Newsletter

The next 20-30 years will see unprecedented demand for growth in transport. European railways have to deliver increased productivity to fulfil the growth demand across all modes in freight and passenger services by 80% and 50% respectively by 2050.

In2Rail will set the foundations for a resilient, consistent, cost-efficient, high capacity European network by delivering important building blocks that unlock the innovation potential that exists in Shift2Rail. Innovative technologies will be explored and resulting concepts embedded in a systems framework where infrastructure, information management, maintenance techniques, energy, and engineering are integrated, optimised, shared and exploited.

In2Rail will make advances towards Shift2Rail objectives by the adoption of a whole system approach linking infrastructure re-design with asset maintenance, and energy management, through the high level Shift2Rail objectives:

- Capacity
- Reliability
- Life Cycle Cost

In2Rail is one of the lighthouse projects of Shift2Rail and will contribute to Innovation Programmes 2 and 3.

In2Rail will pave the way for the optimisation of the design of core infrastructure elements, as well as improve the management of the railway system by adopting a holistic approach, through three sub projects.

In2Rail Objectives and Project Structure

The expected outcomes of In2Rail will be achieved by the adoption of a whole system approach linking infrastructure re-design with asset maintenance, traffic and energy management.
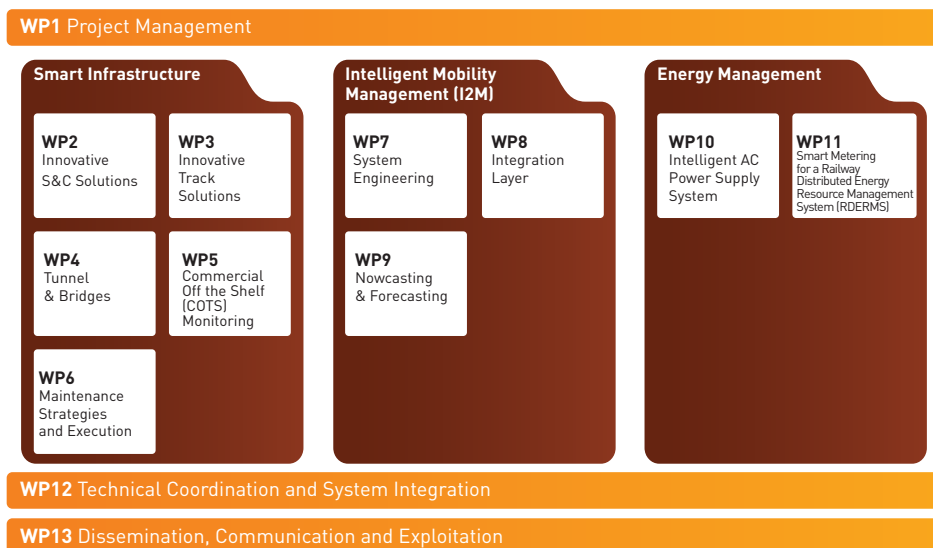
Smart Infrastructure

- Intelligent reliable infrastructure: integrated asset monitoring, self-diagnostic and adjusting assets, efficient design and new materials, exploring mechatronic solutions, with an increased focus on data from low-cost, low-maintenance sensors

- Better system resilience and reduced need for maintenance through innovative infrastructure design, novel working methods and smarter use of data leading to reduced LCC and greatly improved availability

- Overall reduction in carbon emissions, noise & vibration, and improved levels of sustainability

Intelligent Mobility Management (I2M)

- Standardised approach to information management and train dispatching systems enabling an integrated Traffic Management System (TMS)

- Information and Communication Technology (ICT) environment supporting all transport operational systems with standardised interfaces and with a plug and play framework for TMS applications

- Advanced asset information system with the ability to 'nowcast' and forecast network asset statuses with the associated uncertainties from heterogeneous data sources

Energy Management

- The design of a future AC Rail Power Supply System with minimised energy losses and optimised electrical power loading

- The implementation of an efficient energy management system allowing understanding of energy flows within a railway system, a reduction of the energy consumption and cost, optimised asset management and enabling better use of the railway capacity

WP1 Project Management

Smart Infrastructure

WP2 Innovative S&C Solutions	**WP3** Innovative Track Solutions
WP4 Tunnel & Bridges	**WP5** Commercial Off the Shelf (COTS) Monitoring
WP6 Maintenance Strategies and Execution	

Intelligent Mobility Management (I2M)

WP7 System Engineering	**WP8** Integration Layer
WP9 Nowcasting & Forecasting	

Energy Management

WP10 Intelligent AC Power Supply System	**WP11** Smart Metering for a Railway Distributed Energy Resource Management System (RDERMS)

