Newsletter

April 2018

Introduction

In2Rail was set up as a lighthouse project for Shift2Rail to pave the way for improved capacity and reliability and reduced costs. The H2020 project ran for 36 months, collaborating with 54 consortium partners. In2Rail has now completed its aims and objectives that were set out. The holistic approach has been achieved with the multi discipline project, which will now see the outputs from the 3 sub projects (Smart Infrastructure, Intelligent Mobility Management (I2M) and Rail Power Supply and Energy Management) taken forward into IP2 and IP3 of Shift2Rail.

The In2Rail project has set the foundations for a resilient, consistent, cost-efficient, high capacity European network through some of the consortium achievements listed below:

1. A new methodology for monitoring thermal stress to reduce problems in current monitoring procedures with the introduction of a technique that can provide continuous temperature monitoring without stress (SFT) with a significant number of disruption of traffic and the need for personnel on the track;
2. Design of a communication platform (Integration Layer) using standardized data structures and processes managing the Communication/Data exchange between different services and supporting TMS applications connected to other multimodal operational systems;
3. Smart Metering system to demonstrate that non-intrusive sensors allow power and energy calculations through modelling and simulation processes.

The In2Rail project has unlocked innovation potential. Innovative technologies were explored, and case studies documented for the achievements of innovation through the sub projects.

This newsletter brings together all the main achievements of the project by sub project and work package. Each work package outlines the collaboration / inputs into the Shift2Rail programme. The In2Rail project has provided establishing building blocks to the Shift2Rail programme.

The outputs into IP2 will be developed around smart, fail-safe communications and positioning systems; Traffic Management Evolution; Automation; Moving block and train integrity; Smart procurement and testing; Virtual coupling and Cyber security.

The outputs into IP3 will be developed around Enhanced Switch & Crossing System, Next-Generation Switch & Crossing System, Optimised Track System, Next Generation Track System, Proactive Bridge and Tunnel Assessment, Repair and Upgrade, Dynamic Railway Information Management System, Railway Integrated Measuring and Monitoring System, Intelligent Asset Management Strategies, Smart Power Supply, Smart Metering for Railway Distributed Energy Resource Management System and Future Stations.

If you would like to find out more about the project, visit www.in2rail.eu or join us for the In2Rail final event on Thursday 19th April 2018, from 08:00 at Waggon-31-Riesenradplatz 2, 1020 Vienna, Austria.

Amanda Webster
In2Rail Project Coordinator, Network Rail

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No: 635900

WP2 - Smart Infrastructure

Innovative S&C Solutions

Work package 2 focusses on railway switches and crossings (S&C) and considers both short and long-term developments. There are four main sub-projects, including novel S&C locking mechanisms, embedded and integrated sensors, radical S&C redesign and self-adjusting, inspecting and correcting S&C.
Within novel S&C locking mechanisms, concepts for providing redundancy within existing switch points operating equipment (POE) have been investigated and down-selected for detailed conceptual design. The concept of integrating a Hall Effect detection system within existing POE has been developed and assessed for integration within existing signaling systems. A radically new 'Screwlock' system concept, which introduces innovative switch actuation and locking, has also been developed.
The embedded and integrated sensors work has investigated a vast range of different measurement techniques in order to establish relationships between the measurement parameter and asset condition. Technologies including accelerometers, geophones, displacement sensors, high speed filming with digital image correlation, strain gauges, ultrasonic probes for acoustic emissions and small-scale 3D-scanners for S&C rail profile measurements have all been physically implemented across several sites in Sweden, Poland and the UK.

Research into radical S&C redesign has opened up creativity and innovation by removing existing operational constraints. 18 different ideas were generated, scored and down-selected for further work. State-of-the-art multibody simulation and small-scale models have been used to demonstrate concept feasibility and to inform detailed design choices. A preliminary life cycle costs analysis has been completed for the more mature concepts in order to provide recommendations to Shift2Rail.

The objective of the self-adjusting switch task was to demonstrate that manual maintenance interventions related to the switch rails becoming 'out of adjustment' could be eliminated through 'self-managing' assets. A conceptual design using advanced control system logic has been developed and demonstrated within a co-simulation model using Simpack and Simulink. A closed-loop control system has been integrated within the final concept and tested to demonstrate overall feasibility.

Figure 1 - In order from top left; MEMS accelerometer, Geophone, High Speed Camera, Algutsgården site and Acoustic Emission laboratory trial

Figure 2 - Radical S&C concept small-scale model

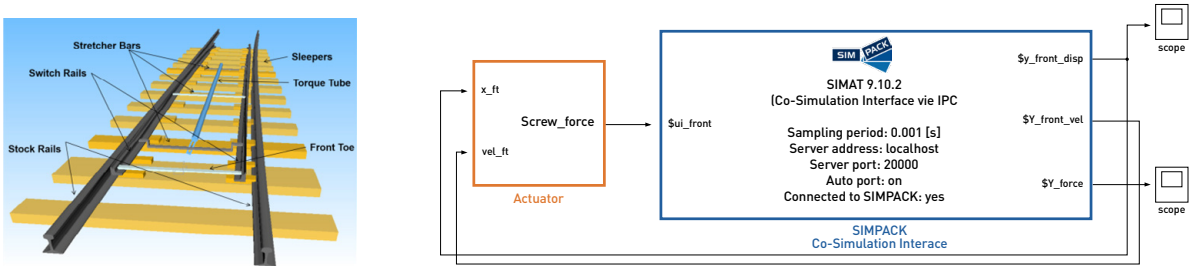
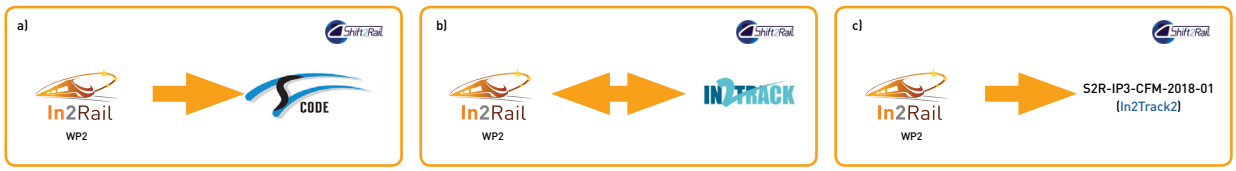


