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SPIDER PLUS project

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Abstract

SPIDER PLUS was a research and development project co-funded by the European Union in the scope of the Seventh Framework Programme (12/2012–5/2015). The project aimed at developing a passenger and freight mobility vision for 2050 encompassing seamless transportation where electrified rail has a central role. Within the "White Paper on Transport" the European Com¬mission published two keywords that are essential for the prospective transport policy: sustainable mobility. That means a massive shift of traffic from road to rail. In the long-term, a rail market share of about 50% is the set goal for both long distance rail passenger service and freight transport over 300 km. 12 European companies and institutions provided cross-modal expertise, coordinated by HaCon Ingenieurgesellschaft mbH. Leading industrial players like Siemens or EADS participated as well as market newcomers such as NTV, European universities and research companies.

During the project, the interdisciplinary team was supported by a network of expertise. The results are oriented on four guiding principles that will put electrified rail at the centre of sustainable mobility:

- Industrialisation of production
- Offer-driven business models
- Seamless and convenient services
- Co-modality and sustainability

Based on the as-is situation and internal/external drivers of change the vision components have been elaborated. Main technological tools and solutions have been identified and assessed in terms of impact and costs.

The SPIDER PLUS Roadmap as final result of the project paves the way to the desired future. It describes the required infrastructure development as well as business models and funding schemes. The integration of national systems into European grid and the co-modality implementation in user friendly mobility environment outline the future network and access points for

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rail passenger and rail freight services. Within the Road Map, special emphasis is given to the intermediate step in 2030 to indicate the minimum target which is needed to reach a European society overwhelmingly served by electrified rail in 2050.
All SPIDER PLUS recommendations are summarised in the interactive Solutions Guide Book which contains the 5 action fields:

- Rolling Stock
- Technology
- Investments
- Governance
- Market Uptake

The Guide Book itself focused on the content and the involved actors. The Decision Support Tool as an additional part has been implemented as a dynamic and interactive Road Map considering temporal aspects, too. Essential actions and steps have been joined in a common project management software environment. Finally, this tool provides information about required steps, temporal sequence and dependencies between various actions.
Decision makers in politics, industry and business are the main target group for the use of the decision support tool. It allows the creation of scenarios that show even far reaching effects of possible delays. Moreover, it illustrates which processes can be done in parallel and which processes have to be done in sequence. The indicated time slots of the various steps to be done are the framework for the fulfilment of the SPIDER PLUS vision until 2050.
The key message of SPIDER PLUS is that the vision of a European society overwhelmingly served by electrified rail until 2050 is achievable if all stakeholders act targeted, jointly and now.

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Keywords: shift to rail; sustainability; industrialisation; europe; spider plus

1. Introduction

SPIDER PLUS was a research and development project co-funded by the European Union in the scope of the Seventh Framework Programme (December 2012 – May 2015). The project aimed at developing a passenger and freight mobility vision for 2050 encompassing seamless transportation where electrified rail has a central role.

Nomenclature

SPIDER PLUS: **S**ustainable **P**lan for **I**ntegrated **D**evelopment through the **E**uropean **R**ail network – **P**rojecting **L**ogistics & mobility for **U**rban **S**patial design evolution

2. Objectives

SPIDER PLUS had two superior objectives, both of immense extent. These objectives are at the same time the main results of the project.

- Elaboration of a rail-based mobility vision:
  Under consideration of possible developments and experiences of the past, the SPIDER PLUS consortium has created an innovative, yet realistic mobility vision for 2050. Thereby, the focus was on the maxim “a society overwhelmingly served by electrified rail”.
- Development of a feasible plan for the implementation of the created vision:
  After having painted a picture of the desired future, the question was how to get there. Critical steps and mandatory achievements are therefore explained in the SPIDER PLUS Road Map. The Guide Book together with the dynamic Road Map has a more instructing character and lists up for every required measure what has to be done, when (in which sequence) and by whom.

