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CAPACITY4RAIL : toward a resilient, innovative and high capacity European railway system for 2030/2050

Laurent Schmitt[a], Fabien Létourneaux[b], Isabelle De Keyzer[a], Paul Crompton[c]

[a] *UIC, Paris, France*
[b] *SYSTRA, Paris, France*
[c] *ARTTIC, Paris, France*

Abstract

CAPACITY4RAIL is an EU co-funded research project that started end 2013. Under the coordination of UIC, it brings together railway operators, infrastructure managers, manufacturers, world leading research organisations, and specialist technology providers. It will deliver research that is innovative, prepares rail for the future and takes into account results from previous research projects and programmes. The project builds on previous useable results and will deliver both technical demonstrations and system wide guidelines and recommendations that will be the basis for future research and investment, increasing the capacities of rail networks in the future. The project aims at developing new concepts for low maintenance and resilient infrastructure as well as optimizing operation and intermodal integration within the global transport system.

Keywords: railway operation ; railway infrastructure ; capacity ; freight system.

Résumé

Le projet de recherche à financement européen CAPACITY4RAIL a débuté fin 2013. Sous la coordination de l'UIC, il rassemble un consortium d'opérateurs ferroviaires, gestionnaires d'infrastructure, industriels et organisations de recherche de renommée mondiale. Par un programme de recherche innovant, il entend préparer le rail pour les années futures, tout en s'appuyant sur les résultats des programmes recherches passés. Il délivrera des démonstrateurs technologiques et un ensemble de recommandations et guides pour le système ferroviaire qui constitueront le socle de futures recherches et investissements, permettant l'augmentation de capacité des réseaux de demain. Le projet vise à développer des concepts nouveaux pour une infrastructure résistante et à faibles besoins de maintenance, un système d'exploitation optimisé ainsi qu'une intégration intermodale du système de transport.

Mots-clé: exploitation ferroviaire ; infrastructure ; capacité ; système fret.

Nomenclature

ICT : Information and Communication Technologies
KPI : Key Performance Indicators
LCC : Life Cycle Costs
RAMS : Reliability, Availability, Maintainability, Safety
S&Cs : Switches and Crossings
SP : Sub-project
TRL : Technology Readiness Level

1. Introduction

In 2011, the White Paper on European Transport reasserted how fundamental transport was for society, for the mobility of European citizens and for the growth and vitality of the European economy. CAPACITY4RAIL is an EU co-funded research project that started end 2013. Under the coordination of UIC, it brings together a wide range of stakeholders in an ambitious partnership that sees railway operators, infrastructure managers, manufacturers, world leading research organisations, and specialist technology providers. It will deliver research that is innovative, prepares rail for the future and takes into account results from previous research projects and programmes. The project builds on previous useable results and will deliver both technical demonstrations and system wide guidelines and recommendations that will be the basis for future research and investment, increasing the capacities of rail networks in the future.
The time used for infrastructure monitoring, maintenance and renewal means 'down time'. New concepts for low maintenance infrastructure, using standardized and "plug-and-play" concepts will be proposed. Non-intrusive innovative monitoring techniques or self-monitoring infrastructure will be investigated, allowing low or no impact on train operations.
The fragility of some key component of the infrastructure system (especially in extreme weather conditions) such as switches may impact the efficiency of the whole system. The resilience of switches to any kind of known failure will be reinforced, as well as the ability of the operation system to recover from incidents. Capacity enhancements will also be achieved by higher speed freight vehicles, allowing an optimized interleaving of freight trains into mixed traffic, and improved planning models for operation. Intermodal integration within the global transport system will be improved through enhanced transshipment of passengers and freight.
CAPACITY4RAIL will also look towards 2030/2050, by proposing guidelines for future deployments in the mid-term, recommendations for technologies to de developed and deployed in the long term and investigating the key opportunities for funding these within national and EU funding schemes.