Figure 3: Multibody simulation of self-adjusting Switch and Co-Simulation model for advanced closed-loop control

Links with Shift2Rail

In2Rail WP2 has completed fundamental research to pave the way for further S&C system enhancements and radical new system capabilities to be delivered within Shift2Rail.
WP2 overlaps the Shift2Rail Open Call project S-CODE and provides early conceptual design work within the area of self-adjusting switches and radical S&C redesign (a).
Moreover, WP2 overlaps the In2Track CFM project and provides initial development work specifically within the area of Embedded and Integrated sensors (b).
Finally, WP2 will feed into the Shift2Rail 2018 CFM proposal In2Track2 and provides early development work specifically within the area of switch self-adjustment, redundancy concepts, embedded and integrated sensors and radical switch redesign (c).



WP3 – Smart Infrastructure

Innovative Track Solutions

Rail Head Repair

The examination of statistics from 3 Member States shows a good business potential for rail head repair techniques to be employed in contrast to total rail replacement. An assessment scheme has been developed and applied to the existing state of the art and one innovation method for Discrete Defect Repair at the rail head. Imperfect weld geometry yields that environments of high line speed and high track stiffness require tighter controls. With a combination of numerical simulations, laboratory testing and validating field tests, an evaluation process can be adopted to 'Streamline' an approval process of weld repair assessment which if realised would significantly decrease time and cost for the approval on new innovative methods of rail head repair.

Solutions to Decrease Noise & Vibration

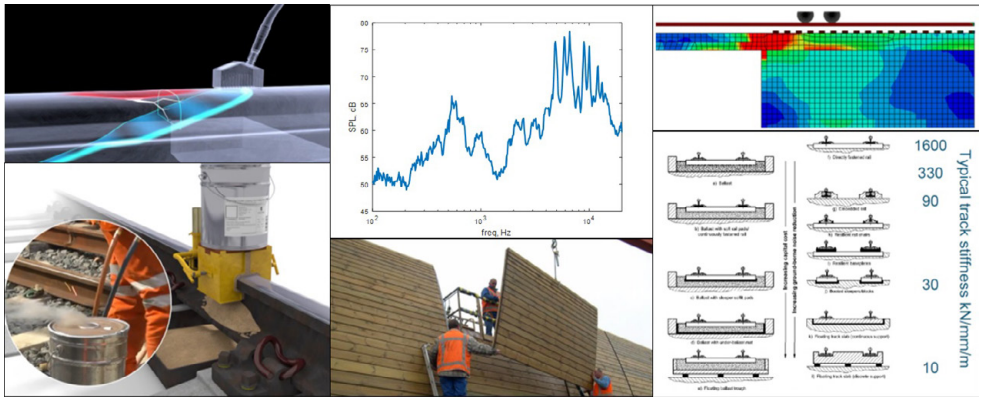
The outcome of the study yielded two models for predicting squeal & impact noise and a validated Finite Element model to predict ground born vibration. Parameters studied identified what can be the leverage to improve existing solutions or investigate new means of mitigation. The models are at the stage to deliver good estimations of the noise and vibration generated against when values of the parameters are assigned based on site conditions and the mitigation employed. The models do require full validation but can already contribute towards further mitigation solution development.

Evaluation of Optimised Track Systems

This study was planned in order to establish the status of track form enhancements, evaluate the selected modifications (including hybrid solutions) towards identified distinct parameters, Key Performance Indicators (KPIs), LCC estimations of short and long-term benefits as well as produce recommendations of solutions/concepts to investigate further in Shift2Rail.

Guideline for Evaluation and Selection of Innovative Track Solution

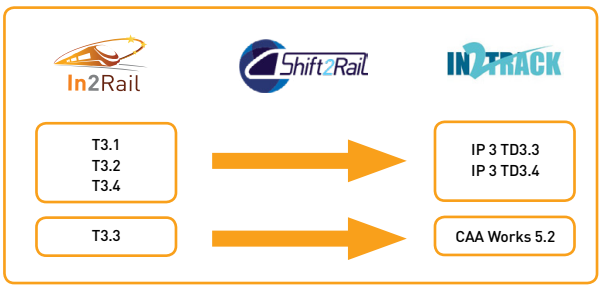
Ballast & Hybrid solutions have undergone a value analysis against key assessment criteria for track, heavily connected to five distinct parameters. The analysis looked further into the structure of global KPIs and contributing KPIs of a selection of innovative track solutions chosen by the partners.



WP3 Innovative track Solutions

Links with Shift2Rail

The illustrated road map shows the connectivity of the In2Rail tasks (bottom & left) to the In2Rail deliverables which subsequently feed into Shift2Rail technical demonstrators (top right).
Noise & Vibration will feed into CCA work 5.2 where the utilisation of the parameters identified & the simulation models will provide insight to the most appropriate solutions to reduce noise & vibration.
All remaining In2Rail tasks and deliverables feed directly into IP3 Technical Demonstrator's (TD) 3.3 & 3.4.



Synergies between In2Rail WP3 & Shift2Rail

WP4 – Smart Infrastructure

Bridges & Tunnels

In the second half of the In2Rail project, Bridges & Tunnels have developed and demonstrated new innovative methods for inspection, monitoring, repairing, strengthening and upgrading of bridges and tunnels. Based on KPIs developed in the early stage of the project, specific technologies were identified. The most promising of them were benchmarked and selected according to defined criteria and some technologies were selected for demonstration. As an example, the following technologies have been demonstrated.

