

Deliverable D10.1 Mid-term Integration Plan

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1. Executive Summary

The Mid-Term Integration Plan looks at progress to date for the Technical Demonstrators (TD's) and specifically investigates opportunities and current progress in terms of the integration of outputs and how these can be developed and exploited into a final Integrated Technical Demonstrator (ITD). In terms of IN2STEMPO, there are three TD's, two of which align very closely in the technical disciplines of power and energy management that combined are the 'enhanced energy' ITD. The third TD is independent in that it does not align closely with either of the other TD's although as described in the original Multi Annual Action Plan (MAAP) document it has synergies with several other IP's and Open Call projects.

In TD3.9 (Smart Power Supply) and TD3.10 (Smart Energy Metering) collaboration has been very good with partners defining software and hardware requirements that will facilitate and enable the final outputs of both TD's to be used in an ITD. Partners have also worked closely with colleagues from DotVision and the University of Bristol who were involved in the previous lighthouse and open call projects IN2RAIL and IN2DREAMS respectively. This has meant that we have been able to make quicker progress and ensure that the key findings and deliverables from this project have been incorporated into IN2STEMPO at the earliest opportunity. Similarly, with the start of the FUNDRES Open Call project, members of both TD3.9 and TD3.10 have been appointed onto the Technical Advisory Board and will ensure that technical outputs from that project will be incorporated and exploited within IN2STEMPO where appropriate.

In the original MAAP document it was noted that whilst TD3.11 was effectively a 'stand-a-lone' TD it does have synergies with several other Open Calls and Members Projects. At this point in the TD, partners have been actively collaborating with the Fair Stations project and also partners from CONNECTIVE. It is anticipated that in the next phase of this TD, collaboration with PIVOT2, IN2SMART2, LinX4RAIL and research investigating Driver Only Operations at stations will be possible.

Overall, progress in developing an Enhanced Energy ITD has been very good and the respective TD leaders are collaborating together and are confident of delivering the required outcomes at the end of IN2STEMPO. Although, not as mature in as the previous TDs the work completed to date in TD3.11, Future Stations confirms that collaboration is progressing and that the relevant WP leads are working in collaboration across IPs and ensuring that research and outputs are being shared to maximise future exploitation and benefits.

2. Abbreviations and Acronyms

Abbreviation / Acronyms	Description
AC	Alternating Current
CCTV	Closed-Circuit Television
CFM	Call for Members
CIL	Control in the Loop
DC	Direct Current
ETS	Electrical Traction Power System
FACTS	Flexible-AC-Transmission-System
FDCTS	Flexible-DC-Transmission-Systems
Hz	Hertz
IET	International Electrotechnical Commission
IoT	Internet of Things
IP	Innovation Programmes
ITD	Integrated Technical Demonstrator
KPI	Key Performance Indicator
kV	kiloVolt
MAAP	Multi Annual Action Plan
NCIT	Non-Conventional Instrument Transformer
ODM	Operational Data Management
RDERMS	Railway dedicated Distributed Energy Resource Management System
RPC	Rail Power Conditioner
SCADA	Supervisory Control and Data Acquisition
STC	Static Frequency Converter
SVC	Static Var Compensator
TD	Technical Demonstrator
TRL	Technology Readiness Level
WP	Work Package

3. Background

IN2STEMPO is a Shift2Rail project addressed in IP3 “High capacity & reliable infrastructure”. The project is organised into nine technical work packages covering three TDs; respectively TD 3.9, 3.10, 3.11 (as shown in the figure below). The mid-term integration plan outlines how these TD’s and their associated deliverables will contribute towards a potential ITD. Further information on collaboration with past and future open calls and other S2R research is also provided in more detail below.