In order to best address this approach the project has been broken down into six sub-projects. These are:

- SP1 Infrastructure
- SP2 New Concepts for Efficient Freight systems
- SP3 Operations for enhanced capacity
- SP4 Advanced monitoring
- SP5 System assessment and migration to 2030/2050
- SP6 Management, dissemination, training & exploitation

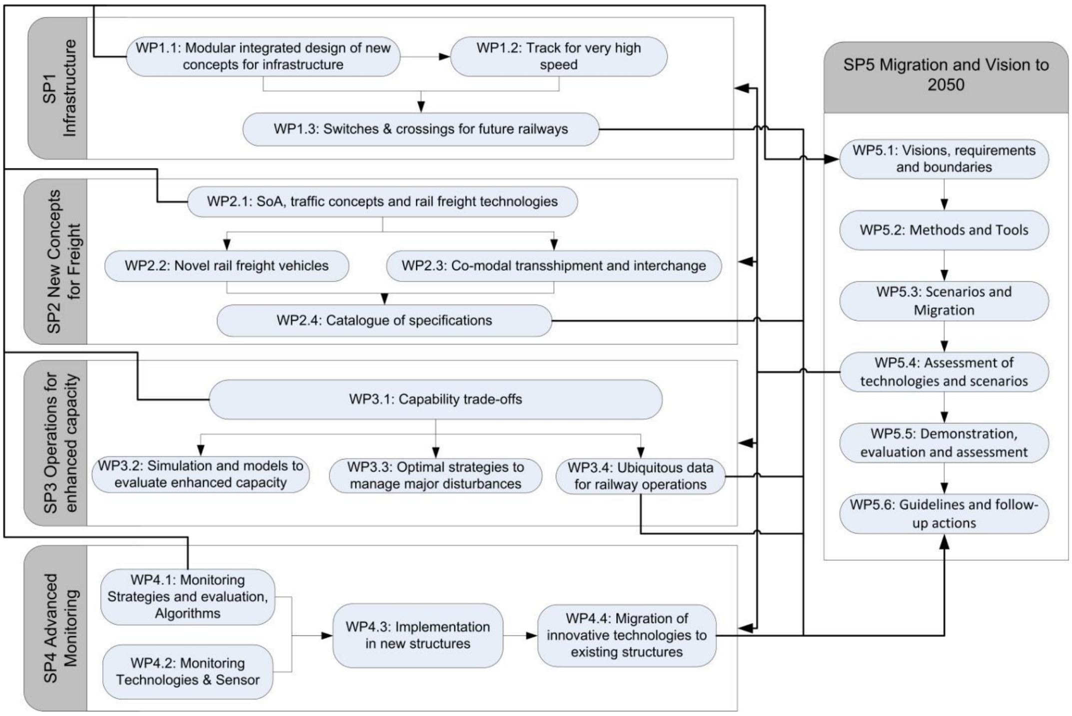

Figure 1 – CAPACITY4Rail structure & interactions

2. Context and needs

Although there is a rising demand for rail transport, mostly driven by energy costs, environmental concerns or road congestion, the use of the rail system in Europe has suffered during the past years, as rail cannot offer the same cost advantages and advances that have been seen in other sectors. The amount of freight shipped by rail has diminished over the past 15 years, with rail's share in the freight land transport market dropped from 20.2 % in 1995 to 15.7 % in 2009 and slowly recovering since then as reported by the European Commission (2013). At the same time, road transport is highly dominating the inland transport market with over 70% share.

The European Commission (2011), projects an optimistic +80% increase in freight transport and +51% in passenger traffic by 2050 compared to 2005 is expected and targets a 30 % shift of road freight over 300 km to other modes by 2030 and 50% by 2050.
On the basis of the White Paper assumptions, recent studies such as performed with the D-Rail EU project [see D-Rail (2013)] have refined several scenarios for transport growth according to different commodities and outlined some technical challenges to overcome to accommodate the traffic expansion.
In any case, all scenarios suggest a significant increase in train activity on existing rail networks, and the challenge is therefore not only for the railway business to regain market share over road, but to contribute at full capacity to accommodate with future traffics and meet the future transport demand of an expanding Europe.

Due to funding constraints, capacity has in most of the cases to be squeezed out from the existing system rather than by building new infrastructures.

To keep the infrastructure available and to release time to operation, Infrastructure Managers need to get maintenance done in a timely manner by optimizing the construction and maintenance process (development of modular plug-and-play systems, predictive maintenance, self monitoring systems, non-intrusive inspection, coordination of maintenance activities), by reducing maintenance requirements, and need to limit traffic unplanned disruption by improving the reliability of the infrastructure and its resilience to higher duty and to extreme climatic hazards.

Capacity management is a system process involving all actors. It is not only a matter of creating extra capacity, but also of using it efficiently and making sure that none of this essential resource is spoilt.

Great and more immediate savings are expected from optimized operation and capacity management, building timetables that are suitable for the infrastructure and resilient to train of infrastructure incident and technical defects, providing the flexibility the market requires through enhanced capacity planning and modeling, developing automation for repetitive driving sequences and delivering optimum and quality information to the drivers as well as to the customers.