- Image analysis - combination of digital image acquisition and processing. The technology has been used to create digital twins of assets;
- Fatigue assessment systems - integration of a monitoring system with a theoretical model for remaining service life prediction. It is intended mainly to determine fatigue deterioration of bridges;
- Electrical resistivity tomography - an imaging technique that provides cross-sectional images with the help of penetrating waves. It may be a suitable technology for detecting and imaging the amount of pipe clogging due to mineral scale deposits in tunnel drainage;
- Ground penetrating radar - uses pulses of electromagnetic radiation to penetrate the surface of the ground to reveal any anomalies in soil or other materials. May be used to evaluate the subsurface properties and condition of tunnels, bridges, foundations and geological layers affecting these structures.

Photo of a bridge and digitalized model from photogrammetry

Links with Shift2Rail

Bridge and tunnel monitoring technologies are an essential part of related Shift2Rail Technical Demonstrator (TD) 3.5 demonstrators. Identified technologies will be transferred to the ongoing In2Track and planned Shift2Rail Annual Work Plan (AWP) 2018 members' projects. Identified technologies, e.g. photogrammetry for creating digital asset twins, hybrid sensing for fatigue damage monitoring, wireless sensors systems, on-board tunnel monitoring will be key enablers for several Shift2Rail objectives for tunnel and bridges including early detection of damage, reducing uncertainties and creating less traffic disturbance.

Synergies between In2Rail WP4 and Shift2Rail

WP5 – Smart Infrastructure

Commercial Off The Shelf (COTS) Monitoring (thermal stress and track geometry)

This work package had two aims, the first aim was to develop a complementary approach to the existing track geometry monitoring, providing much more data from the commercial operation of trains, even if less accurate, in order to carry out more targeted and optimized registration campaigns. Validation was performed using a diagnostic train (Aiace) equipped with a COTS sensor. The COTS sensors chosen as for In2Rail project are mono-axial type, MEMS technology based.
The In2Rail-TG system is installed on the coach 8 of the AIACE-Y1 train. The sensors are installed in four different points of measure:

- two points of measure on the car body;
- two points of measure on the bogie frame.

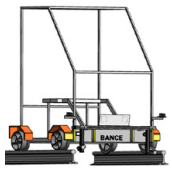
In each point of measure, a lateral and a vertical accelerometer is attached. Each sensor is installed with the sensitive axis parallel to the measurement of interest.

The second aim was to validate the methodology for thermal monitoring considering how thermal stresses influence the risk of track buckling (and rail breaks) and how this risk is related to the current rail temperature, its current stress-free temperature and the track resistance towards track buckling.

The rail temperature measurement was carried out using COTS sensors positioned under a small vehicle built and assembled by Ansaldo STS. The analog data from the sensors were digitized and acquired by a local host; subsequently they are analysed, combined with GPS information (position, speed, etc.) to obtain the rail temperature measurement with the required accuracy. The sensors are mounted in order to observe the upper side of the rail and in such a way to be quite close to the rail. The different tests were performed on a part of the ring present within Hitachi Rail Naples. The sensors were mounted on the small vehicle that is capable of travelling up to a maximum of 30 km / h and the devices with which the vehicle was equipped have allowed to:

- measure the temperature of the rail;
- record all the temperature measurements coming from the two sensors;
- capture and record geo-referenced data (generally location and speed).

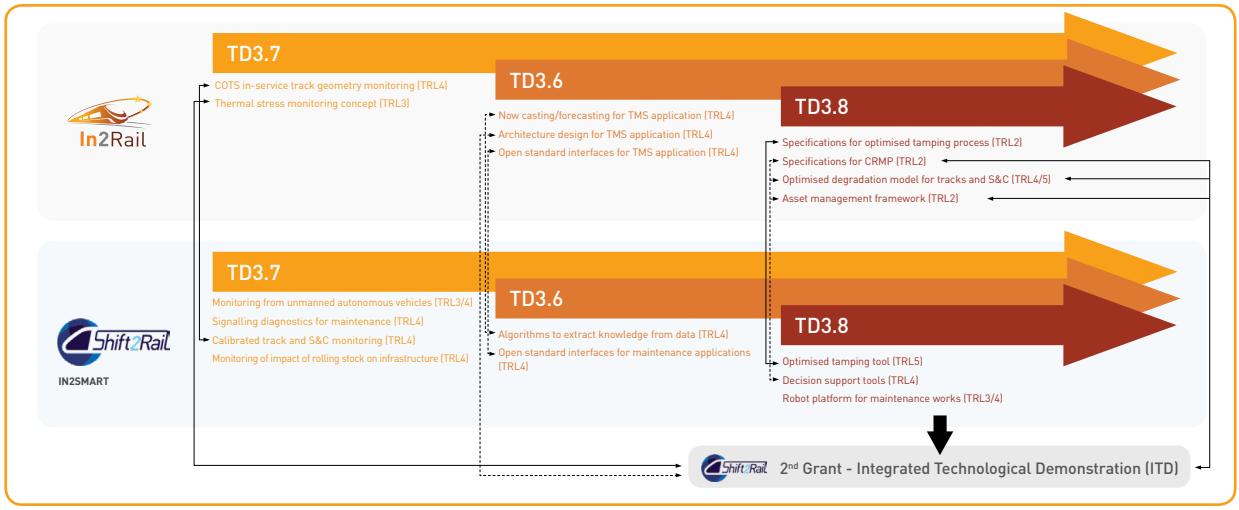
AIACE diagnostic train (RFI-MERMEC)



Small vehicle (ANSALDO)

Links with Shift2Rail

The activities carried out in the WP5 are allocated within the IP3 of the Shift2Rail project and in particular in the TD3.7 of IN2SMART With regard to the monitoring of track geometry, it is important to underline that some concepts have been applied within In2Rail and others have been integrated into IN2SMART's WP4. Both the activities developed in this WP, track geometry and rail thermal monitoring, will continue later in the IN2SMART follow-up project which will start in 2019 and will reach a TRL 7.



