C4R
Capacity for Rail

Towards an affordable, resilient, innovative and high-capacity European Railway System for 2030/2050

#3, September 2016

Newsletter

SPECIAL ISSUE ON OPERATIONS FOR ENHANCED CAPACITY!

FOREWORD

Welcome to the third issue of the Capacity4Rail project Newsletter!

Started in October 2013, Capacity4Rail will soon enter its fourth and last year. The project is running full speed. Innovative concepts have emerged in all technical areas, and the coming year will be a crucial step for the demonstration and multi-criteria evaluation of their expected capacity improvements and economical benefits, before deriving final recommendations to progress further towards the proposed vision for 2030/2050.

This special issue for InnoTrans 2016 focuses on the achievements of SP3 – Operations for Enhanced Capacity

Detailed information on the progress of each SP3 work package is presented on independent leaflets inserted in this newsletter.

The activities conducted until project end will continue to deal with technological developments, demonstration activities and exploitation mechanisms and the related achievements will be published under the form of public deliverables downloadable from the project public website.

More info at http://www.capacity4rail.eu/

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 605650

News from the consortium

Laurent Schmitt, C4R project coordinator will leave UIC at the end of September 2016 to go back to SCNF where he originates from. He will be replaced by **Álvaro Andrés** from ADIF who joined UIC in January 2016.
Meena Dasigi, Leader of SP 3 – Operations for enhanced capacity, will retire at the end of September 2016**.** Meena will be replaced by **Egidio Quaglietta** as SP3 Leader.
In the name of the consortium, we would like to extend our deepest gratitude to Laurent and Meena for their involvement and their excellent work in the consortium. We would also like to wish them all the best in their future projects. Equally, a warm welcome to Alvaro and Egidio!

Forthcoming public events

Capacity4Rail showcased in INNOTRANS 2016 (Berlin, 20 – 23 September)

Capacity4Rail achievements on **Operations for enhanced capacity** will be showcased on the stand of OLTIS Group (Hall 4.1, Stand 312) and University of Birmingham (Hall 7.1c, Stand 305).
More info on http://www.innotrans.de/en/

Capacity4Rail and NeTIRail-INFRA to hold joint dissemination events (Brussels, 3 and 4 November 2016)

The 2nd **Capacity4Rail dissemination workshop** will be held on 3 November 2016 jointly with the **NeTIRail-INFRA mid-term conference** (4 November) in Brussels Grand Place (Belgium).
Register online at www.capacity4rail.eu and http://netirail.eu !





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Work progress

SP1 – Infrastructure Railway Track of the Future

The objectives of SP1 "Infrastructure" are to develop new concepts for railway track of the future, in view of potential application for mixed traffic, but also very high speed. The work progress is outlined below.

In WP11 – Modular integrated design of new concepts for infrastructure, two new slab track concepts have been generated then refined during 4 collaborative workshops since June 2014. The detailed design phase for these concepts is ongoing, and will end in October 2016. Then both concepts will be prototyped by ACCIONA and will be tested in the CEDEX TrackBox in Madrid in 2017.

In WP12 – Track for very high speed, work in Task 12.2 aims at proposing optimized innovative track design for very high speed on the basis of numerical simulation and real scale laboratory test. The numerical simulation phase is already finished and the best combinations of pads and under sleeper pads to test at the TrackBox are already defined. The test campaign that will evaluate the mitigation effect of these solutions will start in October 2016.

Task 12.3 is focused on Structures dynamical effects due to VHST, the aim is to gain improved knowledge on the dynamical behaviour of very high speed trains on bridges, and appropriate design principles. The data obtained during the test campaign that took place on the Madrid – Barcelona HSL (KP 69+500) in November 2015 is being analyzed. The results will show the behaviour of short span frame bridges under VHST.

In WP13 - Switches & crossings for future railways, two deliverables have been completed, namely "Operational failure modes of S&Cs", and "Innovative concepts and designs for resilient designs for resilient S&Cs". A third deliverable is due in month 45.

Work on the six demonstrators of WP13 has just begun:

- Develop decision tool for S&C maintenance based on track recording car information
- Using wireless technology for measurement in S&Cs, preferable acceleration
- Installing a new material for crossing in service S&CMaterial validation data for wear map
- Laser measurements of S&C frog nose
- New innovative technology to remove snow in turnouts.

SP2 – New Concepts for Efficient Freight Systems

The goal of this subproject is to develop the rail freight system of the future, for 2030, 2050 and beyond. To achieve this, the work has been broken down into four main work packages as detailed below.

The state-of-the-art under WP2.1 has delivered D2 in due time. Utilising the findings of this deliverable, Islam, Ricci and Nelldal published a paper titled 'How to make modal shift from road to rail possible in the European transport market, as aspired to in the EU Transport White Paper 2011' in European Transport Research Review journal, September 2016 (http://link.springer.com/article/10.1007/s12544-016-0204-x).

Novel Rail Freight Vehicles under WP2.2 aims to design the rail freight vehicles of the future. It deals with wagon design to enhance its carrying capacity, along with the braking system to increase safety, train length and failure detection in order to enable more reliable paths for rail freight on the network.