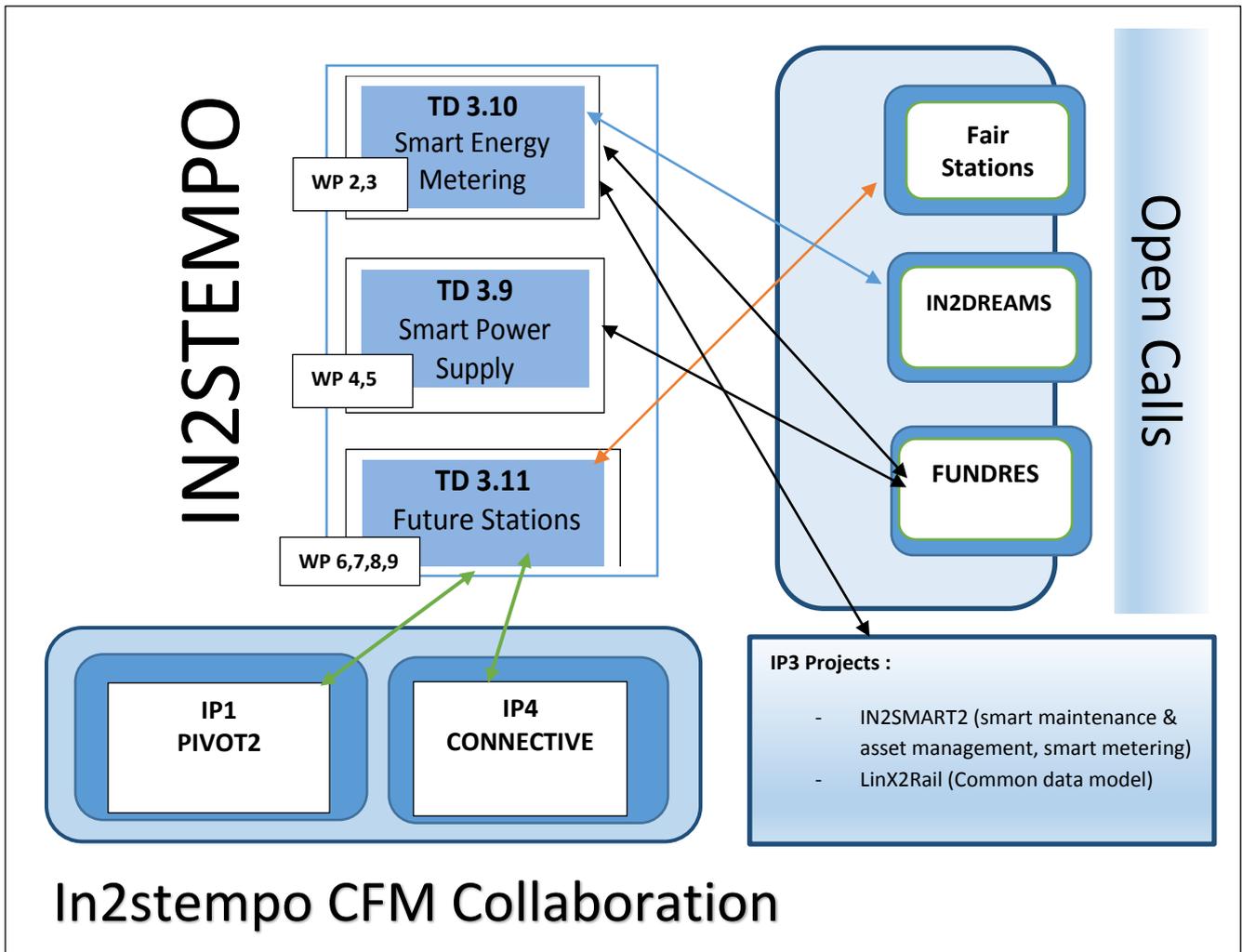


Figure 1: Relationship diagram showing the relationship and collaboration between In2stempo partners, Open Calls and other S2R ‘Call for Members’ (CFM) research.

TD3.9 and TD3.10 relate to energy and power and the third TD focuses on stations and improving the experience of rail passengers. Although technically there are differences between the first two TDs and TD3.11 we have been able to identify links and further synergies that may result in addition integration opportunities. A comprehensive energy management solution should also include stations and so some of the sub-metering capability used in WPs 4 and 5 has an application in stations, albeit in a different context and environment. Similarly, the use of intelligent infrastructure and remote condition monitoring equipment as part of TD3.11 will support and potentially enable more granular and accurate monitoring and measurement of energy consumption – a key component of TD3.10.

Together these make a significant contribution towards ensuring the smart station prototype in TD3.11 is both sustainable in use, as well as having a low-carbon construction footprint. All three TD's address the need for reducing the rail industries CO2 emissions and improving the environmental impact of its operational activities now, and into the future. This is key to addressing the issue of future climate change mitigation and infrastructure adaptation.

Thales and PKP have also been able to collaborate with partners from CONNECTIVE and PIVOT 2 in relation to improving and adding value for WP6 and WP8 (TD3.11). These activities will continue and intensify in 2020/21 as research in these WP's develops further with several deliverables due later in 2020/21.

Detailed information relating to each TD and associated WP's has been provided by each TD lead;
 TD 3.9 – Albrecht Brodkorb/Christoph Hinze – Siemens
 TD 3.10 – Marius Iordache/Olivier Langlois – Alstom
 TD 3.11 – Thomas Petraschek - OBB

4. Objective/Aim

This document has been prepared to provide an interim review of IN2STEMPO TD's and to provide an update on opportunities for further integration in the form of an Integrated Technical Demonstrator at the end of the project. It also highlights where IN2STEMPO WPs have links to other Open Call and Member Call projects with the wider SHIFT2RAIL programme (see Fig 2 below).