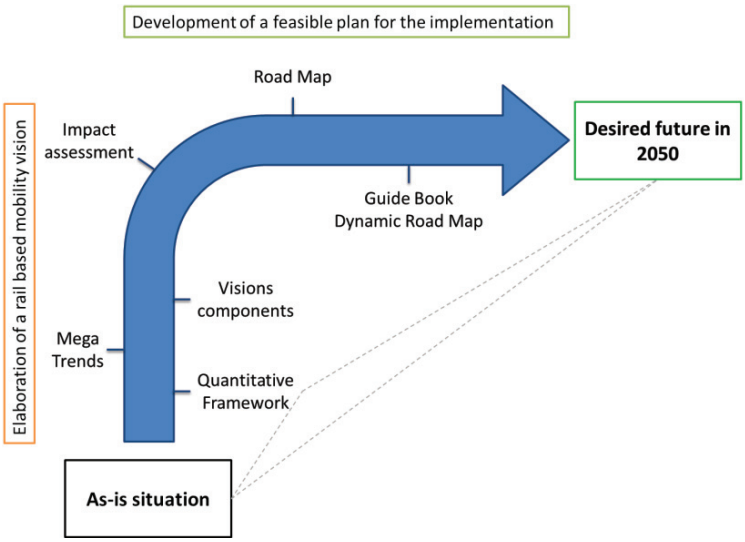

Fig. 1. Objectives and process.

A gap analysis compared and contrasted the estimated future with the desired future. The estimated future is grounded on a 'business as usual' scenario based on existing forecasts as well as expected/planned measures in the European transport area and has two dimensions: qualitative aspects concerning drivers like urbanisation and sustainable lifestyles which shape the future; and quantitative forecasts up to 2030. The estimated future differed significantly from the desired future which was developed in the SPIDER PLUS project based on the EU White Paper targets. The identified gaps were addressed in the design and development of the vision components and formed the backbone of the Road Map to sustainable mobility in 2050.

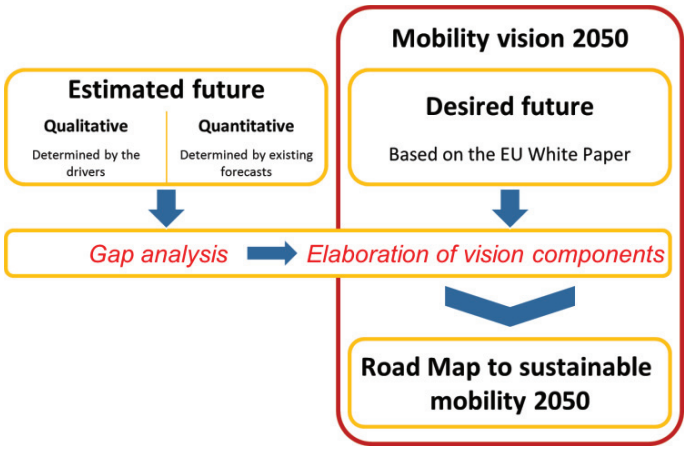

Fig. 2. Approach.

Special emphasis was given to the quantitative framework (Figure 3). Based on the situation in 2010, several forecasts for 2030 were analysed. Under consideration of the decreasing growth rates of demand for freight and passenger services expected for the period between 2030 and 2050, a quantitative scenario for the European transport demand for 2050 was created based on expertise knowledge. In view of the ambitious SPIDER PLUS quantitative scenario for a sustainable mobility in 2050, it became clear that the current rail transport volume would

have to increase substantially. In particular, rail passenger services (excluding tram and metro) would have to increase 2.8 fold by 2050, while rail freight services would have to increase 4.0 fold by 2050; based on figures from 2010.