Co-modal Transhipments and Terminals, under WP2.3, are the conceptual design of transhipment technologies and interchanges of the future (rail yards, intermodal terminals, shunting facilities, rail-sea ports, etc.) WP2.3 has delivered D23.1 in time exploring three main aspects: Rail-Road freight interchange; Rail-Rail marshalling yard; and Rail-Sea: port rail terminal.

The work of Rail Freight Systems of the Future, under WP2.4, is ongoing and has delivered its first deliverable D2.4.1 Catalogue: Rail Freight Systems of the Future (intermediate)' in time. The main objectives of the work are to study and design new concepts for network-based services for fully integrated rail freight systems to meet the requirements of 2030/2050.

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SP3 – Operations for enhanced capacity

SP3 focuses on railway operations strategies that will increasingly use automation for optimised performance and enhanced capacity.

The links between SP3 and the other sub-projects of C4R is depicted below. The developments in the individual work packages are detailed in the leaflets of the work packages.

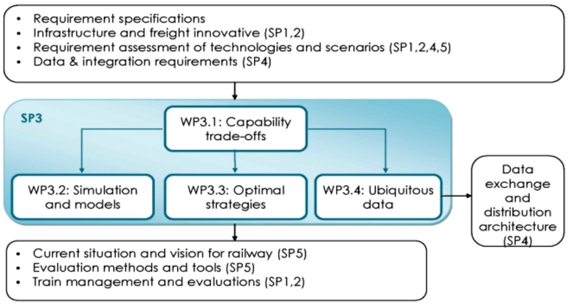

Figure 1 – Diagram of links between SP3 and the other sub-projects of C4R

With over 80% of the results delivered or in the final stages, work in the final year of the project will focus on refinements and co-ordination of the results.

SP4 – Advanced monitoring

To reduce the number of disruptions and delay time and associated life cycle costs of switches, a simple key performance indicator related to the availability for controlling substantial production means has been defined. Moreover equipment standards for the complete system switch or performance diagnostic have been defined, and a strategy for preventive maintenance and an implementation concept have been developed.

The technology to be developed to monitor the dynamic behaviour of the switch and the frog & blade rail for defects is based on the identified technologies, the technology evaluation and the context. Advanced monitoring systems have been identified for monitoring in ideal situations. The developed strategy will therefore be intended to reach the ideal situation.

However two questions remain open: Which technologies could be developed and what is missing on the market for those technologies to emerge? Specific monitoring requirements and techniques for the new infrastructure elements have been examined and interactions/interferences between sensors and infrastructure elements have been analysed. RFID technology, widely used in railway infrastructure for identification and localisation, will be applied.

Concerning the migration of innovative technologies into existing structures, an – Optasence fingerprint of a high-speed line has been evaluated and will be analysed by track specialists at DB.

During the development of applicable micro-measurement technologies by the Universities of Birmingham and Porto, the energy supply and the design of the necessary data transmission technology were driven by Adevice.

Based on literature and personal experience, an assessment table was developed and published in Del. 4.2.2.

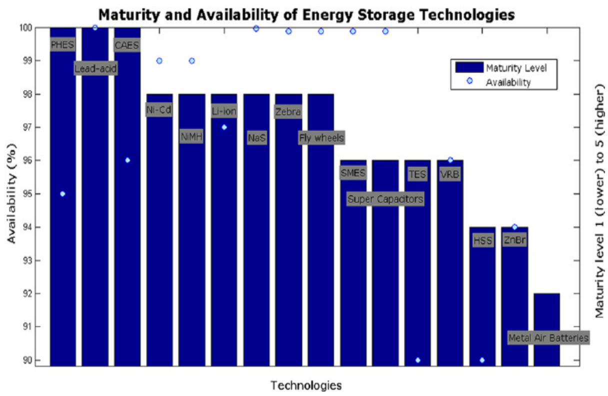

Figure 2 – Maturity and availability of energy storage technologies [Del. 422]

The second important part is the data transmission. At least 8 possible technologies were discussed and compared (among others. RFID, Sub-GHz, Bluetooth, Wi-Fi, Cellular…) Demonstrations of advanced monitoring systems are currently ongoing in the laboratory and in the field by means of track box (CEDEX) validation of the monitoring system embedded in slab track developed in SP1. University of Porto and Infraestructuras de Portugal conducted tests regarding a track buckling on a railway bridge and structural health monitoring of a long span railway bridge applied for demo of retro-fitting.

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SP5 – System Assessment and Migration

"What will the railway of 2050 look like?"

SP5 ensures a whole-system approach across the SPs to identify visions, future requirements and boundaries by identifying necessary steps, developing migration scenarios, and improving tools for assessment, assessing technologies and scenarios, identifying optimal capacity enhancement scenarios and performing demonstrations. The analysis is based on the following rail freight corridors

- Rhine Alpine corridor (RFC1)
- ScanMed (RFC3)
- Mediterranean (RFC6)

The corridors and sites selected are fundamental basis for further work and "real" analyses in the project. The analysis of bottlenecks will be mapped against the innovations and working areas of the project. A Cost Benefit Analysis (CBA) will show the benefit of the innovations.

Beside the CBA, SP5 developed a methodology and tool for Multi Criteria Assessment (MCA) to access the results of C4R with respect to the global targets of the project like Automation, Adaptability, Capacity or Resilience.

Scenarios and migration paths will be developed for some sections to demonstrate the migration from the actual to the future state.