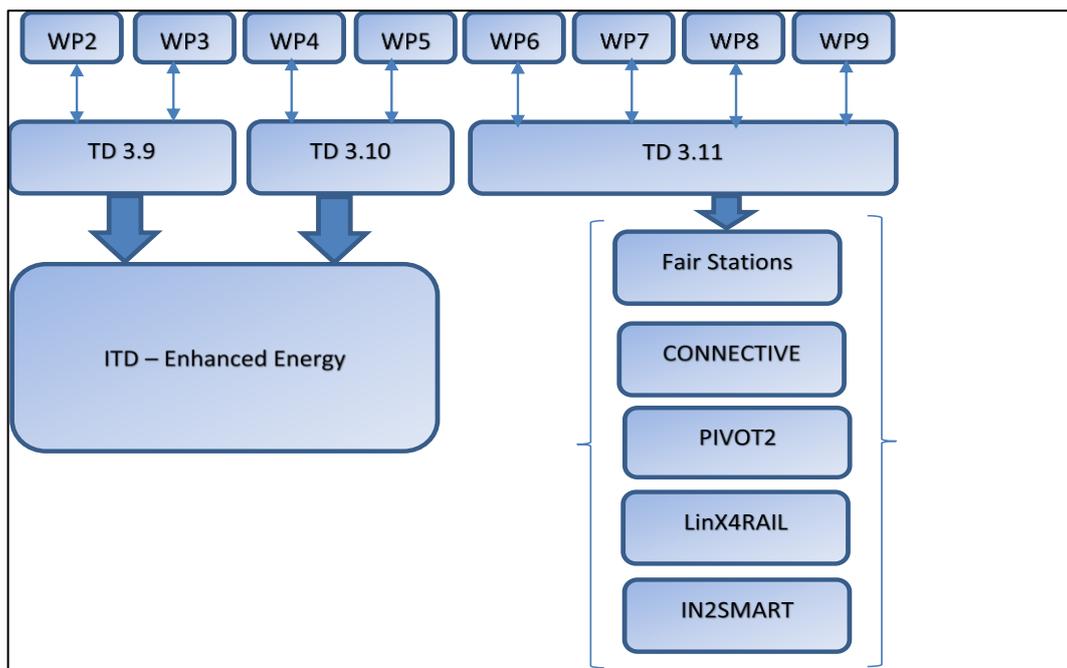


Figure 2 Relationship between IN2STEMPO WP's, TD's, ITD and other S2R Research

5. TD3.9 Smart Power Supply and TD3.10 Smart Energy Metering

5.1 Objective of ITD

The objective of the ITD (Integrated Technology Demonstrators) is to define interfaces and connect the work of TD3.9 (WP2&3), TD3.10 (WP4&5) and related Open Calls. By the interaction between the TDs 3.9 and 3.10, an ITD for enhanced energy supply in railway is conceived. The ITD aims to realize a combined concept for a smart railway power supply, including all levels of primary equipment, control and protection equipment as well as IoT application.

Rail infrastructure and rolling stock requires a complex electrical network to transform the energy from the public energy supply networks, distribute the energy along the track to the vehicles and close the circuit by the return system. The railway infrastructure electrical traction power system (ETS) does not solely consist of the primary equipment enabling the current flow, but also the auxiliary control and protection systems. It must comply with requirements ranging from power quality, electromagnetic compatibility, availability, maintainability to safety and security.

Within In2Stempo several subsystems of the ETS are investigated by the means of the application of new innovative technologies. The project strives out to upgrade different parts of the ETS with smart grid solutions. Yet, each Work Package of TD3.9 and TD3.10 does only consider a fraction of the complete ETS. To enable the evaluation of the ETS in a more complex manner the subsystems of the individual work packages and technical demonstrators shall be combined in an integrated demonstrator.

5.2 Overview of Contributing Work Packages in TD3.9

The ITD consists of the following work packages and open calls:

5.2.1 WP2: 'SMART Control of Rail Power Supply'

Work package 2 aims to design, install and operate a demonstrator (TRL 5) for "SMART Control of Rail Power Supply" in a 16,7 Hz 110 kV railway switchgear station. The demonstrator will investigate the usage of process bus communication according to IEC/EN 61850-9-2 in a railway switching station. To realize the process bus communication, existing devices of the railway power supply and the public energy supply need to be checked for usability and adapted when necessary. Additionally, NCITs (Non-Conventional Instrument Transformer), a modern type of instrument transformers, are included in the demonstrator. This modern technology will enable:

- increase of control functions
- increase of availability by asset monitoring and plausibility checks
- reduction of copper cables
- more process information & automation
- improved remote control and monitoring

A comparison with the conventional technology shall help to evaluate the modern technology. Based on the test results the design and application of the devices will be specified for the 16,7 Hz railway environment as well as the transfer to other AC systems investigated. The WP2 demonstrator is based on a transportable feeder panel for a 110 kV switchgear. The transportable feeder is equipped with the complete primary technology for connecting a high-voltage line to the busbars of the switchgear.