WP12 Technical Coordination and System Integration

WP13 Dissemination, Communication and Exploitation

IN²Rail Project Structure

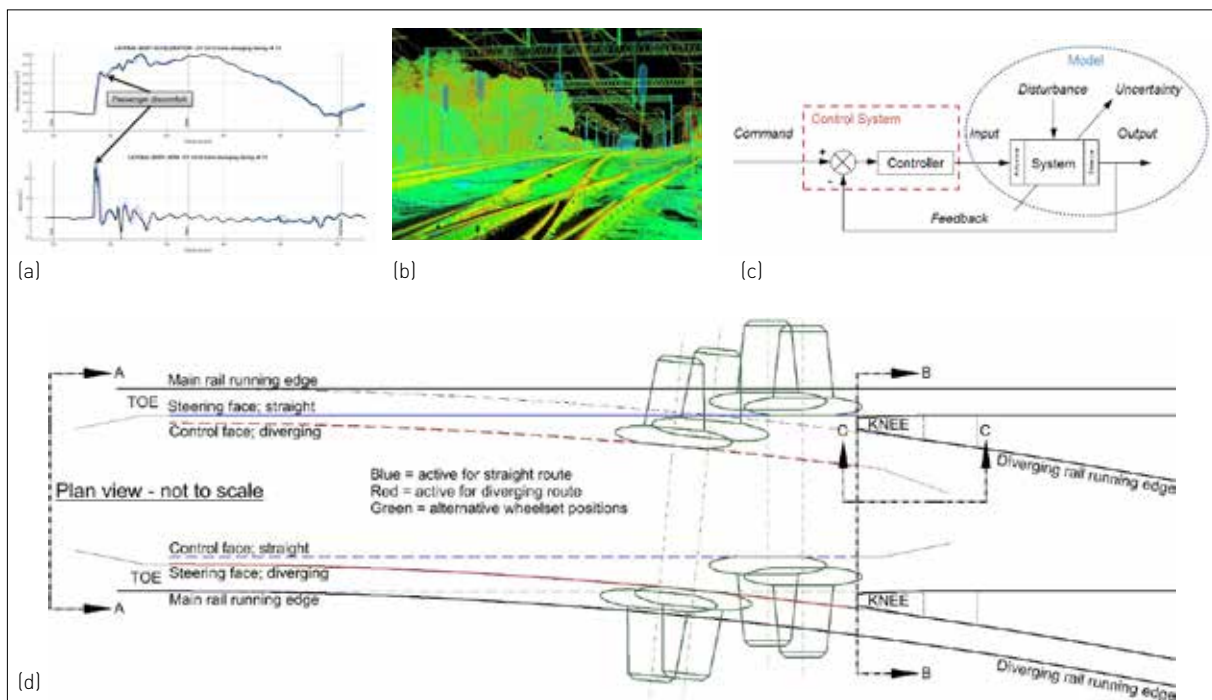## Sub-project 1: Smart Infrastructure

Enhancing Existing/Developing Next Generation Switch and Crossing Solutions

Switches and crossings (S&C) are critical railway assets, providing operational flexibility by enabling vehicles to move from one track to another. S&C is a complex system containing failure modes with the potential to severely disrupt rail services. In2Rail aims to explore, through whole system design, opportunities for enhancing the existing system whilst developing concepts for next generation solutions.

Understanding how the existing S&C system performs and degrades is a critical part of efficiently managing the asset. A range of state-of-the-art sensing technologies have been reviewed and mapped against S&C monitoring requirements to specify an enhanced S&C sensor system. System architecture has been established and will be developed further into a conceptual design and future demonstrator.

Railway switches (Points) are operated by Points Operating Equipment. Actuation provides motion, locking ensures the switch position is fixed and detection informs the signalling system that it is safe to pass trains. Ideas for integrating additional redundancy, to eliminate single points of failure, are being explored. Detailed conceptual designs will be developed for further work within Shift2Rail.

Next generation solutions for reducing or eliminating existing failure modes and manual interventions are also being studied. The principal of enhanced S&C control has been explored and an opportunity to develop, through integrated simulation, a self-adjusting capability has been identified. A range of radical S&C re-designs have also been established, which will be developed into detailed concepts for further consideration by Shift2Rail. Examples include 'back-of-wheel' guidance, vehicle based switching and concepts eliminating the thin switch blade.

(a) Simulation Benchmark Study, (b) PointCloud S&C Monitoring, (c) Advanced S&C Control Concept and
(d) Back of Wheel Guidance S&C Concept

Innovative Track Solutions

The work on Innovative Track Solutions (identified in WP3 of In2Rail) focuses on six key objectives: Rail head repair, Evaluation framework for innovative concepts to support innovative track systems, enhancement of understanding of the mechanisms/parameters regarding track solutions and its transfer into predictive models for LCC estimations, customisation of noise reduction for specific operational conditions and deriving hybrid track solutions that merge benefits of different track systems.