SP5's goal is to coordinate and evaluate the demonstrations on-track, in laboratory or in a virtual environment. Detailed demonstration plans are in progress to define the demonstration activities. Depending on the demonstrators and their impact on the safety of the railway system, simplified safety and risk assessments will be carried out according to Common Safety Methods (CSM).

The results of the project will be summarized in a guideline that indicates the paths and areas for further research and developments.

The consortium

Capacity4Rail is bringing together a range of 46 stakeholders from 13 nations in an ambitious partnership: infrastructure managers, railway undertakings, logistics developers, research institutes and universities, industrial equipment providers, engineering companies, end-users...

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WP3.1 – Capability Trade-Offs Analysis Tool Demonstrator

Planning for Improved Railways

The overarching needs of the 2050 railway across European countries are high capacity, low cost, reliability and seamless integration with the broader transport network.

It is clear that to achieve such a railway requires a holistic, whole-system approach. Operational misalignments, industry fragmentation and disconnect between planning and operations are significantly impacting the useable capacity of the network and the quality of service provided to customers.

The high-level objectives of Capacity4Rail are to support the delivery of an affordable and reliable high-speed, high-capacity railway network for passengers and freight with increased resilience, adaptability and automation.

Making Choices

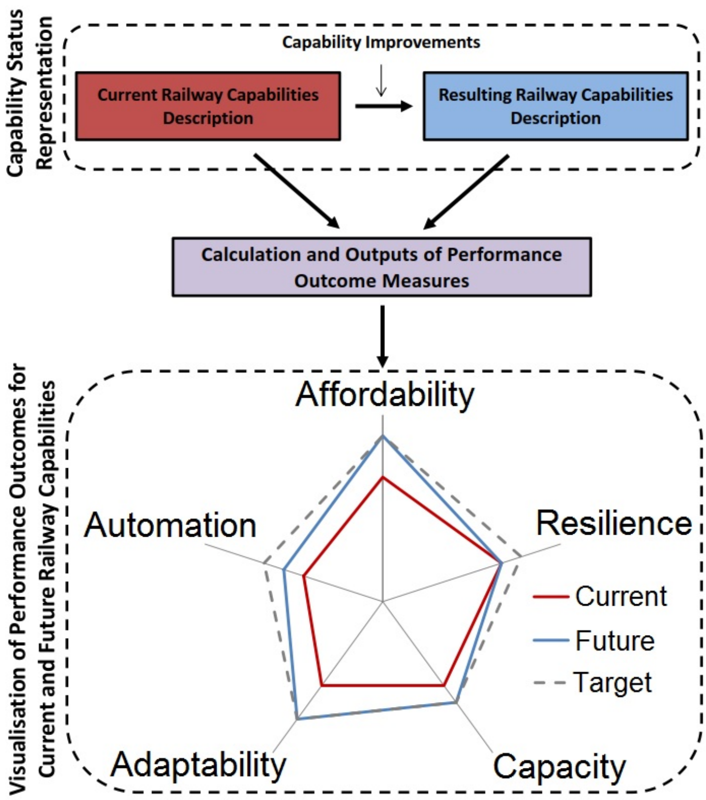
Undoubtedly, trade-offs are required in reaching these high-level goals. The overall railway capability aims of different railways vary; for example, the focus of one may be 'maximal capacity' at the expense of passenger comfort as seen in metro services across Europe, while for another it could be 'moderate capacity and increased quality of service for passengers'.

Capability Trade-Offs Analysis Tool

The WP3.1 team has developed a Capability Trade-Offs Analysis (CTA) tool that can be used to effectively evaluate capability enhancement options. The tool enables the user to evaluate the impact of changes in the capabilities of a railway system. Changing system capabilities within the railway may have direct or indirect consequences through interactions with other parts of the system. The tool takes account of these interactions.

Evaluating Trade-Offs

When delivering a high-capacity railway system, trade-offs will be required and choices will have to be made to realise increased capacity. The CTA tool assigns capability values to the current and upgraded railway relating to the components of the railway system, e.g. track type and rolling stock and shows the effects that improvements have on the high-level objectives. The tool's structure allows the user to evaluate a wide range of proposed improvements to the railway system.



OVERVIEW OF THE CAPABILITY TRADE-OFFS ANALYSIS TOOL

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The purpose of the software tool is to enable infrastructure managers to:

- Use a whole-systems approach and take account of the capabilities of whole railway systems
- Compare the capacity outcome of improvements to different capabilities
- Determine the impact that changes will have on the other high-level goals of affordability, automation, adaptability and resilience

Using the Railway System Model

In the CTA tool, the railway system is decomposed into its multiple components and their related functions. The current and future capabilities of the system components within a selected route are represented by selecting their values in the model.

Evaluating Innovations using the CTA Tool

Any innovation implemented, e.g. a change from ballasted to slab track, or improved freight rolling stock with higher top speed or better braking performance, can be represented in a change in the related capabilities in the model. The performance outcome is calculated via the combination of a series of mappings between capability status and performance outcome.

The tool provides a visual breakdown of the railway system outcome and reports the changes with respect to the five high-level goals, each represented on one arm of a spider diagram. The tool also provides a further breakdown of each goal.