Components included on the transportable switchgear panel are the merging unit for the conventional transformer and the NCIT, a drive control unit and a device for asset monitoring supplementary, merging units will be connected to instrument transformers of the existing switching

station (these merging units are not actively involved in operation, but only to process measured values). The demonstrator itself will be divided into two separate demonstrator panels:

- demonstrator panel 'left' is realizing the connection to the SCADA system of the DB
- demonstrator panel 'right' will connect the demonstrator to WPs 4 and 5

5.2.2 WP3: 'FACTS for 50 Hz AC Rail Power Supply'

Main objective of WP3 is the specification of the design and implementation of innovative 50 Hz smart power supply solutions based on parallel feeding and Flexible-AC-Transmission-System (FACTS). The scope of the project is to investigate different approaches for electrifying railway traction systems for 50 Hz AC systems by using FACTS.

The term FACTS summarize all devices that enable an active control of the load flow using semiconductors. For railway applications the following types of FACTS are investigated: Static Var Compensator (SVC), Balancer (STATCOM), Static Frequency Converter (SFC) and Rail Power Conditioner (RPC).

The work package will address the interface requirements between the traction power system and the upstream utility grid, including specific constraints or requirements in case of parallel feeding concepts. WP3 compares different possibilities for 50 Hz AC railway traction power supply and defines practical and economical supply schemes. For each supply scheme the protection and control methods are specified. Using a virtual demonstrator with hardware in the loop components, a proof of concept of the defined supply schemes and the chosen FACTS shall be provided and their usability will be checked. The evaluation is based on a list of defined criteria for comparing supply schemes with each other as well as ensuring their feasibility.

The WP3 demonstrator is based on a variety of different simulation systems. Each simulation system contributes to a different FACTS and the proof of concept for it. The focus of the investigations will be on SFC's and the capability of double side feeding. Therefore, the largest simulation platform is the coupling of two real-time simulators, including a converter CIL (Control in the Loop), provided by SIE, and a complex network model, provided by SNCF. The real-time simulations are based on two Use Cases of the French railway network:

- UC1: 25 kV 50 Hz (Marseille St Charles to Vintimille)
- UC2: 50/25 kV 50 Hz (Barquet to Carpentier)

5.2.3 WP4: 'Railway System Smart Metering Use Cases'

WP4 defines and implements the three Smart Metering Use Cases described below (CO-OP, STM-OP, IN-OP) in a railway environment. For each Use Case, a functional specification is provided as base for the technical inventions of WP5. The development of WP5 will later be implemented for each Use Case.

WP4 contributes to TD3.10. According to the 3 use cases defined here above, one dedicated demonstrator will be realised for each use case (in WP5). In fact, technical fields, requirements and locations of the 3 use cases are different.

Smart Metering Use Cases are the following:

- UC1: CO-OP: 750 VDC (Tonbridge to Redhill, south London, UK) Commercial line operation use case (CO-OP) aims to realise a fine mapping of energy flows dedicated to the railway systems in commercial operation.

- UC2: STM-OP: 750 VDC (Zaragoza tramway depot, Spain) Stationing and maintenance facilities use case (STM-OP) intends to measure energy consumption of non-traction systems such as stations, depots and maintenance facilities as well as of rolling stock in stabling mode.
- UC3: IN-OP: 25 kV 50 Hz (London North West coast mainline, UK). Electrical infrastructure monitoring use case (IN-OP) aims to implement a continuous supervision of the traction power supply system and its components as well as their specific energy consumption.

The overall objective of TD3.10 “Smart Metering for a Railway dedicated Distributed Energy Resource Management System” (RDERMS) is to improve energy management in a rail system. It should lead to reductions in energy consumption, or to a better usage of the energy.

5.2.4 WP5: ‘Smart Metering Technology Development and Implementation’

The WP5 specifies and if necessary, develops all technological components needed for the implementation of the three Use Cases of WP4. The components include inter alia: the field measurement equipment, connectivity equipment, an Operational Data Management (ODM) platform and the User Applications / Decision Support Tools.

WP5 deals with the technical requirements of sensors for measuring different variables, the data management and the integration of user applications and decision support tools in three use cases. This includes detailed investigations about the existing technical infrastructure into which the sensors are to be integrated, their functionality and technical properties, which are compared to the specific requirements of the use cases (measurement accuracy, non-intrusiveness, measuring range, communication protocol, power supply, etc.). It is also examined to which extent standard products can be used or special sensors are needed. Furthermore, management of sensor data is assessed, as well as respective data traffic associated with the measurements.