The track system has significant safety, efficiency and costs implications for European railways. The work to be carried out will target key aspects to deliver cost effective solutions & look at Life Cycle Cost (LCC) based on previous European Commission projects such as INNOTRACK
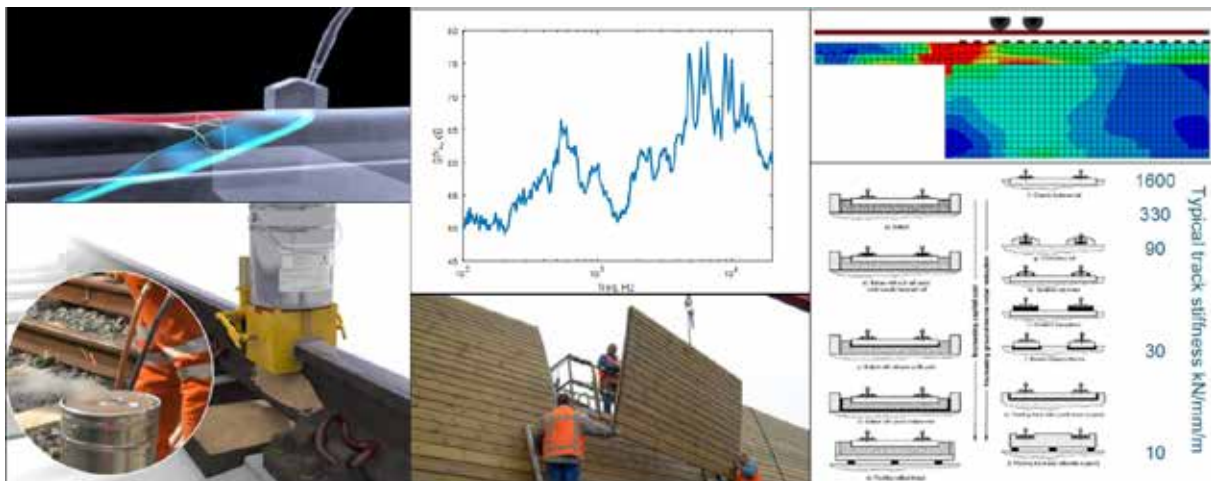
This piece of work has several interdependencies with other work packages of IN2RAIL in the following way

The main objectives feed into 4 tasks that will generate 4 deliverables intended to inform SHIFT2RAIL to progress to higher technology readiness levels for: Rail head repair, noise reduction & optimised track system selection.

Current focus is on comparing existing rail head repair techniques such as Manual Metal Arc Repair, Flux Cored Arc Repair, CTF Sauron, Railtech Head Repair and Discrete Defect Repair

Rail noise is being targeted & modelled in 3 key areas of 1) Curve Squeal, 2) S&C Crossings and 3) Tunnel Ground Borne Vibrations.

Innovative track system solutions being examined are Asphalt Track, Embedded Rail, Grouted Ballast, Under-Sleeper pads and Geo-textile Ballast Solutions.

Smart Infrastructure – Challenges & Innovative Track Solutions)

Bridges & Tunnels

Existing bridge and tunnel inspection, leitmotiv of WP4

The work focuses on bridge and tunnel inspection, involving nine partners in the development of innovative inspection techniques, following a three step plan: definition of relevant key parameters and requirements, identification and benchmarking of new and existing technologies, and proof of concept of most promising innovative solutions.

The definition of requirements has been performed considering the need of alignment with general objectives of Shift2Rail: cost-effectiveness, proactivity, reliability and low traffic disturbance. Based on these guidelines, key parameters and early indicators have been selected in the firm belief that, if thoroughly monitored, these parameters will allow better mid-to-long term planning of unavoidable interventions, application of early unobtrusive corrective measures to avoid or mitigate structural damage and deterioration, and better, longer life for old railway structures.

Once requirements and indicators have been set, on-going work is centred on the identification of suitable technologies to monitor the evolution of the latter while complying with the former. To that extent, not only novel technologies or concepts under development are being analysed: the use of old techniques in new ways is also being studied. Next steps of this work is the benchmarking of identified technologies in order to select the most promising both for the near future and for further development within Shift2Rail.

In the final step of the work to be carried out, those technologies deemed mature enough to undergo a proof of concept within the scope of In2Rail shall be subject to laboratory tests and, if possible, demonstration in relevant environment.

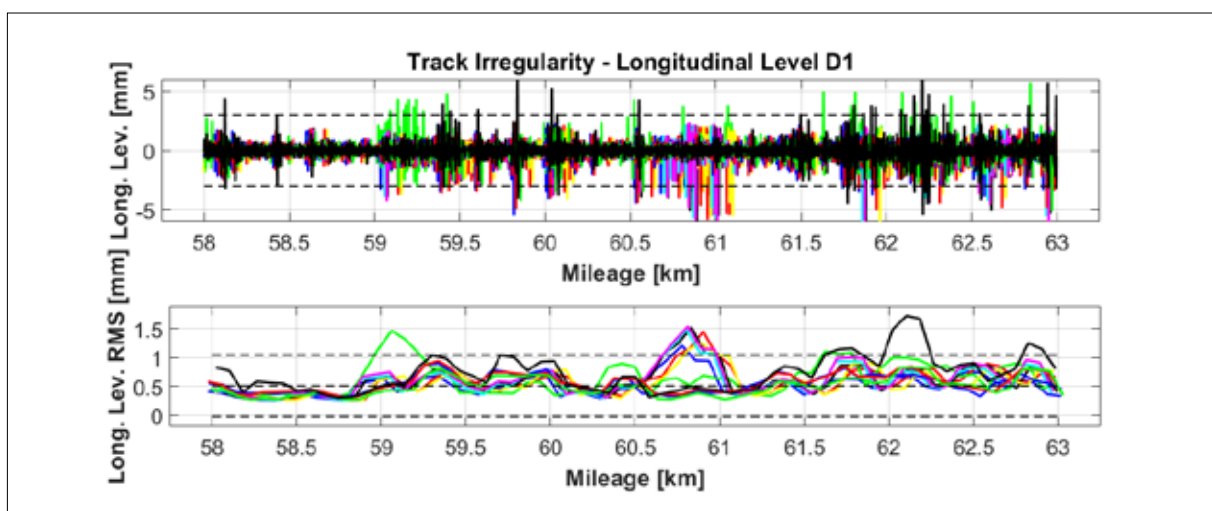# Commercial Off The Shelf (COTS) Monitoring