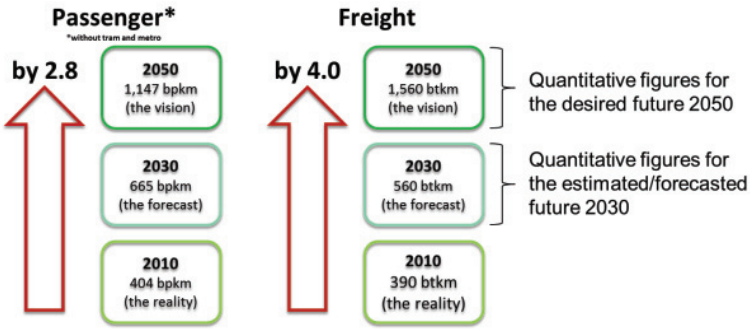

Fig. 3. Quantitative framework.

This massive increase of rail transport volume may be hard to imagine from today's perspective. Nevertheless, the SPIDER PLUS consortium worked out targeted measures that pave the way to an European railway system; on the one hand capable to handle the envisaged shift to rail and on the other hand efficient as well as attractive in competition to road to cause this shift. The vision 2050 and the required measures have been developed and verified with the aid of the networks of expertise and vision that were integral part of SPIDER PLUS. All results of the project are based on four guiding principles that have been identified as mandatory for the European railway system to fulfil the desired mobility vision:

- Industrialisation of production
- Offer-driven business models
- Seamless and convenient services
- Co-modality and sustainability

Derived from the work package structure the project has worked on five action fields concerning the central role of rail and finally delivered all recommendations that are necessary to realise the 2050 mobility vision in the Guide Book and the dynamic Road Map. These action fields account for the biggest part of the rail sector determining (future) mobility:

- Infrastructure
- Rolling stock
- Technology
- Governance
- Market uptake

The action fields and their most important aspects are explained in the following.

3. Action fields

3.1. Infrastructure

Sustainable growth and environmental friendly mobility is particularly challenging when viewed against the 2050 vision given the magnitude of the required increases in traffic volume for both passengers and freight. Therefore, the action field 'infrastructure' is the most critical and determining consideration. It includes:

- EU network development
- Interoperability & modular design
- Predictive maintenance
- Safety & security
- Environment & sustainability
- Stations and nodes

Upgrading of the EU rail network is crucial. The mid-term focus is on the TEN-T core network, including the elimination of bottlenecks as a structural work for expanding capacity, and on the addition of new conventional and high speed lines, which will close existing infrastructure gaps. This way of proceeding is cost-effective, extracting the best benefits from investments.

Comprehensive interoperability must be ensured to enable high quality rail freight transportation in Europe and an effective modal shift. The interoperability goal is key for promoting investments and precluding individual countries' initiatives which may run contrary to the fulfilment of a single European rail area. By 2030, the TEN-T corridors must be completed. The co-modal nodes located in the traffic attraction zones for improving accessibility and last mile distribution must be in operation. The existing rail infrastructure will have the installations to accommodate 750 m long trains everywhere in Europe. On the busiest corridors sustaining traffic industrialisation, the infrastructure will be capable of managing 1,500 m long trains (with potential for combining trains and path sharing).

In the period between 2030 and 2050, one focus is on the comprehensive network, which, in addition to the TEN-T corridors, provides the transport capillaries into suburban and rural areas. Urban/regional lines play an important role as connectors and feeders for long distance services. The second focus is on a significant increase of the network capacity, by innovative rail operating schemes, as well as new lines/by-passes for rail freight services. This will reduce conflicting paths with passenger traffic in the most intense urban areas where passengers have priority.

All developments, constructions and upgradings must take into consideration both operational optimisation and cost reduction as well noise protection which is a key factor in gaining public acceptance.

Existing plans for upgrading the long distance high speed rail (HSR) passenger lines must be accomplished to support seamless passenger transport on a European scale while at the same time, conventional long distance services are necessary to cover more rural areas. Although the attitude towards HSR has changed in recent years, the HSR network is also a measure to unmix passenger and freight traffic. New lines free up capacities on conventional lines and thus support rail freight transport. In European cities, the integration process in the central hubs can take different paths. Station upgrading enables full functionality of all modes.