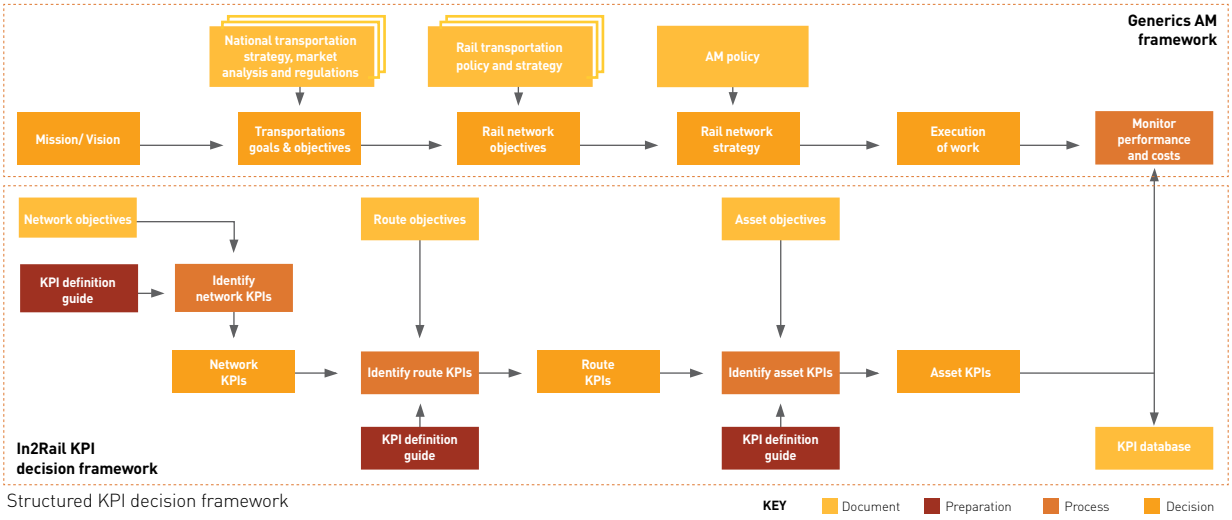
Synergies between In2Rail WP5 and Shift2Rail

WP6 – Smart Infrastructure

Maintenance Strategies & Execution

This work package of In2Rail is related to the technical demonstrator (TD) 3.8 of Shift2Rail and In2Rail WP6 dealt with several aspects of this TD. This included 1) an asset management framework, 2) for both track and S&C introducing dynamic modelling, 3) condition and risk-based maintenance planning (CRMP) and last but not least, 4) improved tamping methods as an example for new working methods.

For the asset management framework, the result includes a framework for KPI decision making and a framework for performance prediction, modelling and decision support. The result fills the need for a structured KPI decision framework (see diagram) and includes a KPI definition guide.



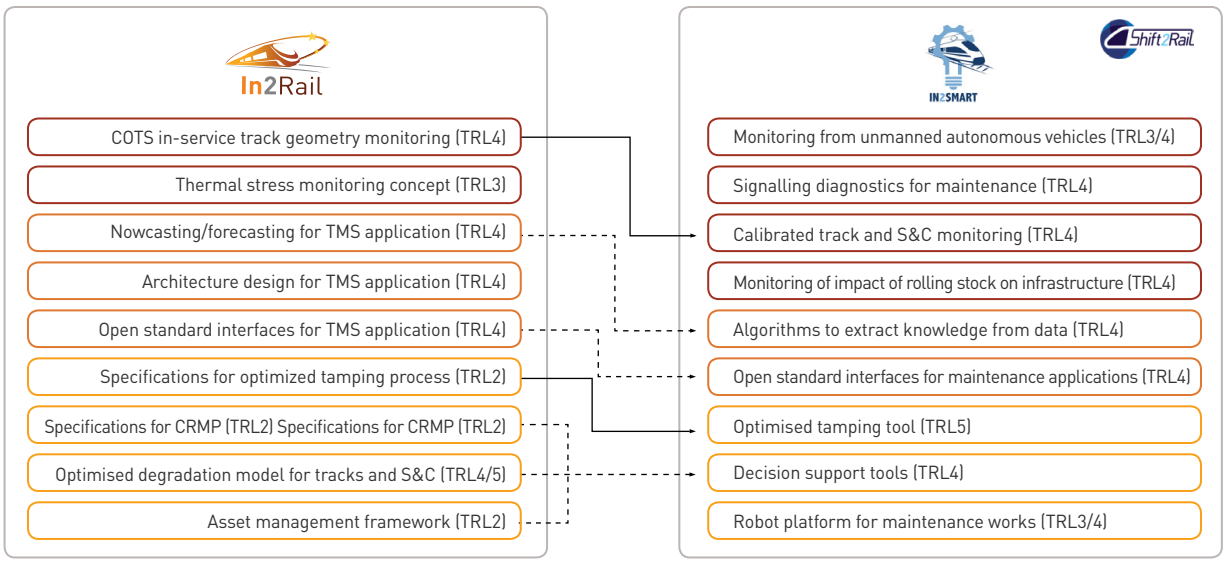
Structured KPI decision framework

Both the dynamic model for track and respectively dynamic model for switch maintenance have chosen a similar approach. Innovative modelling combining functional and maintenance effectiveness models is tested based on real life data and expert knowledge. Multiple factors degradation models are used for local assessment of status indicators in order to provide decision support. The deliverables present concepts, prototypes and tests for these improved and innovating modelling approaches. The results show the potential and lay the foundation for future work.
The CRMP linked the theory of the planning concept to the railway practice using real-world use cases. Use cases involve day-to-day planning with a rolling time horizon and focus on an optimal usage of track possession windows. The results show the relevance of the CRMP system.