The main scope of the work of this research activity is to improve knowledge on track condition and rate of degradation achieving monitoring and predictive abilities for thermal stress and track geometry. This is met by using improved COTS technologies, combined with lean procedures and intelligent analysis methods, to achieve an integrated monitoring concept that will pave the way for the Technological Demonstrator of the Shift2Rail initiatives. The main influencing parameters have been defined and finalised. The scope was to outline the current data collection procedures and future needs, including current guidelines and constraints for both track geometry monitoring and thermal stress monitoring which are both currently under development.

As far as the first ongoing task is concerned, the partners are working on a concept for on-board track geometry monitoring by exploiting data collected from commercial trains equipped with simple and existing on board sensors and by focusing on a more efficient evaluation of track geometry by means of innovative methods, ready to be integrated in predictive maintenance procedure, reducing both management costs and traffic disruption. The proposed innovative methods have been already tested in lab starting from the signal analysis of train dynamics measurements (indirect measurement) provided by RFI, which have been processed following the Statistical Process Control approach, here below is reported a figure showing the first results achieved till now:

With reference to the second task, the work is focusing on the development of two key components. On one hand, the concept for an innovative rail thermal-stress monitoring system for a continuous non-destructive SFT measurement. On the other side, a concept for a risk-based operational model linking rail stress monitoring outputs to dispatching and maintenance decision-making processes is under development in order to ensure compatibility of both concepts with the IN2RAIL Intelligent Mobility Management concept.

The last task of this work stream, focused on *Technology validation*, will start in April 2017 and will develop proof-of-concepts for the developed monitoring solutions. In this regard, RFI will provide both a railway line for tests and one of their diagnostic trains that will be used to install the sensors and collect additional to be also used for comparisons.

Validation – correspondence between exceeds of the RFI's standards and exceeds of proposed control charts)
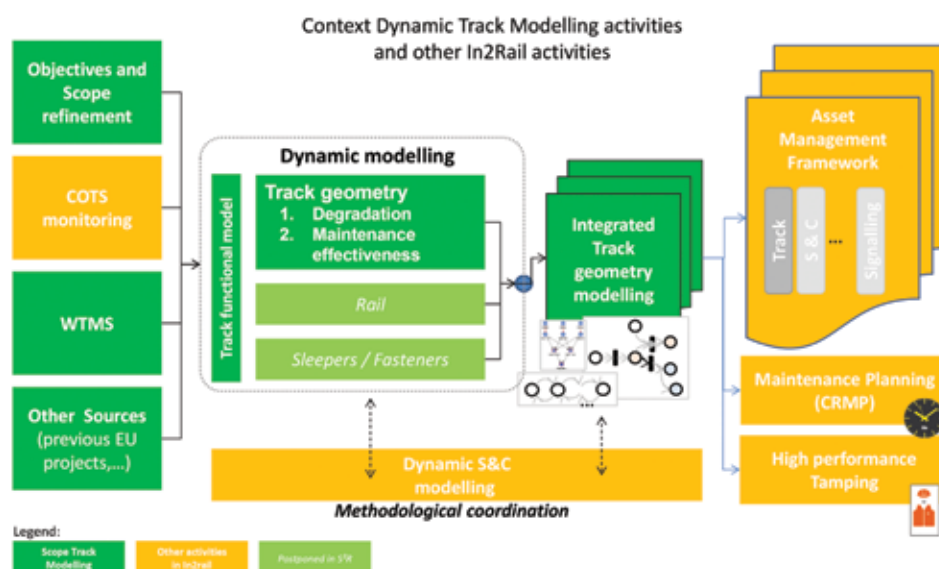
Maintenance Strategies & Execution

The work on Maintenance Strategies & Execution (identified in WP6 of In2Rail) involves 14 partners and covers 5 themes: Asset Management Framework, Dynamic model for track and switches, Condition and Risk-based Maintenance Planning and Maintenance Execution.

The Asset Management Framework forms the sound basis for future work in Shift2Rail. Since asset management is on the agenda of the rail sector in general, to avoid duplication, it has been decided to take the UIC framework as a basis. Focus in In2Rail are KPIs and a decision support framework taking into account the whole supply chain. The objective is to give guidance to practical use of Asset Management in the sector.

In alignment with the work above, Condition and Risk-based Maintenance Planning elaborates basic features of a maintenance planning concept using information on current and predicted asset condition from now- / forecasting ("condition-based"). Decisions are based on risk assessment, considering probability and consequences of failures on system or component level ("risk-based").

The modelling concerning track and switches develop new approaches, adapting existing models and new data sources. For track, 4 aspects of modelling have been identified: functional modelling, track degradation modelling, maintenance effectiveness and an integrated track model. For S&C, 4 sub-models are under development, addressing a functional approach, one dedicated to failures, one for settlement and a degradation model. These form the basis for a whole S&C system model.