The stations have to be designed in a co-modality framework and serve as central mobility hubs, offering a variety of services, including direct interchanges with airports. Newly constructed stations extend over multiple levels integrating all mobility services with suitable accessibility. Metro and rail lines such as high speed, commuter and conventional are integrated underground to avoid conflicts with surface transportation at street level. At street level, tram and bus services interchange with mobility segments such as taxis, automated shuttle transportation and bike sharing. Limited space is needed for drop-off and pick-up locations for private vehicles. It is important to allow easy walking access to the hubs for people of all ages.

The freight nodes must be located in the middle of the European traffic attraction zones, providing proper interchanges between corridors. They have to fulfil the task of traffic bundling for achieving rail freight industrialisation and be capable of offering a variety of ancillary services to the users, promoting an effective co--modality. Advanced technologies will have been deployed to manage the planned traffic volumes. Hubs and terminals are open 24/7 to be compatible with the seaports' production cycles and the overland interchange borders of the Union.

The European ERTMS Deployment Plan foresees installation of the ERTMS equipment to more than 25,000 km of railway lines by 2020. A number of key European freight lines have also been identified for ERTMS deployment. For both, freight and passenger services the implementation of moving block operation (ETCS Level 3) where a substantial capacity increase of up to 40% versus conventional system can be expected is a long-term target.

Especially in combination with new rolling stock technologies predictive maintenance contributes to an efficient management of the infrastructure.

3.2. Rolling stock

For the transition to a future oriented rolling stock park there are three key elements of crucial importance:

- Hybrid locomotives & train sets
- Automatic coupling, electric wire & new braking technologies
- New light weight wagon design

Locomotives with energy recuperation are state of the art. Optimised hybrid locomotives and train sets enable the provision of seamless services between electrified and non-electrified parts of the network both for freight and regional passenger services. The support of efficient last mile services will improve the competitiveness of rail freight services, especially in the intermodal industry as well as for private sidings.

Automatic coupling together with continuous electric wire, facilitate efficient shunting operations and new production schemes. Electronically controlled braking and automated brake tests are innovations which are creating step changes especially in rail freight services. Instant electronic braking reduces derailment risks and improves the general safety and security of the train operation. This is especially important for longer, heavier, commercially faster trains which will be an important pillar of future rail freight services.

Another step change will be done in wagon design with advanced lighter materials and alloys such as carbon fibres to reduce dead weight for higher payload. Modular design for freight wagons becomes standardised.

The pace of innovation must be fast providing suitable services for increased traffic volumes. The process of speeding up the replacement of the existing park is paramount and needs therefore to be strongly supported by public funds (national and/or EU).

Even if rolling stock characteristics are different for passenger and freight wagons, lighter materials, modular design, preventive maintenance and embedded ICT are common features.

3.3. Technology

The evolution of the rail service sector by introduction of new technologies is mandatory to be more efficient and competitive in short- to mid-term horizon. Here, three major key-elements are identified:

- Rolling stock design and materials
- Automation in movements/transfer
- Comprehensive ICT-based management

For passenger services, new design train sets are modular, energy efficient and eco-friendly by reduced tare weight. Maintenance on demand is important for cost efficiency by optimised use of the fleet in service. Demand criteria like comfort and well-being as well as extended on-board services and reduced noise, are important elements of the improved service profile.

Design and materials for the next generation of freight wagons as well as the refitting of existing fleet is guided by a reduction of noise emissions and abrasion of the tracks. For freight the automation of all loading/unloading and controlling processes are of main importance for the reduction of increasing labour costs and acceleration of train dispatching.