As one of the biggest capacity consumers is the very difficult interleaving of traffics at different speed bands, efforts need to be made not only to improve the proper capacity of longer and lower-tare or heavier freight trains, but also to improve the vehicle performances to rise the speed up and keep both environmental impact and infrastructure damaging low.

The capacity challenge is not only to create extra capacity but also to allocate and use it in the most clever way, trading off constrains and needs of suburban, long distance passengers, and freight operators altogether.
The Capacity4Rail project consortium allows such a system view by bringing together stakeholders and actors of the whole logistic chain, involving clients, shippers, infra managers, wagon owners, railway undertakers, system suppliers.

3. Project objectives

The overall objective of CAPACITY4RAIL is to increase capacity, availability and performance of the railway system through major step changes in;

- infrastructure design
- construction and maintenance (including advanced monitoring)
- operations management
- incident recovering through real-time data management
- freight operations, with a particular focus on transhipment and improved specifications for rolling stock.

Detailed objectives for each of the subprojects are listed in section 3 'Project Approach' but CAPACITY4RAIL will:

- provide an overall increase in railway capacity by developing a holistic view on the railway as a system of interacting technical components driven by customer demand
- develop the vision and requirements of the railway system in 2030/2050 including environmental and socio economic aspects in terms of infrastructure and operation (including provision for an increase of freight traffic)
- identify the technologies and development/implementation steps in short-, medium- and long-term, necessary to move towards the railway system for 2030/2050
- develop new concepts for railway track of the future, in view of potential application for mixed traffic, but also very high speed (over 350 km/h), that encompasses cost savings, rapid construction, resilience and enhanced maintainability
- provide general track design guidelines for very high speed with identification of limiting factors especially in terms of admissible track irregularities and transition zones
- demonstrate, in real rail freight corridors, the feasibility of the most promising designs
- specify the requirements of an efficient freight rail freight system 2030/2050 to fulfil the EU targets
- provide a conceptual design for the rail freight vehicles (wagons and trains) of the future design transhipment technologies and interchanges of the future (rail yards, intermodal terminals, shunting facilities, rail-sea ports, etc.),
- design modern fully integrated rail freight systems for seamless logistics and network-based performance and develop their catalogue, standardisation pack and technical specification;
- develop modelling and simulation tools for high volume traffic management
- derive joint requirements, European standards and testing for incident management plans
- develop new concepts for railway structural and operational monitoring to enhance the availability of the track

- elaborate a system for a fast-check of track and structures after natural hazards

Each of the proposed subprojects will have an effect in its corresponding domain in the mid to long term. The following is a summary table of the key performance indicators that each SP expects to impact

Infrastructure :

- life cycle costs for slab track,
- availability for capacity: less time spent for intervention including maintenance and repair after unpredicted events

Freight :

- carrying capacity per train,
- number of trains per track length,
- investment cost per train,
- maintenance cost per train,
- cost per produced ton x km,
- reliability increase

Operations

- capacity from consistently predictable train movements,
- reliability for passenger and freight,
- more efficient response to perturbation,
- more efficient use of infrastructure, energy and rolling stock,
- reduction in operational costs through manual intervention.

Monitoring

- reliability of Infrastructure thanks to early pre-failure detection,
- availability of Infrastructure thanks to less failure and non-intrusive monitoring,
- higher maintainability of Infrastructure thanks to earlier and more accurate diagnoses.

4. Project approach

4.1. Infrastructure

The efficiency of current railway operation in Europe is often lowered by incidents that cause delays, or major engineering works on the infrastructure that entails either delaying or rescheduling trains.
Significant progress in terms of track availability for running trains and increased resilience will come only from new track systems that are designed to provide greater reliability through focusing on designs targeted to the actual use and much lower maintenance. An improvement of the reliability of switches and crossings is also required.

The subproject infrastructure will deliver:

- New concepts of track mainly based on modular slab track incorporating as far as possible embedded elements for power system, signalling and telecommunication, in view of mixed traffic but also for very high speed.
- New concepts for switches and crossings (S&C) designed based on failure modes analysis, revisiting curving physics and incorporating sensors for condition monitoring.
- New optimized designs for switches that is more resilient to extreme weather condition
- Prototypes of the most promising concepts both for regular track and switches demonstrated on mixed traffic lines.
- New RAMS and cost driven track design method.
- Improved modelling knowledge of track and subgrade behaviour to severe thermal and humidity condition, along with the design guidelines with respect to flood and heavy rain.
- General track design guidelines at very high speed and identification of limiting factors especially in terms of admissible track irregularities and transition zones.