Summary

The CTA tool provides an overview of the extent to which improvements contribute to the move from the current status of a railway towards a desired future railway. It expresses the outcome in terms of the 5 high-level objectives: capacity, affordability, automation, adaptability and resilience. In this way, the tool provides the qualifying analysis that railway infrastructure managers require to identify solutions for increasing capacity using a whole-system approach.

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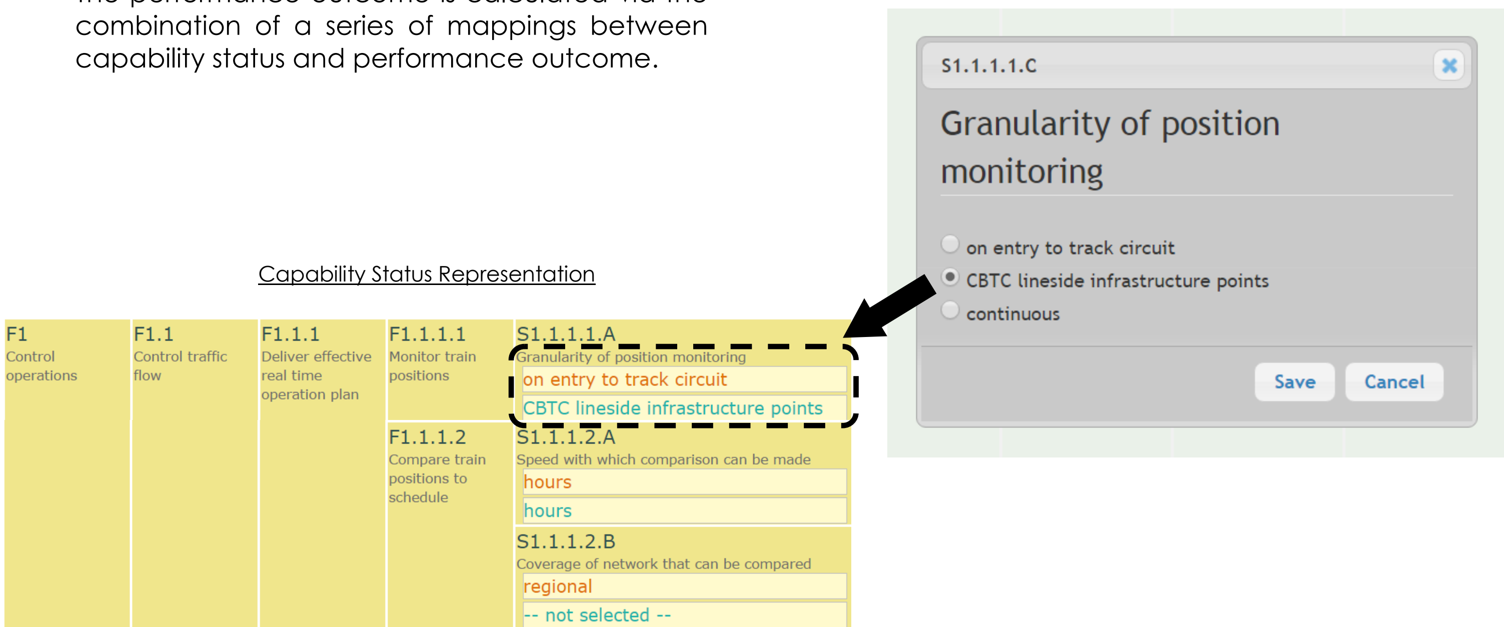

Defining Railway Capabilities in the Capability Trade-Offs Analysis Tool

Network Rail | oltis group | TRL THE FUTURE OF TRANSPORT | UNIVERSITY OF BIRMINGHAM

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WP3.2 – Simulations and Models

Scope

The purpose of SP3.2 of the Capacity 4 Rail project is to increase capacity with better methods for timetable planning and operational traffic and to analyse and evaluate the capacity of infrastructure and new traffic systems.

The project covers strategic, tactical and operational rail capacity planning processes, as well as driving advisory systems (DAS) in several European countries, and how modelling tools and simulation are used in planning and control. The perspective is mainly from the point of view of the infrastructure manager.

Research gap

An overview gap analysis has been performed, from the viewpoint of the infrastructure manager, with a vision for 2020 of tactical planning and operational traffic control.

Operational control of railway traffic is recognised as the critical factor in railway systems that requires an improvement. The application of novel computer-based decision support systems is recognised as a potential approach. The discrepancy between the current state of the existing tools for real-time traffic control and the practical operational requirements is identified as the main gap.