Concerning the high-performance tamping, besides the fact that the requirements have been developed, a first test has also been performed. 1700m of track has been tamped based on the data directly from the measurement train.

Links with Shift2Rail

Work Package 6 of In2Rail is directly related to the Shift2Rail's IN2SMART member (CFM) project. See diagram below for the links with the work packages in IN2SMART. Work on the optimized tamping is on-going. The planning building blocks, optimized degradation modelling and asset management framework are the basis for the decision support tools in IN2SMART.



Synergies between In2Rail WP6 and Shift2Rail

System Engineering

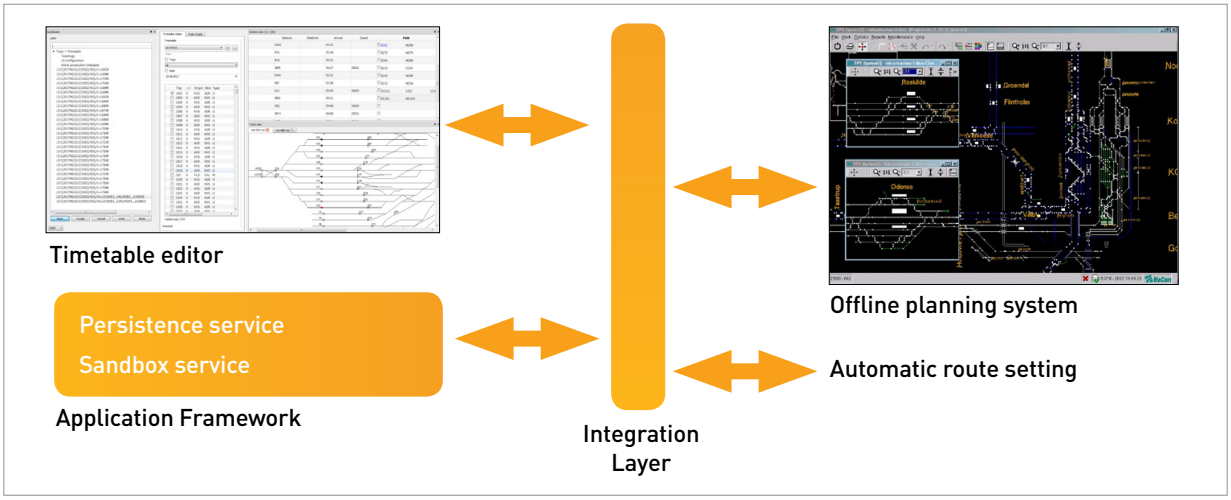
The objective of WP7 in the second part of the project is the proof of concept for the specifications developed in WP8. The specification is comprised of:

- Data set definitions required for modelling the TMS operations;
- Integration Layer providing data management and data access facilities;
- Application Framework establishing a platform for plug-and-play microservice architecture.

During the proof of concept, the question about scalability and completeness of the specification must be answered:

- Is the system able to cover small and large railway networks?
- Is the level of detail sufficient to represent existing infrastructure and timetable data?
- What are the technical limits for the selected set of products?

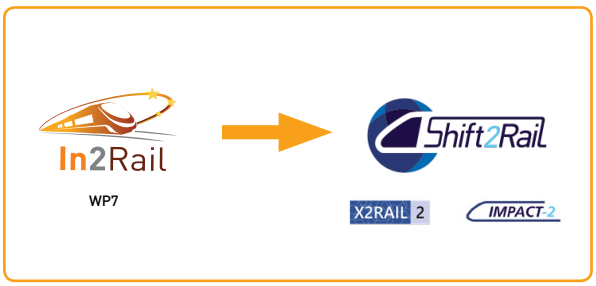
To answer this question a complex software system was created from existing systems and simulations, with newly developed components and services (Figure below).
The system uses real data from existing production systems covering a railway network with 5000 km tracks and over 1500 train movements daily. The prototype was tested on a portable computer cluster to evaluate failover functions and concepts. The evaluation results show that the concepts developed in WP8 are able to cover at least medium sized networks and support innovative functions in the future TMS.



Software system with newly developed components and services

Links with Shift2Rail

The prototype developed provides a mature platform for development of technical demonstrators in X2Rail-2 (WP6) and Impact-2 (WP7). To allow compatible solutions, it is essential that the preliminary specification undergoes an evaluation step in the prototype. As a consequence, in the mentioned Shift2Rail projects, the parallel prototype development by several companies can start earlier and provide compatible software solutions.