Since WP5 is directly linked with WP4’s Smart Metering use cases (contributing to TD3.10) demonstrators are common for WP5 and WP4 and are described in WP4 section above.

5.2.5 Open Calls

- In2Dreams: focuses on the integration of hardware and software components into the three Smart Metering Use Cases (TD3.10). It covers sensors, communication connectivity, open data management platform and user applications. In2Dreams has been designed to answer the challenges related to technology development.
- FUNDRES: focuses on the investigation of ‘future unified DC railway electrification system’ (TD3.9). The project aims to study the changing of railway electrification systems to 9 kV DC by the means of Flexible-DC-Transmission-Systems (FDCTS) usage. It will provide simulation tools and a Digital Twin on equipment and system level to evaluate the performance of such systems.

5.2.6 Structure of the ITD

In Figure 3 a basic scheme describing the concept of the planned ITD is provided. The ITD is split into the TD3.9, consisting of WP2, WP3 and the open call FUNDRES as well as TD3.10, including WP4, WP5 and the open call In2Dreams. The main function of the ITD is the sampling and pre-processing of data in TD3.9 which is then sent to TD3.10 and there further processed and edited for final User Applications. The transfer of data needs devices and configuration in both TDs. The needed specifications and use case descriptions will be provided by TD3.10 based on its preliminary work. The open calls will be connected to the corresponding In2Stempo work packages.

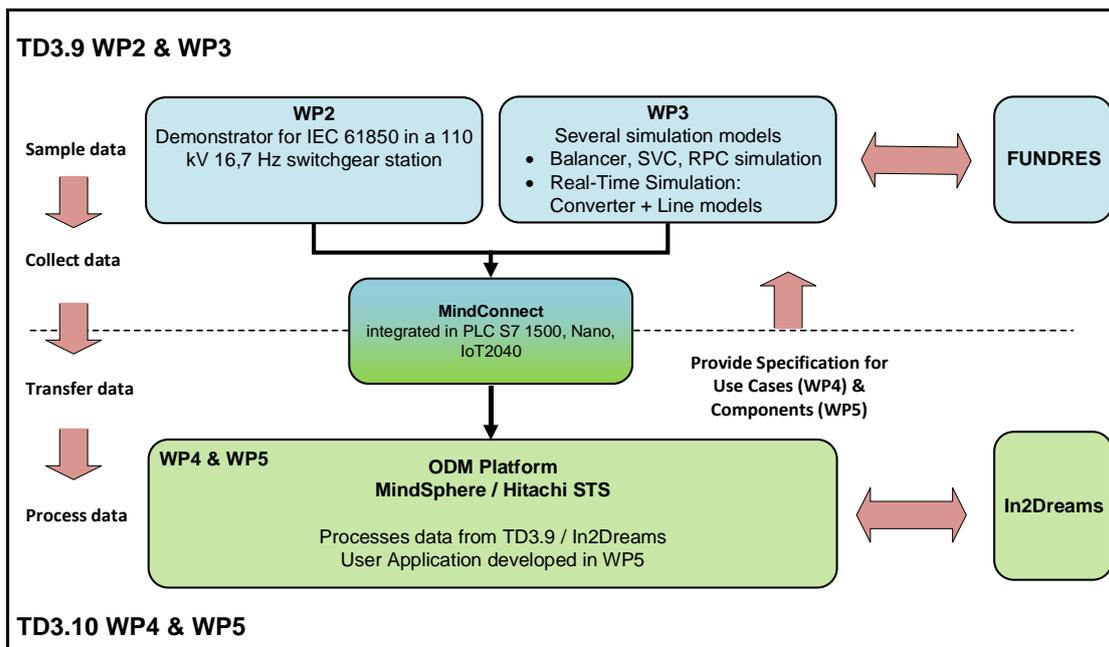


Figure 3 Structure of the ITD

As a data management solution MindSphere and/or Hitachi STS platform will be used for the ITD (TD3.9 and TD3.10). To realise the interface between physical sensors and the data management platform, MindConnect is an edge solution that is likely to be used.