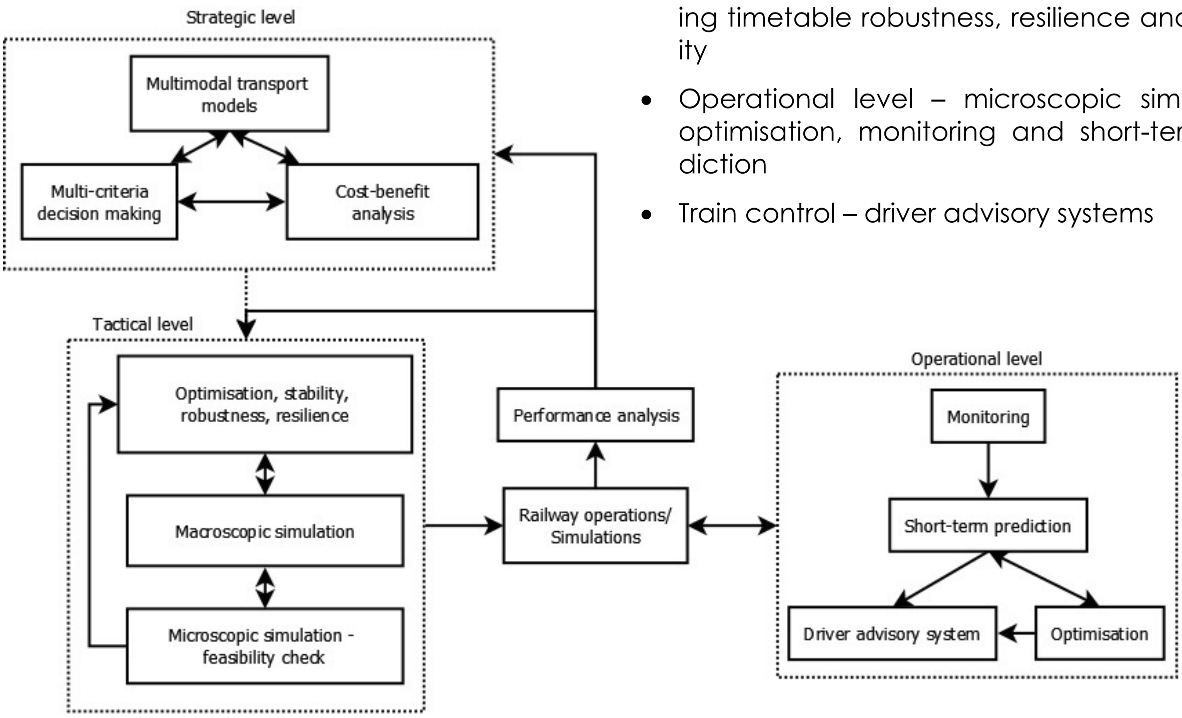
Existing framework

The figure shows the existing framework for decision support using modelling and simulation.

Modelling and simulation is used for analysis of transport systems – infrastructure investments, timetable planning one year and ad-hoc and operational traffic.

The modelling and simulation techniques are:

- Strategic level – socio-economic analysis, cost benefit analysis, multi-criteria decision making, integrated multimodal transport models, etc.
- Tactical level – macroscopic simulation, stochastic simulation, optimisation, and improving timetable robustness, resilience and stability
- Operational level – microscopic simulation, optimisation, monitoring and short-term prediction
- Train control – driver advisory systems



EXISTING FRAMEWORK FOR MODELLING AND SIMULATION

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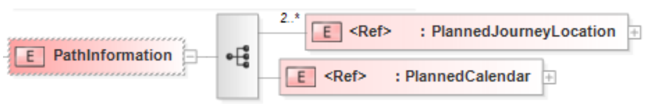
The CAIN system, developed by Oltis Group, serves as real time software for the input of ad-hoc train paths into the real timetable. The subsequent optimisation of the timetable and simulation of different scenarios is one of the main tasks, where CAIN interacts with the model from LiU, Linköping University.

CAIN Demonstrator

The CAIN demonstrator has been developed by OLTIS Group. The process follows several consecutive steps:

- Import static data of railway infrastructure, timetable and vehicles – the corridor Malmö – Hallsberg [data in RailSys and railML format]
- Process the data, create a virtual network and display the railway network
- Make new request for an ad hoc path (manually or imported)
- Optimisation and creation of an ad hoc path
- Construction of a new timetable and render a new train path
- Export of a new timetable in **TAF TSI structure** (PathInformation) for interaction with the LiU model by mutual data exchange



Structure of element PathInformation

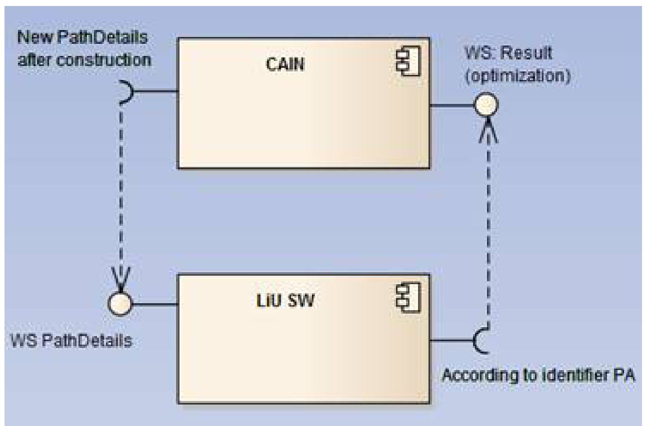
Interaction CAIN – LiU

The LiU team is analysing the data from the Trafikverket "Lupp" database of historical traffic data. The goal is to evaluate suggested ad-hoc path requests with respect to robustness. Preliminary results show that this problem is particularly interesting for the selected corridor as there are many freight trains that are rescheduled at short notice. The distribution of freight train delays indicates that many of them take paths that are not included in the planned daily timetable and thus had to be inserted into the existing one.