Maintenance Execution has taken tamping and related activities as an example. The main outcome until now: pre-alignment activities before tamping could be substituted using track geometry measurements directly. This requires accurate positioning of recorded geometry data, using GNSS and additional measurements and the quality assurance for measured data. Post-processing of inspection and positioning data provides adequate basis for generation of tamping values.

Context Dynamic Track Modelling activities and other In2Rail activities

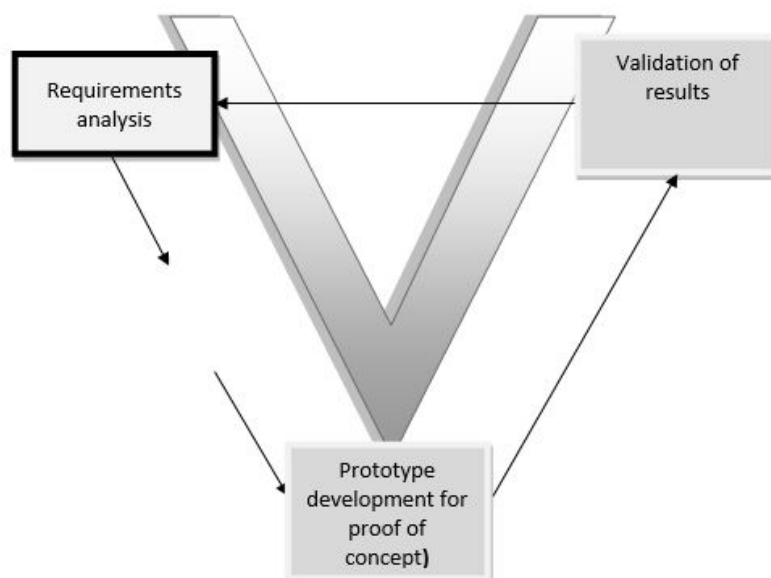# System Engineering for Future Railway Traffic Management System

The first step of every development is the definition of requirements. In case of the modern Traffic Management System (TMS) more than 40 documents containing recent tenders of European Infrastructure Managers, national projects and European Standards for interoperability were analysed. The resulting list contains 1042 requirements. They will be used for definition of Integration Layer as well as for Application Framework which should simplify development of interoperable functions inside of TMS.

In the next step the requirements were specifically described in the context of use cases. They were structured into seven groups including the classical traffic management and the integration of maintenance tasks, ad-hoc trip planning, post processing of traffic situations, restriction management, etc.

Further step in requirements definition, a larger Rail-end-User's Group Survey was made aimed to identify and evaluate customer expectations, with regard to Traffic Management Systems and Transportation Services, focusing on punctuality, reliability and availability to promote seamless and interconnected travel. The total number of customers represented by the survey is around 4.5 million.

In the next step a set of principles and guidelines for the design of a standardised Operator Workstation (WS), as part of the Integrated Traffic Management System (TMS) will be provided.

Other works will concentrate on definition and implementation of the proof of concept for the architecture delivered in Integration Layer and Application Framework. A prototype based on real data coming from one or two European Infrastructure Managers should be developed to proof functional and non-functional requirements analysed until now.

Main content of the system engineering steps in this work package

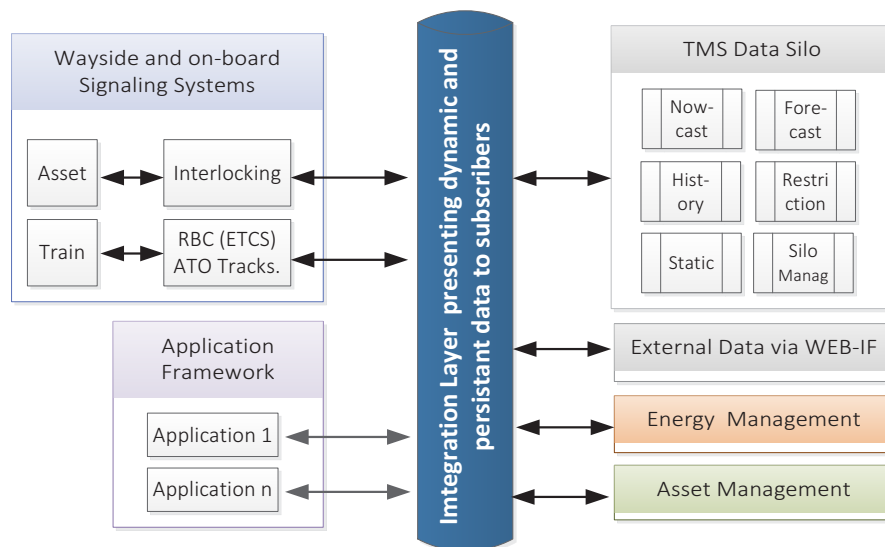# Future Data Highway for Rail Business Services

The key requirement of a future state of the art integrated Rail Traffic Operation System is the ability to provide sharing of any information relevant to the Integrated Mobility concept. The Integration Layer (IL) will provide these Data at the right time and deliver them to the right destination.