5.3 Contribution of each WP to the ITD

Based on the ITD structure described in previous chapter, the basic legwork of the two TDs can be split into providing data by TD3.9 and processing data by TD3.10. Both TDs are taking part in the needed connection to realise this concept. The individual contribution to the ITD of each work package will be:

WP2

- provide measured line data and asset data from a 110 kV 16,7 Hz switchgear station, including:
 - real voltage, current and network parameters
 - asset status information
 - protection process information
 - performance information on the used process bus network
- adjust data measurement equipment (already available)
- pre-process data within the demonstrator of WP2
- implement connectivity equipment and enable upload of data to ODM platform
- apply User Applications / Decision Support Tools defined in TD 3.10

WP3

- line data and asset data can be taken from different simulation models, including:
 - real-time voltage, current and network parameters
 - train operation data
 - system parameters
- pre-process data (data measurement equipment is not needed)
- enable upload of data to ODM platform
- apply User Applications / Decision Support Tools defined in TD 3.10

WP4

- provide functional specification for use case implementation, including:
 - requirements
 - potential KPI
- WP2&3 are to be considered as further use cases

WP5

- provide functional specification for needed components:
 - measurement equipment
 - connectivity equipment
 - data management
- test applicability of technical components developed in WP5 for usage in TD3.9
- data management platform ODM
- define User Applications / Decision Support Tools for TD3.9

In2Dreams

- provide principle and functions of the “Operational Data Management” platform (ODM)
- experience from ODM solutions tested on a preliminary use case, initiated during the lighthouse project In2Rail

- experience on User Applications

FUNDRES

Due to the late project start in October 2019, the contribution of the FUNDRES project to the ITD is yet to be evaluated. In general, the project will provide data similar to the WP2 and WP3 of TD 3.9.

5.3.1 Integration plan & KPIs

To ensure the implementation of the ITD within the project duration of In2Stempo, four TD's comprehensive Milestones are defined. Each Milestone is to be respected by all contributing work packages. The milestones are:

MS-ITD-1 (M30 – February 2020)

- This milestone is time-aligned with start of Task 2.7 and Task 3.10 (interfaces with other WP's)
- Start of work in each individual WP as base of the ITD: specify concept and design of TD3.9 and TD3.10
- Define a concept and project plan of the ITD
- Define a general structure of the interface between the TDs, to be considered in the application design of TD3.9 and TD3.10
- Provide a general overview of Use Cases for the ITD based on the results of TD 3.9 and TD 3.10

MS-ITD-2 (M42 – February 2021)

- Finish the installation of the Demonstrators TD3.9 and TD3.10 and start test operation.
- Specify the interface for all interacting devices between TD3.9 and TD3.10
- Specify the data exchange platform between TD3.9 and TD3.10
- Provide functional description of User Applications / Decision Design Tools

MS-ITD-3 (M46 – June 2021)

- Implement connection and test data exchange between TD3.9 and TD3.10
- Develop User Applications / Decision Design Tools on the ODM platform
- Start test operation of the ITD.

MS-ITD-4 (M58 – June 2022)

- Finish test operation of the ITD.
- Evaluate results by comparison with the KPIs.



5.3.2 ITD: Final Key Performance Indicators:

To evaluate the performance of the integrated technical demonstrator, the following KPIs shall be used:

- Unconstrained Data exchange between all WPs.
- No major failures during test and validation period.
- Data for User Applications / Decision Design Tools is provided (for at least one month).
- Successful trial run of User Applications / Decision Design Tools.

6. TD3.11 Future Stations

6.1.1 *General approach of 'future stations' demonstrator*

TD3.11 demonstrator activities are planned in a way to show results of research activities in a real operational rail environment.

In total there are 4 work packages connected to TD3.11; 3 of them will directly deliver results with demonstrators, namely WP6, 7 & 8. The interaction between these 3 work packages and activities carried out in IP4 and IP1 will be incorporated into the Integrated Technology Demonstrators (ITD).

In the case of WP 6 & 8 an essential interface exists with the Open Call project, FAIR Stations.

6.1.2 *Overview of contributing work-packages*

The contributing work packages and relevant Open Calls are

- WP6: The overall objective of WP6 is to significantly improve customer experience and safety in large & high capacity stations (especially large interconnected stations and multimodal hubs) both during standard operations and in emergency cases by using tools allowing to represent crowd simultaneously as a flow or a large group of persons with individual motivations. This will be achieved with the development and use of passengers, users and crowd behaviour models within a realistic 3D simulation system relying on real time data for simulation alignment and validation and delivering short term prediction and staff training (TRL5).
- WP7: The aim of this task is to deliver significant improvement of the small stations design and provide a catalogue of specifications and design prototypes to improve low capacity stations in remote areas, including new materials, innovative products, energy and smart solutions. Results of theoretical research will then be tested with numerical simulations and validated in real railway environment; Jurata, Poland (TRL6).
- WP8: this investigates current issues with the platform, train interface focusing on how these impact on passengers, rolling stock operators and infrastructure managers. Potential solutions and strategies to improve the accessibility for persons of reduced mobility and the general public will also be provided based on current research (TRL5).
- FAIR Stations (Open Call): The objectives of the FAIR Stations open call project are closely aligned to those of TD 3.11. The outputs of this research will be incorporated into individual WP's and also integrated into TD3.11 where appropriate. These are shown in Fig 4 below