In the context of the overwhelming increase required of rail based intermodal services, the automation of handling of Combined Transport (CT) units in hubs and terminals is a sine qua non. Supported by the equipment of all intermodal wagons with continuous electric wire the comprehensive introduction of robotics/mechatronics in transfer, pin setting and controlling will contribute to the efficiency and capability of rail based intermodal services in competition in cost and quality to road. These functionalities performed in the nodes define the terminal profile of the future. Efficient IT-based interactions with shippers /receivers, forwarders and road feeder services are another

key efficiency driver. Future transhipment terminals concentrate on efficient transfer of CT units between trains to facilitate the integration of feeder terminals/urban logistic centres in the European intermodal network. Automated composition/shunting of train sets supports the efficiency in yards where the assembling/disassembling can be arranged for competitive operation on the long distance part of the rail transport chain.

Comprehensive ICT based management, as well as advanced e-solutions support all operations and the seamless integration of rail in overall logistic distribution and supply chains. Applications for rail are developed to control traffic volumes, increase safety of operations and improve asset utilisation. Satellite solutions such as Galileo support future advanced pan-European real time data collection and information.

3.4. Governance

Holistic governance including all actors in their respective responsibility is crucial for the proper development of the rail sector:

- Network governance
- Transport industrialisation
- Legal framework

Governance ensures investment effectiveness, coordinates planning, and facilitates technological development and successful market uptake. Targeted regulation and planning ensure an European wide coordinated approach, an integrated mobility system, and the harmonising of existing and future guidelines e.g. for TEN-T realisation, European rail port network, capacity of hubs compatible with corridors' capacity, and the desired single EU rail space.

The role of European agencies is evolving; the governance is shifting from national to European authorities. An adequate balance in mutual relationships for a new European model for co-modal transport authorities is required.

Rail transport services need a performance upgrade through industrialisation models enabling economies of scale and have to be supported by respective governance measures. Efficiency is reached by working on all system components like trains, tracks, terminals, rolling stock & unit loads equipment, ICT and energy in a co-modal integrated perspective. The outlined elements for passengers are optimised connectivity, different types of services, coupling/sharing of train modules, and high frequency services with integrated timetables. For freight services longer, commercially faster & heavier trains and the comprehensive transition to 24/7 working cycles by all in the transport chain involved stakeholders are of high importance.

TSI (Technical Specifications for Interoperability) and IRS (International Rail Standards) are features set to harmonise technical components and operating processes. Legal framework and policy measures are fundamental to support harmonised and integrated business models enabling true EU wide market opening and efficient competition, as well as EU focused for rail system construction, renewal, upgrading and operation. Funding schemes to support the stakeholders for the required migration of the existent rail area to the desired vision for 2050 are fundamental. Simplified European approval procedures and appropriate R&D programs are main supporters of the change.

3.5. Market uptake

Beside the technological evolution, soft elements fostering an appropriate market uptake are the precondition for the required evolution of the European rail system towards the vision 2050. Two aspects are especially important:

- Collaboration and offer-driven business models
- Permanent education and training

The move from the recent national monopolies to an international collaborative culture is key for reliable market uptake of new business solutions. Pioneer experiences exist in many areas: OSS (One stop shop) – single point of contact & multichannel distribution approach, logistic engineering, new offerings & collaborative

logistics/warehouses, single ticketing for the whole journey. Their development requires new processes, appropriate ICT technology and upgraded/new business models, to be incorporated in a regulatory framework.

The renaissance of the rail industry relies on the abilities of the involved staff. The natural turnover of 'old' with 'new' staff facilitates the introduction of new and qualified employees in general. Measures like permanent training and education for technical/technological and commercial skills remain the only way to guarantee a high level of competences. The educational aspects are as important as the technical ones.

In the end, 60 measures have been implemented in the Guide Book and the dynamic Roadmap. The Guide Book which was realised as innovative touchscreen online tool (www.spiderplus-project.eu) summarises all recommended actions, each in about one page. Stakeholders and decision makers can inform themselves very quickly about all relevant factors.

In addition, the measures have been integrated into a dynamic Roadmap which is intended to give an overview of the chronological and logical structure of the SPIDER PLUS recommendations.