The specification for the non-functional requirements of this "Data Highway" is under final review. Next step will be the specification and description of the architecture of the Integration Layer. The main work herein will be the definition and structure of data needed for actual and future TMS applications and the critical parameters presenting status changes of a defined first set of assets (e. g. Switch) affecting the actual (Now-Casted) and future (Fore-casted) traffic status. This integration of data of different business services into one Data Highway is one of the major innovations of this programme.

Another specific focus within the design of the future IL will be to specify the Interfaces to external business services outside the rail environment such as weather forecast systems or road based services and all links to trackside Traffic Control Systems such as Automated Traffic Operation (ATO) and the communication system for ETCS (Radio Block Centre).

The second targeted major innovation of this work program is the specification of a standardized framework for business service applications which are connected through the Integration Layer and allowing a plug and play installation and operation of Business Logic SW Modules.

The specification of the non-functional requirements for such a framework has been delivered and the design of an architecture including functional description of applied substructures and Interfaces is in progress.

Trackside Data Integration through Integration Layer

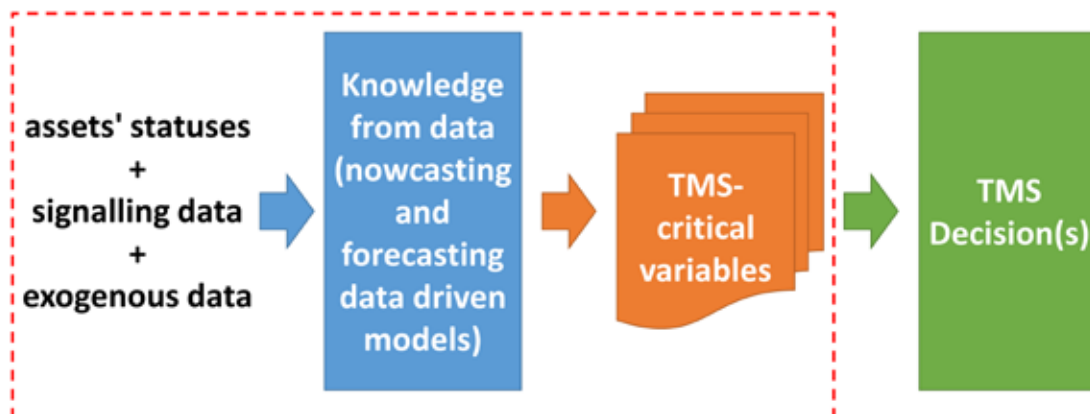# Knowledge from Assets' Status Data to Enable TMS Risk-Aware Decisions

The work focuses on Nowcasting and Forecasting in Intelligent Mobility Management (I²M) has already achieved a number of important results. Among them:

- The definition of a model for the static and dynamic representation of assets' status

- The design of an IT architecture to access assets' field data and manage them in a Big-Data environment

- The definition of nowcasting and forecasting scenarios to generate knowledge (TMS-critical variables) from data to be used by Traffic Management Systems (TMS) to take more informed risk-based decisions

The proposed model for the static and dynamic representation of assets' status is based on the integration of the railML, RailTopoModel (UIC IRS 30100) and sensorML models and a first version will be available – with some modelling examples on key assets – in the last quarter of 2016 to serve as a basis for further analysis in Shift2Rail.

The IT architecture to access assets' field data and manage them in a Big-Data environment has been designed to cope with heterogeneous field databases avoiding data replication and structured and non-structured interfaces, to allow Big-Data processing capabilities and to interface with other railway systems through the I2M integration and application layers.

The TMS-specific nowcasting and forecasting scenarios are addressing the following topics: train delays on the basis of the train positions and weather conditions; delay attributions based on train positions; risk of failure of switches and crossings based on train movements, historical failures, asset utilization, weather conditions, maintenance operations and track description; risk of train derailment based on diagnostic data, weight in motion and weather conditions; influence of weather on malfunctions of assets; influence of the maintenance done on asset status. The results will be demonstrated in the second part of the project.