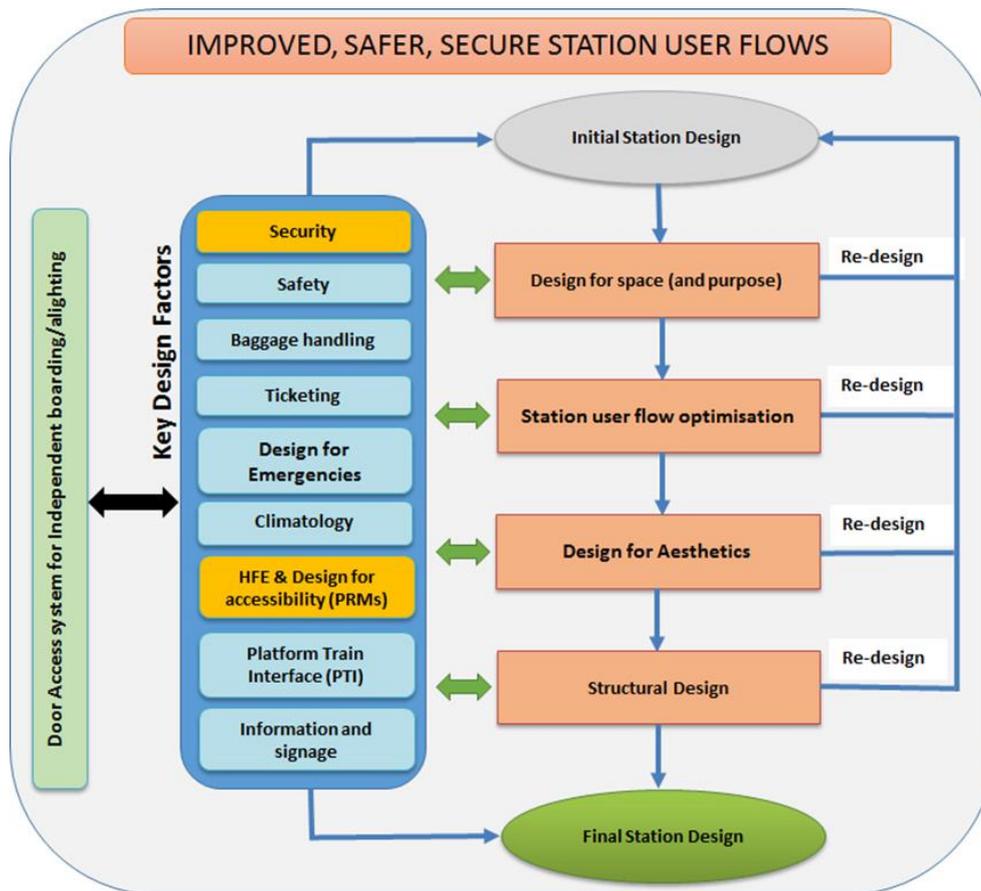


Figure 4 Fair Stations Research Relationships.

In addition to these work packages a fourth one is delivering results but not on demonstrator level:

- WP9: To develop solutions for improving the safety and resilience of railway stations through the development of models, rail specific risk assessments and the development of a railway Security Manual that catalogues materials, fixings and station furniture that can be used to mitigate the impacts of blast. Analysis of options for advanced CCTV technology that analyse specific human behaviours to provide pre-emptive information. (TRL4).

6.1.3 Contribution of each WP to the TD

The individual contribution to the ITD of each work package will be:

WP6

- provide reference use cases, scenarios and KPIs for standard and emergency operations
- provide data collection for crowd measurement and analysis
- provide implementable behaviour models
- 3D model of a major station later on used as demonstrator platform
- provide accessibility to major station as demonstrator platform

WP7

- provide design criteria for a small station that can be used as demonstrator platform, including a catalogue of specifications concerning materials and components, future technology options to reduce energy consumption, enhance cost management (investment, operations) and new ticketing facilities;
- develop a 3D model of a major station to potentially be used as demonstrator platform
- provide accessibility to major station as demonstrator platform

WP8

- provide functional specification for use case investigation FAIR Stations
- provide scientific knowledge with detailed specifications to maintain the work on crowd management in major stations.
- provide research with detailed specifications to support and enhance the WP on crowd management in major stations.