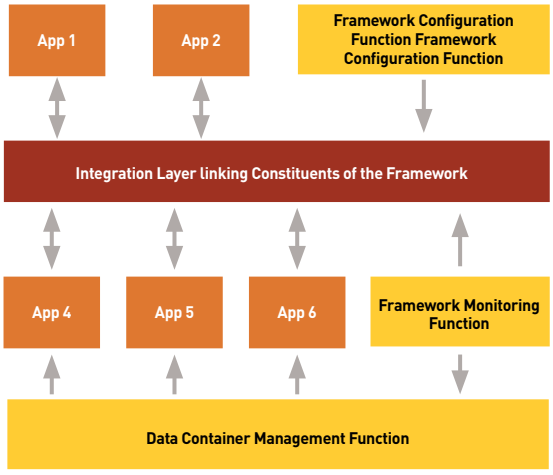
Synergies between WP7 and Shift2Rail

WP8 – Intelligent Mobility Management

Integration Layer

WP8 "Integration Layer" of In2Rail (Lighthouse to X2Rail-2 WP6 "Traffic Management Evolution" and IMPACT-2 WP7 "Integrated Mobility") is part of the Intelligent Mobility Management (I2M) sub-project and comprises the specification of a standardized Communication Platform ("Integration Layer") and a generic Platform for Business Applications ("Application Framework").
The work on "Integration Layer" has delivered the requirements, processes and Data structures of the Integration Layer needed for Traffic Control and Time Tabling operations, data exchange with Asset and Energy Management services and the communication with external clients via WEB-IF. The main innovation of this concept is a common Data Model and a standardized data structure for all data and messages to be exchanged between connected services.
Existing implementations can be easily integrated via standardized interfaces and the proposed "In-Grid-Data-Memory"- Technology allows substitution and reduction of the complexity of point-to point communication applying Subscribe & Publish (S&P) Principles to link different business services and applications.
The new communication platform allows the integration of different rail asset status data into one commonly shared communication layer and will therefor improve the efficiency of decision-making processes of all linked rail business services enabling them to meet their future targets for capacity growth, reliability improvement and cost reduction.

The activities of "Application Framework" have delivered a specification of how Plug-and-Play installations of the different business service applications in a framework can be ensured. It is therefore possible to avoid complex and costly functions and data mapping processes within the interface structures.
The concept of the Application Framework allows systematic deployment, configuration, monitoring, management including failover, maintenance, load balancing and removal of the applications managed.
In the future it is assumed that a Traffic Management System will be created by many Apps representing a form of microservices design pattern and originating from different vendors. In this case the usage of an Application Framework is inevitable. The following picture illustrates the generic functional design of such a framework.



Generic functional design of an Application Framework

The proof of concept of the design of the Integration Layer and the Application Framework is currently executed under WP7 Task 3.

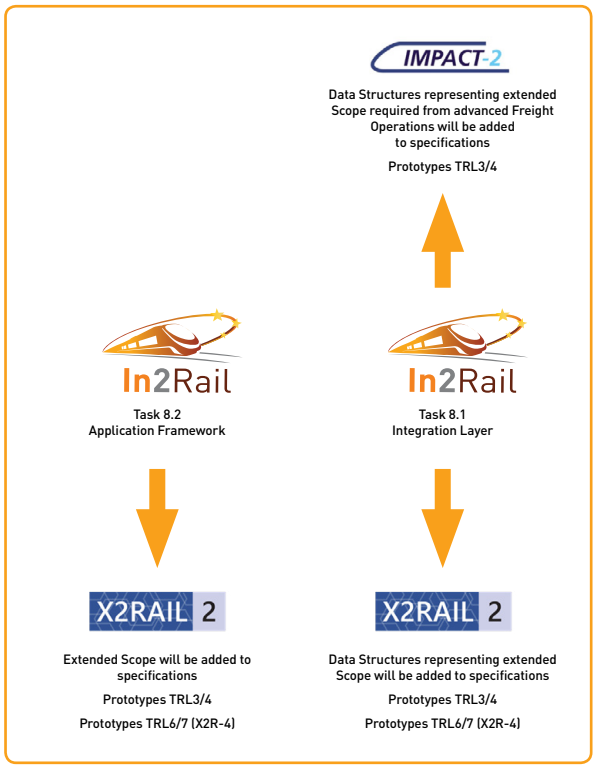
Links with Shift2Rail

Deliverables "Requirements of the Integration Layer", "Interfaces", "Description of the Integration Layer" are complemented by "Interface Control Document for Integration Layer Interfaces, external/WEB interfaces and Dynamic Demand Management" in order to deliver input for the extended scope addressed in the "Integration Layer" and "Functionalities and Interfaces for Dynamic Demand and Information Management to and from external Clients" in X2Rail-2

In parallel, the results from In2Rail WP8 are required for IMPACT-2 WP7 "Integration Layer" where all necessary data structures representing new Freight Train/Cargo Status Information are added to this Communication network.

The Integration Layer interfaces the TMS with trackside signalling infrastructure for ATO (X2Rail-1, WP4), RBC and Interlocking and RBC (needed for ETCS L3 operation), Asset Management Services (IP3), Grid (Energy) Management Operations (IP3) Freight Forwarder Planning and Monitoring Systems (IMPACT-2, WP7 and IP5) and via WEB-IF Passenger Information providers (IP4) and other external businesses requesting rail traffic status information.

WP8 Deliverables "Requirements of the Application Framework", "Description of the Application Framework", "Interfaces" and "Test Concept" are input documents for X2Rail-2 WP6 "Application Framework".



Synergies between In2Rail WP8 and Shift2Rail

WP9 – Intelligent Mobility Management

Nowcasting and Forecasting

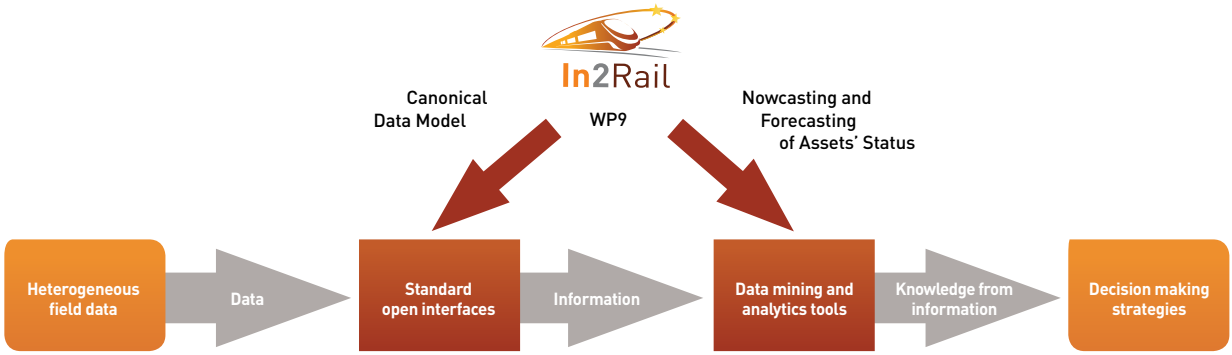
The main WP9 achievements for the second part of the project have been:

- Innovative nowcasting and forecasting scenarios based on data;
- Significant progress in the definition of a Canonical Data Model (CDM).