4. Milestones

SPIDER PLUS developed and assessed a suitable approach how the ambitious vision of a European society overwhelmingly served by electrified rail can come true. Although additional research, refinement and constant updating are required, the main message is clear: A more sustainable, rail based mobility is achievable, but all stakeholders have to act targeted, coordinated and required actions have to start immediately.

In the light of the ambitious target in 2050, a clear progress has to be achieved already until 2030; otherwise the remaining 20 years until 2050 will be too short to make the vision come true. Therefore SPIDER PLUS has given a special emphasis to the intermediate "Must have 2030" step. Under consideration of the inert rail system and the very strong market position of road transport (in passenger as well as in freight services), a doubling of the rail freight volume and an increase in passenger transport by the 1.6 fold (both compared to 2010) until 2030 is the least, otherwise the final targets cannot be realistically achieved in 2050. This precondition mirrored against the estimated future problem is visualised in the figure below:

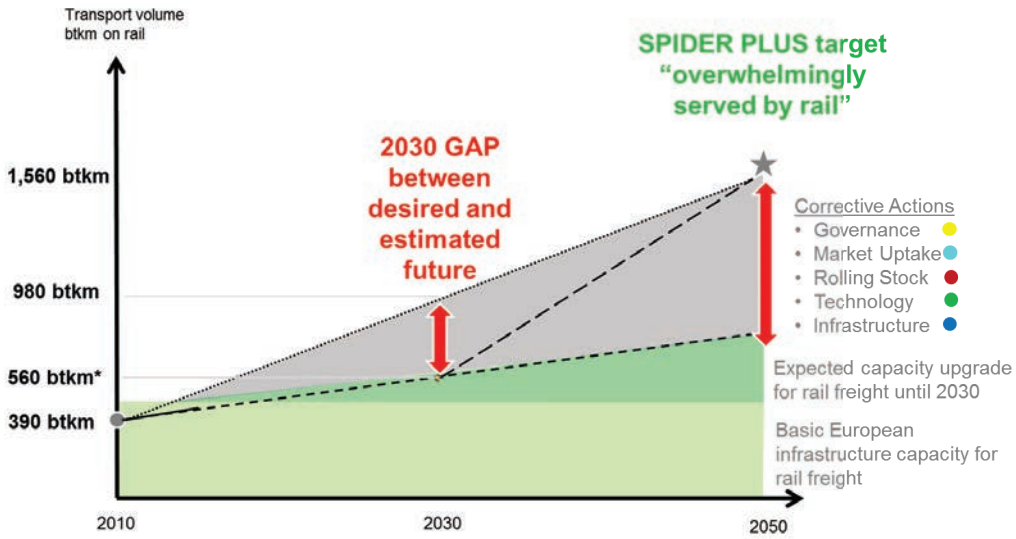

Fig. 4. Intermediate "Must have 2030" step.

In order to develop a resilient Road Map, the project partners have defined crucial issues that have to be addressed so that the minimum targets for 2030 can be achieved. The most important measures are the following milestones that have to be implemented until 2030:

- Infrastructure upgrade for 1,500 m trains (on Core Network Corridors (CNC) in central Europe with significant importance for freight)
- Improved bi-trilateral coordination of HSR upgrading incl. HSR access at airports
- Comprehensive communication and cooperation of all actors for train path management and rail
- Clear progress in the implementation of ETCS Level 3, especially on the CNC
- Clear progress in the implementation of automatic centre buffer couplers (ACBC) and electric wire (enabling new braking technologies)
- "Smart ticketing" and harmonised travel assistance (including seamless ticketing for international connections and last mile services)
- Pushing and fostering of an increased implementation of offer-driven business models for freight services
- Industrialisation based on approved business models for freight services
- Coordination/Management of all infrastructure and services/operations related to capacity, quality and standardisation along the CNC