Principle of the conceptual link between CAIN and the LiU model:

- LiU model provides a system for real time train positions and predictions
- Cooperation of LiU and Oltis to integrate different data exchanges
- LiU to evaluate by simulation the new timetable with respect to overall robustness and returns a prediction of the expected delay.
- The target is to develop a traffic prediction module able to be integrated into a real time dispatching system and ad hoc timetable system

The CAIN demonstrator will be documented in "Deliverable 32.2 Capacity impacts of innovations (PU, R)" planned to be published in March 2017 according to the project plan.



Communication scheme via WebService CAIN with use of messages according to TAF TSI version 2.1

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WP3.3 – Optimal strategies to manage major disturbances

Objectives

WP3.3 provides control and information strategies for real-time traffic management for future operations, i.e., how to operate trains so as to maximise capacity for passengers and freight at low carbon impact.

The increasing demand for rail transportation is leading to a deficit capacity on today's railway. Automation is increasingly being seen as a tool to bridge this deficit.

Researchers have been looking at the applicability of automation to the needs of today's railways based on their context, location and technology. Studies are being done to assess the levels of automation currently applied on the railway, to group complimentary technologies that deliver efficient and resilient railways in the future and finally a roadmap is proposed for future research and development that will enable the delivery of a smooth and flexible railway.

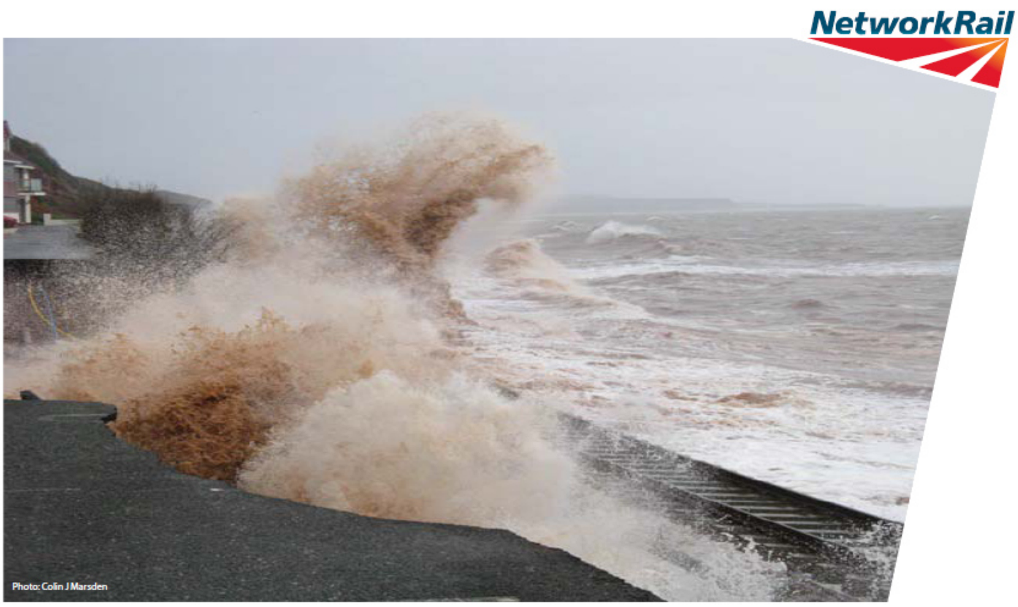
Disruption Management

Large disruptions are unplanned events that require changing the way in which resources were originally planned and managed by Infrastructure Manager (IM) and Railway Undertaking (RU) controllers.

The management of large disruptions involves IMs (in some cases many of them) together with RUs. In general, the scope of large scale disruption covers:

- Crew or rolling-stock unavailability;
- Train failure and infrastructure degradation interrupting a line section;
- External factors as extreme weather, strikes, etc.

Building on the seminal work done in the ONTIME project (FP7-SCP0-GA-2011-265647), we formalize the disruption management process in Europe through SysML activity diagrams.



STORM AT DAWLISH STATION IN THE UK (SOURCE: WEST OF EXETER ROUTE RESILIENCE STUDY, NETWORK RAIL, 2014)

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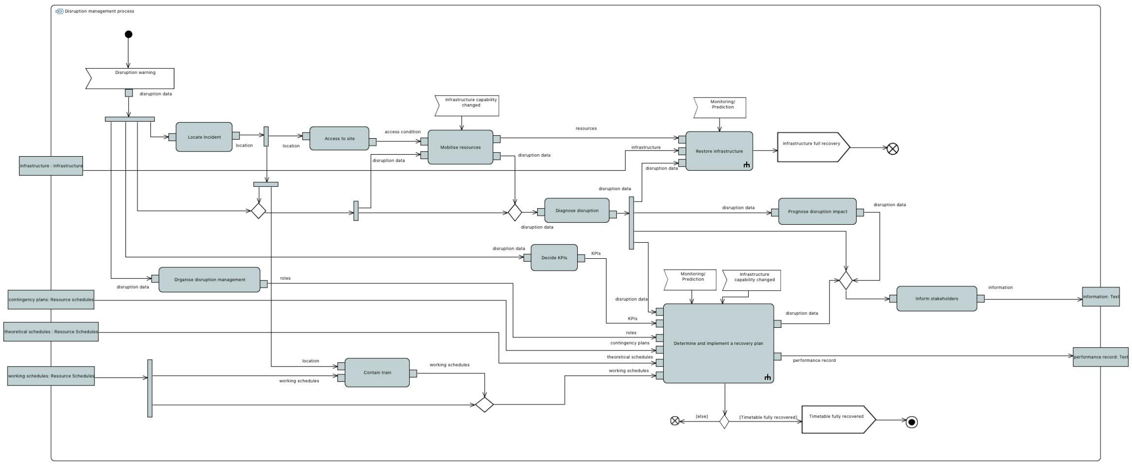


SysML activity diagram of the disruption management process

These diagrams are also translated into a state graph to check properties of the system behaviour. After doing so, we analyse the extent to which the so obtained unified framework represents the current process in the UK, Spain, France and Sweden. Indeed, although some differences exist, the general process formalized captures the main aspects of disruption management in all these countries.