- Improved knowledge on the dynamical behaviour of very high speed trains on bridges, and appropriate design principles.

4.2. New concepts for efficient freight systems

The main goals is here to develop a modern, high-performing, automated, intelligent, fully integrated system for efficient, reliable and profitable freight operations capable of providing computerized real time information to customers and operators at any time.
A virtual simulation, working as guidance for real demonstrators, adapted to the real situation in different European regions, will be produced and disseminated to the various actors within the European transport and political sector. The newly designed systems will be market-driven ensuring seamless low cost operations for service providers and customers alike. The main idea is to build on the concepts, ideas and results of previous projects and channel their merits into a logistics design that maximizes the system performance of a future supply chain seamlessly integrating rail with maritime and road transport. This means introduction of economically feasible technical development of rolling stock, capacity management, terminal operations, infrastructure maintenance and upgrading. New traffic management systems for better utilization of existing network capacity can only be fully exploited together with better performing rolling stock.

The results will substantially increase the overall capacity of the rail freight system; with adapted, time and cost efficient terminals, with multiple innovations on the wagons, with simultaneously introduction of new modernized wagons components, with novel sensors and monitoring, also using the enhanced traffic operation tools - thereby allowing freight trains easily to blend with passenger train traffic. The target is an overall capacity improvement by 5-10 % at the end of the project, 20 % in 2020 and an ability to guide how to proceed to a 50 % increase by 2030. Pre-studies on new concepts and designs of rail freight systems and networks have now been carried out which are indicating that these improvements can be achieved.
The results will be specified for the different types of stakeholders, and will specify system related measures for all the following areas:

- Train/wagons: Length, speed, performance, central/automatic couplers, EP/electronic braking, electrification, automation, weight,
- Operations: Wagon shunting, intelligence for vehicles in terminals, terminal operation,
- Facilities: Marshalling yards, terminals,

4.3. Operations for enhanced capacity

Railway operations strategies that will increasingly use automation for optimised performance and enhanced capacity will be developed. This subproject will develop road maps for technology that will transform decision support systems into automated systems that enable the rail industry to meet the challenges of the future, such as high-speed freight and greater levels of transhipment between rail and other modes.
This will enable the future controllers of the railway to focus on fulfilling the challenges of, for example – running ‘on demand’ trains variations in resource allocation and collaborative working within and between countries and improved efficiency of trans-shipment at nodes while the systems take care of routine operations and recovery from small or maybe even medium perturbations which in to-day’s world need the intervention of the controllers.

The subproject will issue:
Approaches, the majority of which will be fully automated, that help planners to understand and prioritise system capabilities and decide on optimal strategies to: increase overall system capability; respond dynamically to planned and unplanned changes; and support real-time punctuality management. These strategies will take into account the requirements from the new concepts for efficient freight systems:

- New and innovative data processing methodologies and algorithms to interpret and summarise raw measurements to make the data more practical for use in data analysis tools.
- More relevant and effective data analysis tools to enable the processed data to be used in decision making; and new data visualisation and presentation tools to assist strategic and operational decision making.
- Research that focuses on data systems that are able to provide ubiquitous data on train position and condition that enable automatic decision support systems and operations and planning staff to make better decisions;

- Proof of concept models that support the development of roadmaps for future modelling and simulation and operational strategies that provide a vision for future improvements in automated railway operations.

For each of the outputs improvements will be quantified through the simulation or real-world demonstration of the project outcomes.

4.4. Advanced monitoring

The objectives of Advanced Monitoring are to develop new concepts for railway structural and operational monitoring to enhance the availability of the track combined with automated maintenance forecasts, a prediction of the structural lifetime, a fast-check of track and structures after natural hazards and a support for train operation by train monitoring.

The expected results of this SP will define railway specific monitoring strategies to improve RAMS and LCC of railway transport; provide an overview of up-to-date monitoring technologies from other industries; develop a concept for further use of ICT in maintenance and for operation support; new concepts for using advanced monitoring in embankments, bridges, different tracks types, switches etc. designed for life-time prediction, condition based maintenance and fast health reporting after natural events (e.g. extreme weather); as well as prototypes of the most promising concepts both for regular track and switches demonstrated on mixed traffic lines. They will also include recommendations for approved, sustainable sensors and energy harvesting technologies in railway applications, and will provide improved modelling knowledge of track and sub-grade behaviour for more efficient application of monitoring systems.