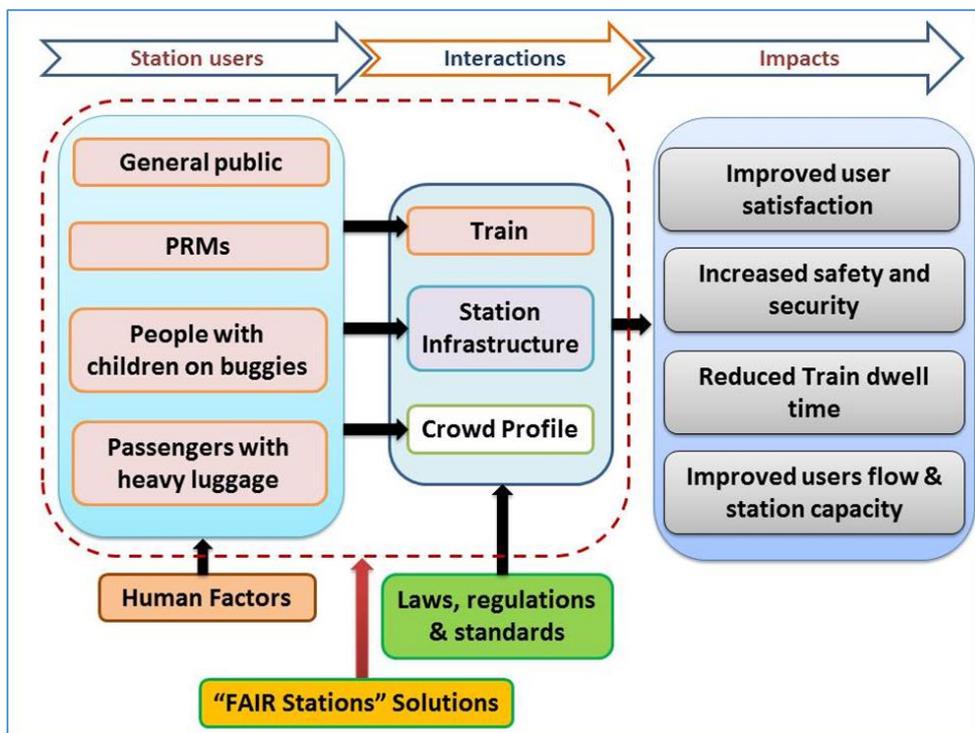


Figure 5 Fair Stations Outputs and contribution to ITD.

6.2 Integration plan & KPIs

The integration of the diverse outputs from WP's within TD3.11 will be better understood during the second half of the IN2STEMPO project. It is clear that the outputs will benefit several other IP's and also that research from other IP's will enhance and add value to the work being undertaken in IN2STEMPO. Current and planned integration and collaboration between TD3.11 and other IP's and Open Calls is outlined below;

- WP6 – CONNECTIVE/Fair Stations
- WP7 – Fair Stations/LinX4RAIL, IN2SMART2
- WP8 – Fair Stations/Pivot2
- WP9 – to be confirmed

Milestones are outlined below but will necessarily be updated as these WP's progress in 2020.

MS-ITD-1

- start of work in each individual WP: specify concept and design of WP 6, 7 & 8
- define concept and project plan
- define the interface between the IP's
- define added value that TD3.11 can add across other IP's

MS-ITD-2

- first draft of detailed implementation plan with specifications of all interface activities between TD3.11 & IP1 / IP4
- first draft of specifications concerning data exchange platform between TD3.11 & IP1 / IP4

MS-ITD-3

- validate with colleagues how the outputs from TD3.11 can be integrated into other TD's and potentially ITD's to maximise technical value.

MS-ITD-4

- evaluate results

6.3 ITD: Final Key Performance Indicators

To evaluate the performance of the technical outputs from TD3.11 and the integration into other IP's the following KPIs shall be used:

1. Validation of outputs from TD3.11 (Number over the project duration).
2. Number of outputs from TD3.11 incorporated into other ITD's within S2R (Number over the project duration).
3. Integration of outputs from Open Calls incorporated into TD3.11 (Number over the project duration)



7. Conclusions

Progress has been very good and a clear integration plan with appropriate tasks and milestones is evident for TD3.9 and TD3.10 resulting in the 'enhanced energy' ITD. Not only is there good collaboration between these two TDs but partners have actively engaged with and incorporated previous research, specifically the outputs and deliverables from IN2RAIL and IN2DREAMS. Similarly partners from both TDs have joined the Technical Advisory Board of the FUNDRES open call project and will be incorporating the outputs from this research into their own IN2STEMPO deliverables where required.

For TD3.11, significant progress has been made in collaborating with the Fair Stations open call and partners attended the final event and have had a constructive dialogue to ensure that the outputs from this research is included in INSTEMPO WPs (WP6, WP7, WP8). Collaboration between WP6 and partners from CONNECTIVE has also been valuable and enhanced the outputs from this WP.

It is anticipated that in the second half of this project we will also be working alongside partners from the LinX4RAIL and IN2SMART2 projects, as well as with colleagues from PIVOT2, in order to improve and maximise value from work done within In2Stempo project.