The lessons learned here are the starting blocks for the study of automation development.

Automation

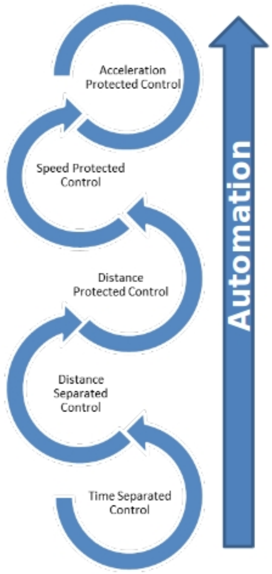
The levels of automation of the railway system in different countries are studied, with particular attention to the disruption management process. The developments already under implementation are analysed and a roadmap for the increase of automation is proposed.

One that could benefit from increased automation is the field of delay prediction, where automated tools based on Big Data techniques such as the Extreme Learning Machine can be used to deliver more accurate predictions of the future state of the network than current univariate statistical approaches without an operator-in-the-loop.

Summary

The formalization of the disruption management process proposed in this work package allows the observation of this complex process under different perspective.

First, it allows underlying similarities and differences in different European countries. This will be particularly useful for the actual construction of the Single European Railway Area. Second, it allows the analysis of the level of automation currently implemented or envisaged. In turn, this analysis makes it possible to define a realistic roadmap for the achievement of an automated railway.



Example of different levels of automation in the Railway System

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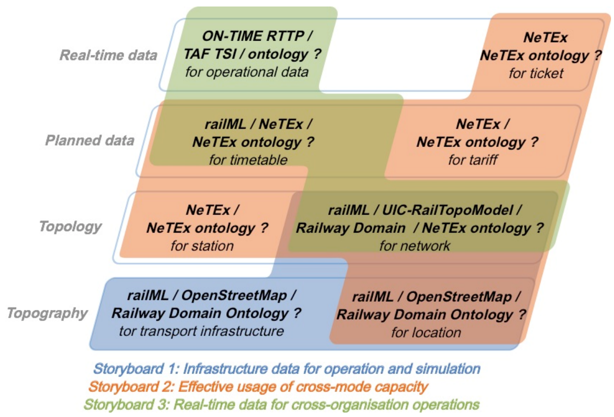
WP3.4 – Ubiquitous Data for Railway Operations

WP3.4 of the Capacity4Rail project has focused on information for railway operations, and specifically has dealt with the topics of appropriate architectures for information sharing in the rail industry, data notations and models, and the use of open data in support of railway operations.

Data notations

Based on a detailed survey of existing data exchange formats used by the railway industry, academia, and the operators of connecting transport modes, C4R project members have produced recommendations for appropriate data models to be used in support of a range of backcasted storyboards derived from visions of the railway in 2050. The diverse data requirements of the storyboards, which cover a wide range of the commonly seen data types involved in railway operations and the broader multimodal transport sector, are summarised in the figure below presented alongside candidate model recommendations in each area.

A key contribution of this work to the industry comes in the form of a joint consideration of "traditional" plain text and xml derived data models, with the upcoming semantic web standards (ontology & RDF). Although previously studied in isolation, work in C4R considers the relationship between the two philosophies, and shows how they can best be used in tandem. Full details can be found in C4R project deliverable 3.4.1.



DATA REQUIREMENTS AND CANDIDATE MODELS FOR C4R STORYBOARDS

Data architectures

In order to adapt to the changing data needs of an increasing connected railway, particularly with respect to intermodal connections, the industry needs to move from monolithic, siloed ICT systems, to a collection of transport industry services linked by messages on one or more service bus. Linked Open Data architectures, based around semantic data models and implemented as sets of decoupled web services, provide an excellent paradigm for this. Within the C4R project, the WP3.4 team developed examples of this type of architecture, with a particular focus on the interactions between low velocity data (e.g. infrastructure layouts) and high velocity data, such as sensor data from RCM systems. An example architecture can be seen overleaf, and full details are provided in C4R project deliverable 3.4.2.

Improved situational awareness

The transport industry is driven by the satisfaction of its passengers. In situations where normal operations are disrupted passenger satisfaction is known to drop to very low levels, and this is commonly attributed to a lack of / the delivery of poor quality passenger information on the evolving situation. As part of C4R, the WP3.4 team have investigated how open data from social media can be leveraged to give railway stakeholders improved tactical awareness of operational incidents that are in progress on the network; this information can then be used to both inform the operational response, and be fed back to passengers.