One of the main problems of the current European railway system is the uncoordinated and inefficient implementation of important developments in the system due to the absence of a proper European wide migration scenario supported by funding and investment programmes. For this reason SPIDER PLUS has set up five steps that are vital for the successful implementation of most of the new technologies and innovations. In various cases, this approach also applies to the introduction of new business models. The sequence of steps (which also was basis for the elaboration of the dynamic Roadmap) is shown in the following:

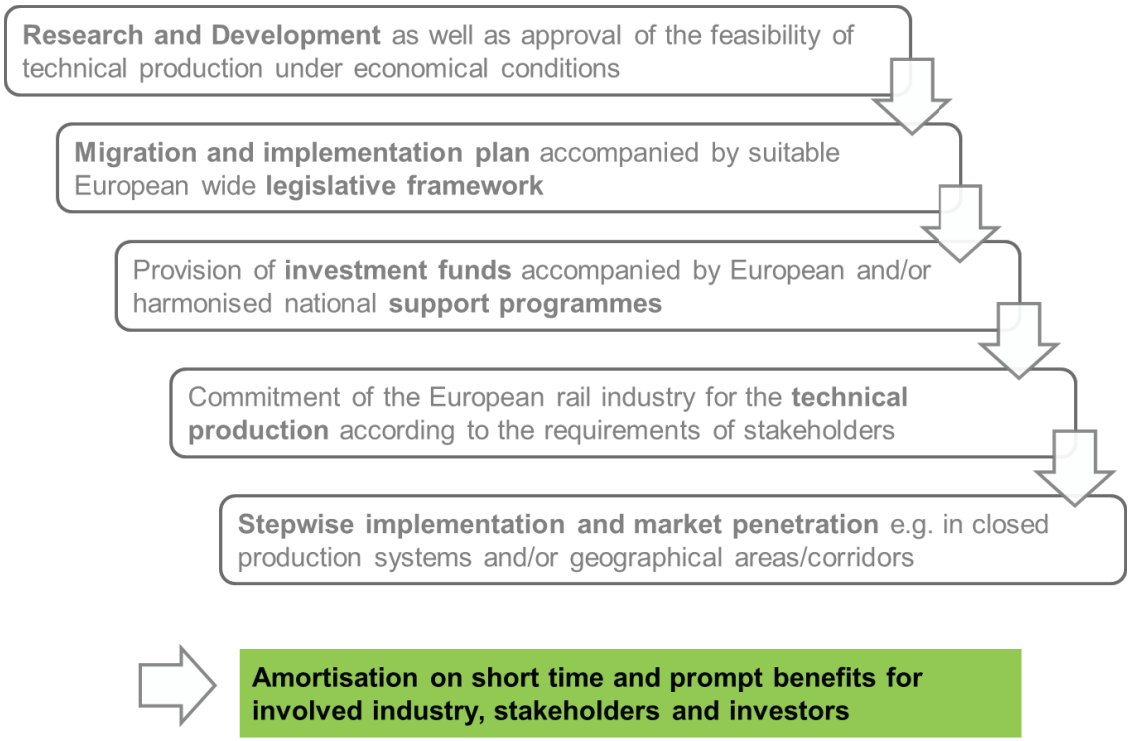

Fig. 5. Required steps for the successful implementation of new technologies/innovations.

5. Results

The consortium partners have delivered/performed the following project work:

- Detailed analysis of the “As-is situation” of transport in Europe, especially concerning railway services
- Identification and evaluation of the “Mega Trends” that will affect the European society and its mobility
- Development of the quantitative framework 2050 that is implicated by “a European society overwhelmingly served by electrified rail” considering the potentials of freight and passenger production systems
- Creation of a detailed mobility vision for Europe in 2050 following the “White Paper on Transport” targets
- Identification of suitable solutions for the fulfilment of the vision and respective evaluation in terms of impact (incl. cost-benefit analysis)
- Development of a detailed Road Map for rail towards 2050
- Creation of an innovative Solutions Guide Book and a dynamic Road Map, available on the project website.