Knowledge from heterogeneous data to enable TMS risk-aware decisions
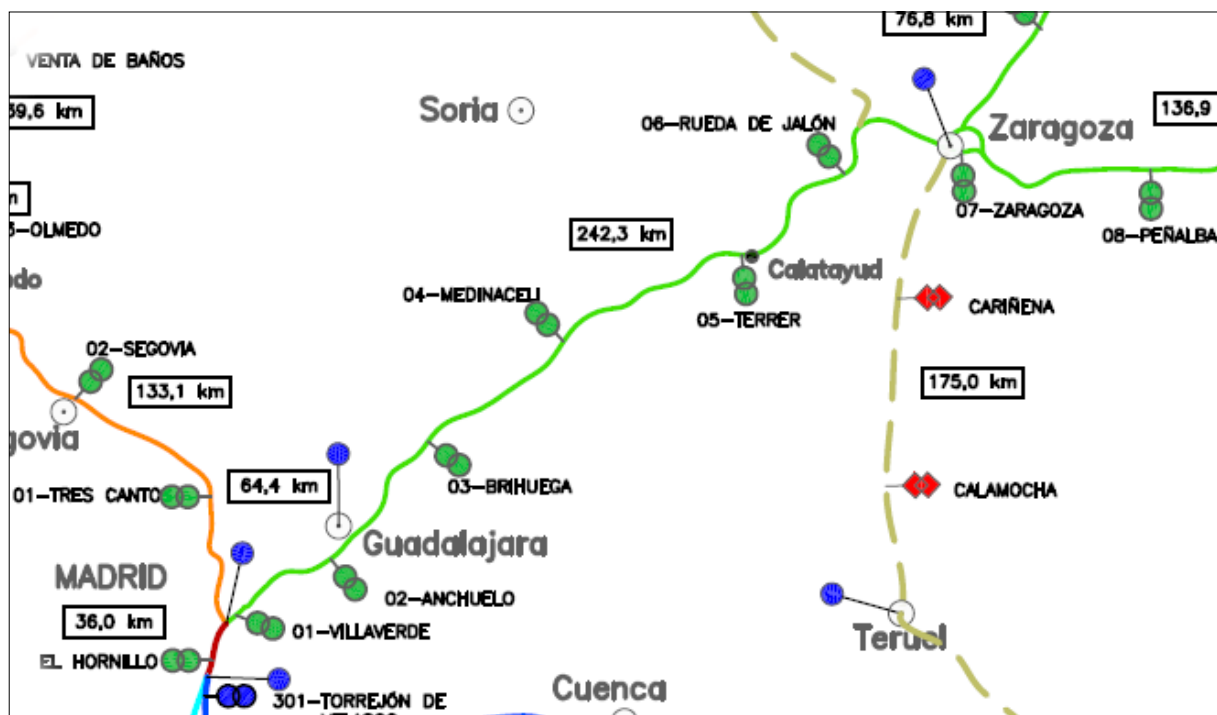
Intelligent AC Power Supply

Former Projects such as Railenergy and Merlin have shown the potential to increase the energy efficiency in Railway AC Power Supplies. Simultaneously the development of power electronics and information electronics lead to new opportunities to improve Railway AC Power Supplies. Major task is to investigate the maturity level of upcoming technologies in terms of investment and operational costs.

New power electronic converter substations need additional investment costs. Savings on investments may result from the need for a lower number of substations or smaller equipment. Saving on operational costs are related to energy consumption and to the power quality towards the feeding grid. Classical power quality parameters like unbalance, power factor, harmonics and flicker, the prediction of energy consumption and the avoidance of power peaks are becoming more important.

The latest developments in information electronics and new standards for protocols lead to higher availability of the traction power supply due to increased redundancy and mutual information exchange between all components. Advanced protection concepts including monitoring and optimized maintenance are enabled.

The investigation of 3 lines in Spain has started. This will finally lead to a distribution network simulation under consideration of the specific characteristic of Railway Systems.

A novel protection scheme is developed for 16,7 Hz in order to provide a higher availability of the power supply with a similar amount of components. As there is no wear in power supply components the failure rate of control electronics is determining the availability. Self monitoring and redundant functions can increase the availability and enables repair under operation.
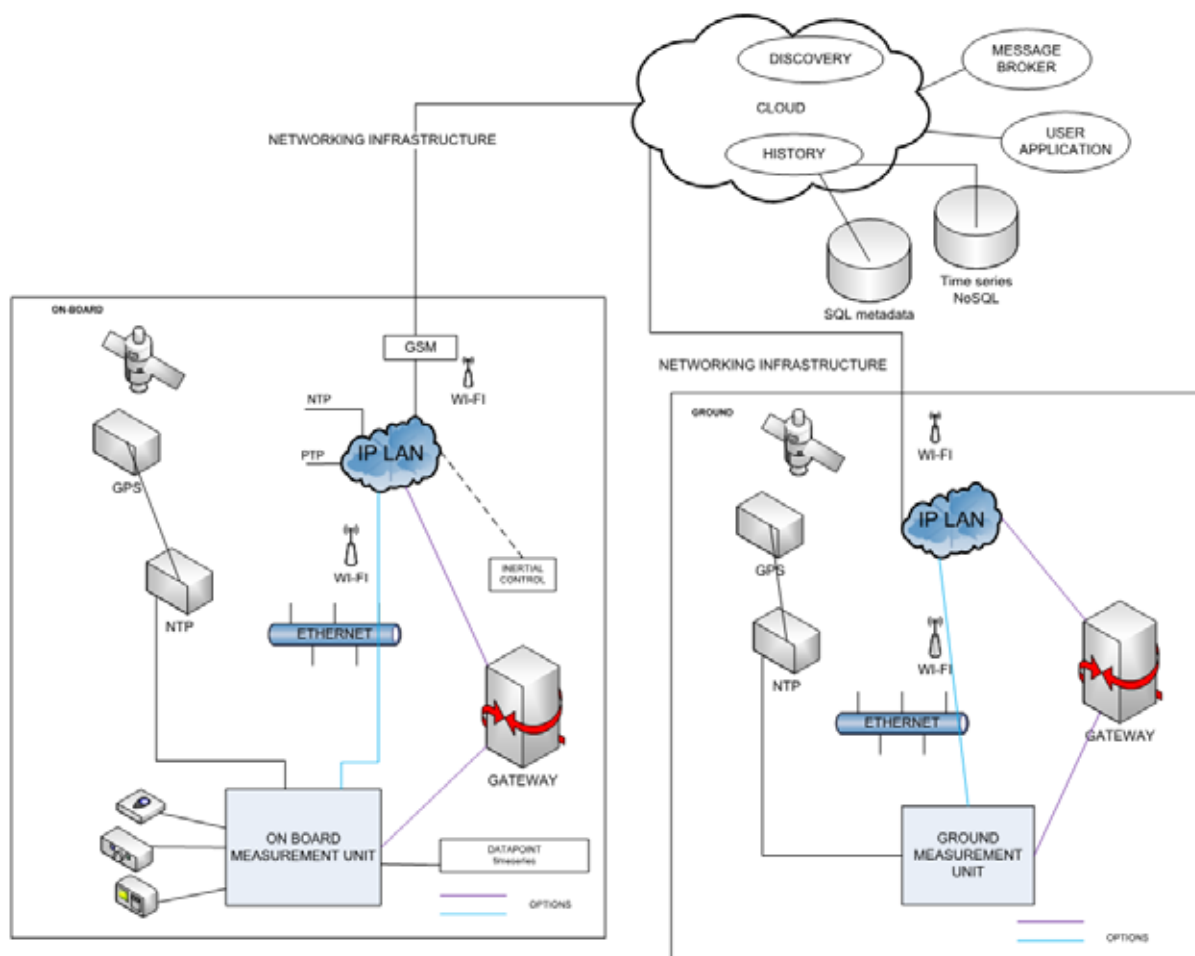