4.5. System assessment and migration to 2030/2050

A common task will run through all of the technical ones, to examine the state-of-the-art, evaluate existing data and customer requirement and define the requirements and boundaries for the work to be carried out. It will harmonise these approaches and deliver the overall system requirements.

Global scenarios will be then developed for future rail systems and, at the end of the project, will bring together the final results, analysis and recommendations ensuring the future work will fit into this same system approach and ensuring the migration from existing system to the future system
It will draw the common vision for an affordable, adaptable, automated, resilient and high-capacity railway, and develop a ‘roadmap’ that paves the way for the target system.

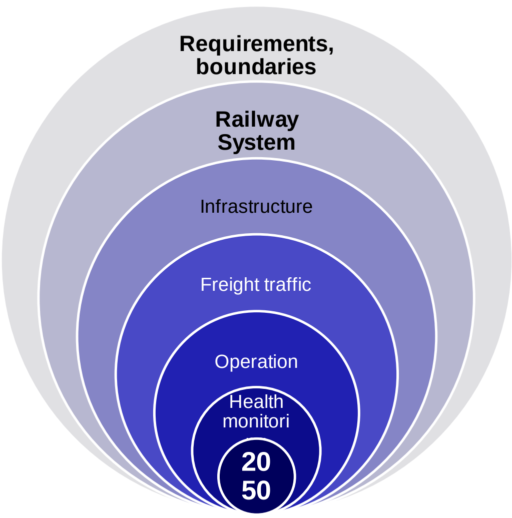

Figure 2 **:** Capacity4Rail migration model

The results will be based on the outcomes from workshops, reviews of White Papers, policies and strategies of IM's. Also the experience from other transportation modes will be the merged with the requirements for improvements developed in the other work-packages

Depending on the assessment of the "Technology Readiness Level" (TRL) of the technologies to be developed, the direction and paths for migration from the existing system (i.e. what is the current situation today) to the visionary system (i.e. where we want to be) will be defined. The project aims at identifying and developing the specifications and technologies as well as the intermediary steps that will deliver the increase in TRLs for key technologies. It will thus identify the milestones that need to be reached in order to establish concrete step changes to achieve a European railway network of enhanced capacity

Furthermore, supporting real and virtual demonstration of technologies, the sub-project will :

- Evaluate the impact of the step-changes in the new concepts on RAMS, life cycle costs, operation and environment,
- Provide adapted methods and tools for the assessment of innovations, technologies and concepts with respect to the vision and roadmap as well as technical, economic and environmental requirements and boundaries.

5. Building on existing

Capacity4Rail will be building on a firm and wide state-of-art, developing results from large amount of current and past studies and project, a few examples of which are described below:
Drawing vision and scenarios to the 2050 rail system will incorporate results from D-RAIL (2013), from NEWOPERA (2008) which aimed at contributing to revitalize the role of rail in freight transport and logistic chains over the internal borders of the European Union or from SPECTRUM (2012), about market opportunities for the transport of time sensitive, low density high value goods.
INNOTRACK (2010) will provide essential elements for the innovative and performance-based design of switches and crossings.
Capacity4Rail SP2 will also cooperate with the "5L" initiative to develop future innovative vehicle concepts and freight systems as presented in the white paper from König & Hecht (2012).
ON-TIME (2012) will be as well a basis for SP3 and its results will mean a better train operation management by introducing methods and algorithms for smoother running of trains, and to develop processes for capacity planning including simulation systems and decision support.

6. Conclusion

Started in October 2013 for a duration of four years, CAPACITY4RAIL will be a unique opportunity to influence the vision for rail transport over the next 30+ years. It will achieve this by;

- demonstrating the capabilities of new technologies
- developing standards for future technologies
- providing guidance and recommendations for the overall rail system and the implementation of new and future technologies
- identifying all possible sources for funding and development that can be leveraged to ensure the future of rail transport in Europe.

Of course, to achieve these ambitious objectives, the consortium needs to have a diverse range of stakeholders who 'buy-in' to the CAPACITY4RAIL vision and adopt the system approach that is advocated in the project.
CAPACITY4RAIL has brought together this diverse range of stakeholders, in an ambitious partnership that consists of 46 manufacturers, railway operators, world-leading research organisations and specialist technology providers. The construction of the consortium has been driven by the technological needs of the overall project and the expertise necessary in each of the SPs.

CAPACITY4RAIL is being coordinated by UIC which holds a unique position in the European Rail network and is ideally placed to lead such a complex project;

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