The work of WP9 has been focused on data collection, algorithms study and implementation, verification and validation for the following nowcasting and forecasting railway scenarios in support to TMS and maintenance applications:

- Studying train delays depending on train movements and weather conditions:
  - Nowcasting train delay in the next "check-point" based on the past train movements and past/actual weather conditions;
  - Forecasting train delay in all the sub-sequent "checkpoints" based on the past train movements, past/actual weather conditions, and future predicted weather conditions.
- Studying repair actions reports and weather data for different assets and failures to predict Time to Restoration (Function Restoration Time, Repair Time, Response Time, Travel Time);
- Using switch monitoring data to now- and forecast switch conditional / functional status;
- Nowcasting the probability of failure of switches and crossings for replanning the routing of the trains in the railway network.

The scenario of nowcasting and forecasting train delays has been further developed to become part of the WP7 proof-of-concept.
WP9 has also started the development of a Canonical Data Model based on railML dealing also with the problem of dynamic data modelling that emerged from the data analytics applications.

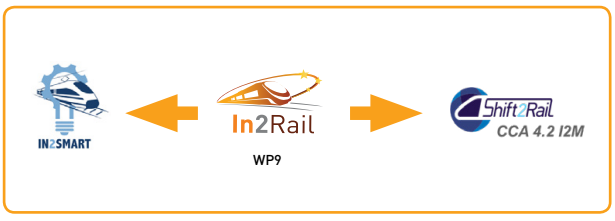


Contribution of WP9 to the general data processing in Shift2Rail IP3

Links with Shift2Rail

In2Rail WP9 is linked with and has contributed to the following S2R initiatives:

- The S2R Cross-Cutting Activity (CCA) 4.2 Integrated Mobility Management (I2M) The S2R project Intelligent Innovative
- Smart Maintenance of Assets by integRated Technologies (IN2SMART)