Media content related to railway operations is crowdsourced from online communities and then associated with geographical locations or specific services, enabling the appropriate operation staff to respond from the wide range of stakeholders that exist within the industry. Both "official" (railway stakeholder provided) and unofficial sources are utilised, allowing associations to be drawn between know events and on-the-ground passenger feedback. The types of information that can be gathered using this approach range from reports of crowding

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and on-train incidents (disruptive passengers etc.), to service disruptions and general comments on the level of service. Sentiment analysis allows messages to be characterised, and text mining is used to group messages into topics.

Information that is connected to a single service / originated in a particular geographic area is gathered together into a colour-coded marker, indicating the likely importance of the topics contained. These can then be expanded to view more in-depth information, such as detailed message content. An example of the process in action can be seen at the foot of the page and full details are provided in C4R project deliverable 3.4.2.

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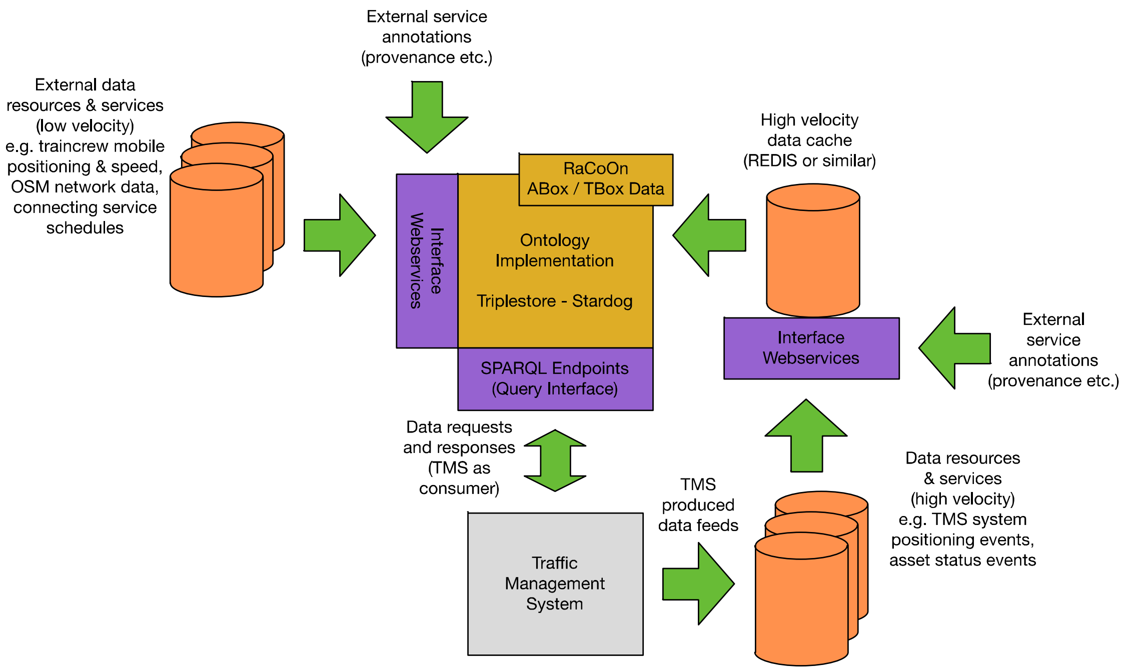
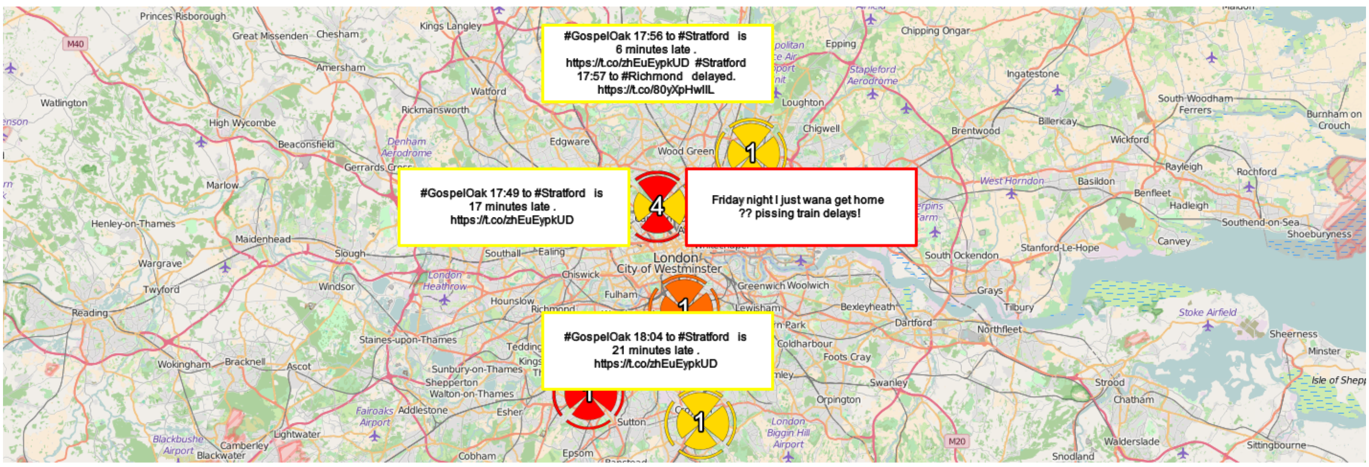


Example semantic data architecture for railway operations



Example of improved situational awareness through mining of social media

University of Birmingham
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