One use case

Smart Metering for Energy Management

The main objective of the work is to design an open system dedicated to the fine mapping of different energy flows within the whole Railway System on a synchronized time basis. The main aims are:

- To realize the design of a non-intrusive Smart Metering sensor network at a Railway System level.

- To define an open system and interface for data collection, aggregation and analysis in an open source ODM (Operational Data Management) Platform.

- To realize a set of User Applications design and specifications. The Applications will exploit the energy analysis process with the aim of enhancing the energy decision making and the line operation patterns.

- To provide the building blocks for Shift2Rail demonstrator implementation.

Global smart metering system architecture

Intelligent AC Power Supply

In line with Shift2Rail strategic targets, the expected output of this system implementation is a clear understanding of energy flows within the railway system, a reduction of the energy bill, an optimised asset management and an increase of the railway capacity offer.

Three main achievements were realized until now:

- The smart metering system architecture main blocks and the definition of all subsystems and their functional specifications, has been performed. The interfaces between the different modules and User Applications have also been identified.

- The state of the art technologies and solutions overview has been performed. This included a detailed analysis on sensors and metering solutions, data management solutions, wireless network technologies and application design. A wide range of technical solutions, related to energy data management and analytics have been investigated.

- The possible application of existing standards has been analysed; the main standards related to on-board equipments, e.g. energy measurement on board trains EN 50463, as well as train communication network standards have been analysed. Moreover, a gap analysis between some Standards used in the railway domain and the architecture of the RDERMS has been performed.

In the coming months, work will focus on data management design and a proof of concept, from measurements to analysis, to experiment several technologies in such a smart metering system. This will be done with regards to the general architecture mentioned above.

Past and Upcoming Events

In2Rail Kick-off meeting
7 May 2015, Brussels

The In2Rail project kick-off was successfully held in Brussels on 7 May 2015. The event was organised in two parts: a common session with the other lighthouse projects started under the Horizon 2020 first call and specific sessions for each individual project.

TRA2016
8-21 April 2016, Warsaw

TRA is the major conference on transport in Europe, supported by the European Commission, the Conference of European Road Directors, and four European Technology Platforms: ERRAC, ERTRAC, WATERBORNE and ALICE TP. In2Rail project was presented by Mr. Roberto Bianchi, Siemens AG, with a poster focused on the digital substation.

WCRR2016
29 May-2 June 2016, Milan

The 11th edition of the World Conference on Railway Research was held in Milan from 29 May-2 June. The numbers of this edition were impressive, with over 1000 participants from more than 30 nations around the world, and more than 300 speakers, papers, e-posters and proofs of concept. In2Rail brochure was distributed at UNIFE stand and its staff provided the participants with information on the latest developments of the project.

Innotrans2016
20-23 September 2016, Berlin

InnoTrans 2016 is the biggest rail infrastructure event in Europe which will take place from 20 to 23 September 2013 in Berlin. The project will be presented by In2Rail Project Coordinator Network Rail at UNIFE stand during a dedicated Shift2Rail Lighthouse session on Wednesday, 21st of September, at the UNIFE stand.

In2Rail Mid-term conference
17 November 2016, Brussels

The mid-term conference will be held at Sheraton Brussels Hotel (Place Charles Rogier 3, 1210 Saint-Josse-ten-Noode). Registration is now open. For more information please visit www.in2rail.eu.

Notes

Facts and Figures

Total Budget:

€18
million

54
Partners

Duration:

36
Months

Project Start Date:
1st May 2015

Project End Date:
30th April 2018

Grant Agreement No:
635900

Partners

Project coordinator