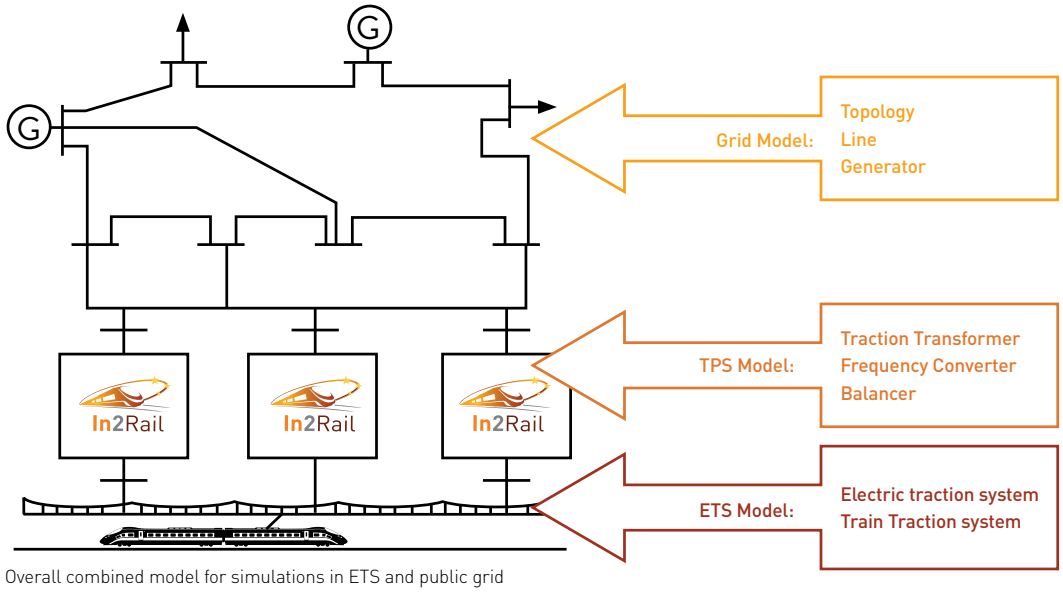


Synergies between In2Rail WP9 and Shift2Rail

WP10 – Energy Management

Intelligent AC Power Supply System

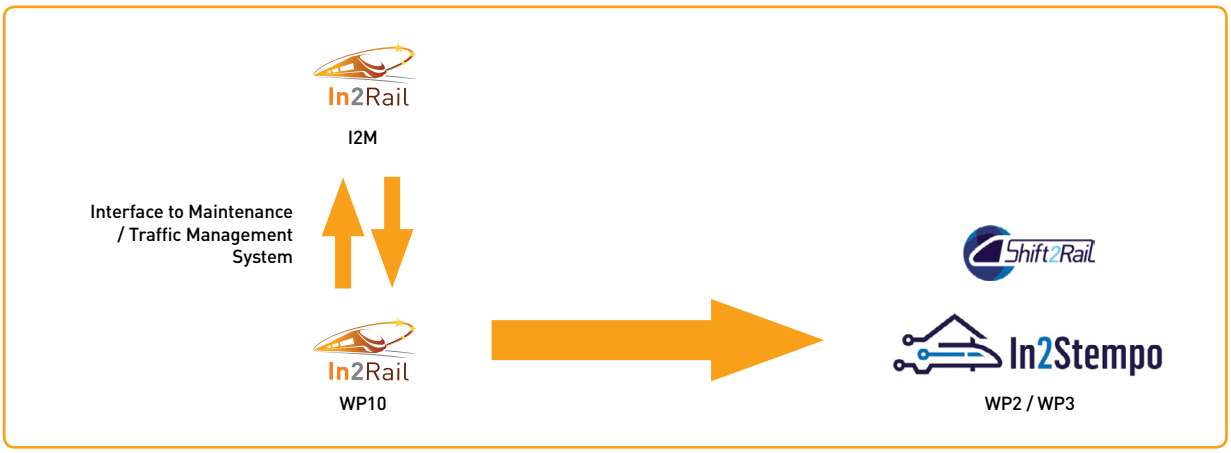
WP10 focuses on intelligent AC power supply in electric traction systems (ETS). One of the main topics is the use of power electronics for 3 existing lines in Spain. Among others, increasing traffic on an existing line might lead to violation of the grid code for connection of loads to the public grid. In such case, the infrastructure manager is at risk of being disconnected, resulting in huge delays in the train schedule. This can be overcome by the application of power electronics for balancing or converter feeding. Resulting impact on public grid as well as on the ETS itself is analyzed. Converter feeding reduces the short-circuit current and enables double-side feeding, thus leading to reduced peak power demand and avoidance of phase separations. By using this technology for conversion of a DC electrified line to AC power supply, investment in public grid connection is reduced, efforts for revamping the overhead contact line system are low, efficiency in the ETS is increased by up to 99 % and total energy demand is reduced by up to 19,9 %. Furthermore, the interface to a maintenance and traffic management system is described with definition of use cases for enabling a digital substation. In this way, significant improvements on quality of traffic and maintenance planning or operation are expected as well as considerable cost reductions. Last but not least, a concept for the use of process bus communication in traction power substation is introduced for reducing cabling efforts and increasing availability by introduction of redundancy.



Overall combined model for simulations in ETS and public grid

Links with Shift2Rail

WP10 is directly followed up by WP2 and WP3 of the In2Stempo (www.shift2rail.org/cfm/in2stempo/) project. There are two demonstrators that will achieve TRL 4-5 for smart control of rail power supply and for the application of power electronics for 50 Hz AC rail power supply. Furthermore, the interface to maintenance and traffic management system is part of the In2Rail sub-project Intelligent Mobility Management (I2M).



Synergies between In2Rail WP10 and Shift2Rail

WP11 – Energy Management

Smart metering for a Railway Distributed Energy Resource Management System

The main objective of this work package was to design an open system dedicated to the fine mapping of different energy flows within the whole Railway System on a synchronized time basis.
During the first half of In2rail, the smart metering general architecture was defined, including main blocks and their functional specifications. The state of the art technologies and technical solutions overview has also been performed.
During the second half of the project, the work was focussed on data management design, from measurements to analysis and applications. Smart Metering demonstrates that non-intrusive sensors allow power and energy calculations through modelling and simulation processes. This minimises the number of measurement points.

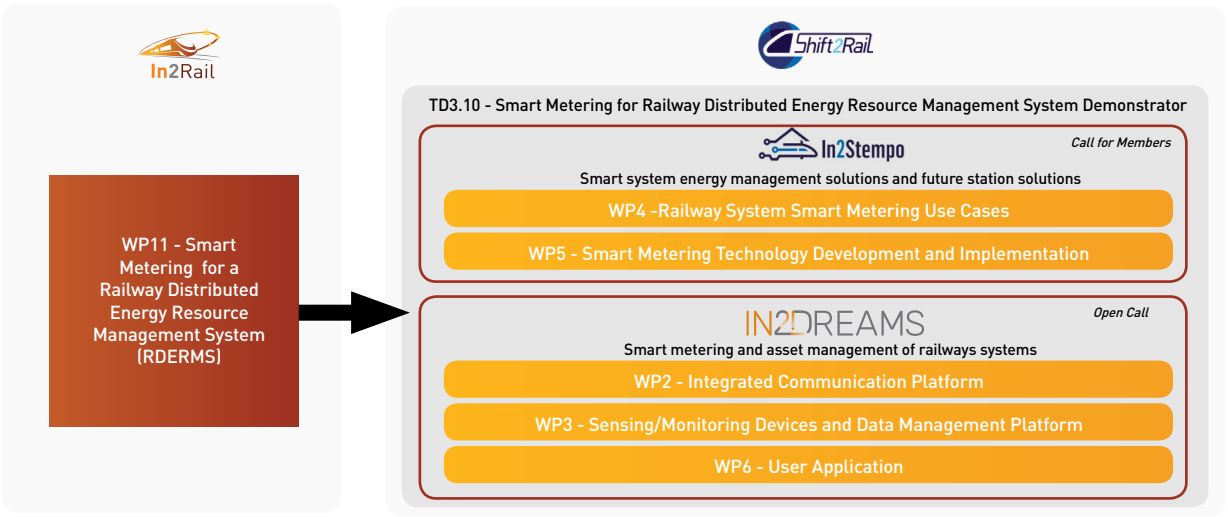
Another important achievement was the implementation of a Proof-of-Concept in a tramway system in order to experiment several technologies required by the Smart Metering system. The architecture for data collection, transmission, storage and analysis was deployed in a small scale open source Operational Data Management Platform. A wide range of technical solutions has been investigated:

- Sensors and metering technologies to measure current voltages and other energy related information, on-board as well as trackside, in a traction power substation.
- Data transmission using several communication protocols and means, especially wireless network, from sensors to database.

Smart Metering system for Energy Management tested on a limited-scale railway network

Links with Shift2Rail

In line with Shift2Rail strategic targets, the expected output of this Smart Metering 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. The investigations and Proof-of-Concept made during In2Rail provide the building blocks for the Shift2Rail technical demonstrator.



Synergies between In2Rail WP11 and Shift2Rail

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

NetworkRail

ALSTOM
Ansaldo STS
A Hitachi Group Company
BOMBARDIER
RFI Rete Ferroviaria Italiana
Gruppo Ferrovie dello Stato Italiane
mermec
an ANGEL company
SIEMENS
Ingenuity for life
Strukton Rail
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