertise and more important expertise outside the sector, will deliver step change solutions. As some partners investing in that domain are coming from outside the rail sector, they are following, and for some of them, investing new development. They are in a position to bring in new technologies and approaches.
- Freight:
  It is also the first time in the history of EU Programs that this domain is covered comprehensively with a longer term support than previous EU projects that were a patchy contribution to that issue.
  S2R is only addressing the main line freight issue and is not covering the urban freight issue.
- CCA:
  Most Work Areas of the CCA activities are covered by S2R. However, for the Rail Sector there is a clear need to anticipate the future evolution of the society as well as the future emergence of new services that could negatively impact the sector business (not being a follower). H2020 should support R&D in economics, new paradigms that could impact business models.
  Human capital that is vital for a sector has also to be supported by H2020. The first element that would be critical to ensure successful implementation of research and innovation results in the transport sector is a proper way of training people e.g. through improved and smart learning methods.
  Last but not least, as most of the urban and mainline rail operators, infrastructure managers and other relevant stakeholders and authorities have not been involved from the beginning in the S2R programming, it is clear that some topcs will need further research and work. Consquently, it is necessary that H2020 offers other opportunities for the rail stakeholders to work on these general topics.

4. Conclusions

This Deliverable has been produced to provide guidance and input into the European Commission's process for formulating the 2017 and later Transport calls of the Horizon 2020 research and innovation programme. As rail sector research will be mostly undertaken within the Shift2Rail JU, the focus of this document is in the first place concentrating on pan-modal transport issues: infrastructure, energy and environment, and on socio-economic and other non-technical and cross-cutting areas of research and innovation that will have a bearing on the future of railways and are envisaged in H2020.

Nine headline themes have been identified based on the work of ERRAC, the EC funded ERRAC Roadmap CSA project as well as partly on the work carried out by the EC funded FOSTER-RAIL CSA project of which this report is a Deliverable. These themes are:

- Deploying Innovative Technologies
- Intelligent Transport Systems
- Energy and Sustainability
- Climate change mitigation
- Health, Safety and Security
- Socio-economic and behavioural research
- Competitiveness of the European transport industry in global markets
- Resource Utilisation across the transport sector
- Urban Mobility

However, as the FOSTER-RAIL SRRIA and resulting 10 Roadmaps for Technology and Innovation have a wider scope than only the co-modal and multi-modal aspects of the European transport system, also a short summary is given of some high prioritiy areas which have been identied in each of the Roadmaps. Beides this – and this would possibly have a more future oriented relavance – a number of rail sector priorty areas have been identified which have not been included and cannot be covered by the present S2R JU activities.

It is the hope of the European railway stakeholders that this overview of the priorities and & recommendations of the sector's R&D needs & priorities will prove to be very useful for the European Commission in designing its future Research Programmes.