# Virtual Environments – A Solution for Testing Novel Applications for Railway Traffic Management Systems

Paul Hyde, Cristian Ulianov, Jin Liu*
*NewRail - Newcastle Centre for Railway Research*
*Newcastle University*, Newcastle upon Tyne, the UK
paul.hyde@ncl.ac.uk
cristian.ulianov@ncl.ac.uk
jin.liu@ncl.ac.uk

Gabriele Cecchetti
*Institute of Communication, Information and Perception Technologies (TeCIP)*
*Sant'Anna School of Advanced Studies*
Pisa, Italy
gabriele.cecchetti@santannapisa.it

***Abstract*— Development of sophisticated novel sub-systems for controlling railway operations, and processes for collecting and distributing information related to those operations is currently ongoing. The collective aim of many of these developments is to increase operational efficiency, resilience and capacity by developing and implementing integrated and digitised railway operational systems. Connecting information sources and outputs, and enabling implementation of optimised operational decision-making and decision implementation. This paper summarises first the background, i.e., the relevant topics in this area, and then presents the Integration Layer (IL) and demonstrator platform for traffic management approach that connects the relevant systems and provides a virtual testing environment for ongoing developments in traffic management systems (TMS) respectively. The IL concept and demonstrator platform is currently developed in the EU-funded Shift2Rail (S2R) project OPTIMA. The article discusses the need to test the novel TMS sub-systems and their modules in a virtual environment and details the proposed testing procedures to be implemented in the OPTIMA project for the integration layer and communication platform demonstrator itself and for the initial candidate modules developed by the relevant S2R members from railway industry. The target of the virtual testing to be carried out in the OPTIMA project is to validate the developed integration layer and communication platform demonstrator as a testing environment, and the performance of the candidate sub-systems in a relevant controlled environment, with representative interfaces and interactions with other sub-systems, and information providers and subscribers.**

## I. INTRODUCTION

With the increasing demand for rail transport, railway infrastructure managers are looking for sophisticated real-time solutions for traffic management, which has determined the particular goal of Innovation Programme 2 (IP2) of Shift2Rail Joint Undertaking. New solutions for advanced Traffic Management System (TMS) are investigated in S2R IP2 by the development related to Technical Demonstrator (TD) 2.9 [1] the objective of which is to specify and design "a new TMS based on standardised frameworks, data structures, real time data management, messaging, and communication infrastructure including Interfaces for internal and external communication between different subsystems, applications and clients, that aims at significant higher Integration of status information of the wayside infrastructure, trains, and maintenance services together with management of energy and other resources.". Furthermore, the implementation of TD2.9 includes Task 2.9.7 Integrated Demonstrator, where: "To proof and validate the targeted achievements of the new TMS with integration of status information from different services a platform will be established".

The OPTIMA (cOmmunication Platform for TraffIc ManAgement demonstrator) project and its complementary projects X2RAIL-4 and FINE2 have been awarded within S2R IP2, and the key objective of OPTIMA is to design and develop a communication platform using standardised data structures and processes to manage the communication/data exchange between different services/clients and supporting TMS applications connected to other multimodal operational systems. The technical objectives of OPTIMA are listed below:

1. Providing seamless and dynamic data exchange between the various rail services, these data will be transmitted in one common layer which is permanent available for communication.
2. Enabling new applications for traffic management and traffic control, including the integration of new functionalities developed by S2R projects and allowing the optimisation of traffic flow with advanced-algorithm-based decision support system.
3. Integrating of new technologies/functionalities for new generation of railway traffic management system, such as: ATO, Moving Block, Data provision/exchange for new advanced Maintenance Strategies, Freight Transport, and Passenger Information services;
4. Standardising of constituents and workflows inside a Control Centre.
5. Specifying and developing a Conceptual Data Model to enable a common data structure within the Integration Layer (IL) of the communication platform ensuring interoperability.

In this paper, we first introduce the general architecture of the communication platform developing within the OPTMA project, and the validation approach for the IL and Communication Platform Demonstrator (CPD) is illustrated and discussed.

## II. OPTIMA PROJECT

### *A. Architecture of communication platform for TMS*

The OPTIMA project is keen to develop a new communication platform which works as a middleware providing all the functional entities required for digitised and automated TMS services with seamless and standardised communication and data exchange. The communication platform mainly includes the Integration

Layer (IL), the Application Framework (AF), the Databases (DBs) for the persistence layer (containing the data used), and the standardised Operator Workstations (OW) to be installed in the Control Centres. Operations and route data are fed into this to enable the system response to be tested.

Within the communication platform, the IL plays the most important role across the whole project, since it integrates the different components and data sources and consumers, and enables integrated and automatic data exchange process and permanent real-time availability of data though a publish and subscribe messaging pattern. The IL also provides an interface for the communication with external clients and services, like Weather Forecast and Passenger Information Services through web-interfaces (WEB-IFs). In particular, it can integrate existing functionalities of legacy service applications via adaptors, it can connect existing signalling infrastructure based on dedicated software (SW) clients connected to the IL through interface services, and it enables access to be granted to external clients and services to pre-determined relevant information available in the system via webservices.

### *B. Validation of the communication platform demonstrator*

The key activity of work package (WP) 7 of OPTIMA project is to validate the proposed CPD as a whole, including the test of integrated traffic management system modules, external services and databases. It will also be used to validate TMS modules developed in other S2R projects, which in turn will serve as validation of the CPD as a testing environment. WP7 will develop a validation plan and testing program for the CPD based on the outputs of WP4, WP5 and WP6, i.e., the delivery of IL, component modules and databases of the traffic management system demonstrator platform. The activities will comprise:

1. Analysis of the requirements, criteria and performance indicators (in particular those relating to interfaces) for the Integration Layer and CPD at each validation stage;
2. Development of test program: (a) specifying test cases and scenarios; (b) defining test configuration for test case/scenarios; (c) specifying the HW, SW and participant requirements for each test scenarios; (d) compiling the test cases and scenarios into a test programme workflow.

The performance indicators are mainly generated by the analysis of:

1. Existing requirements documents: including those determined in OPTIMA (determined considering outputs of X2RAIL-4 and IN2RAIL projects), TMS related Technical Specifications of Interoperability (TSI), public railway standards on TMS and communication.
2. Use cases of IL: use cases are described in the beginning stage of OPTIMA project as well as IN2RAIL and X2RAIL, and it is important to understand the roles of the IL/CPD in each use case and determine the key indicators in each use case.
3. Developer and Stakeholder consultation to determine performance indicators by the means of discussing functionalities, development and application challenges, etc. with project partners and advisors at periodic project meetings and conference calls.

### *C. Validation of communication function through IL*

The communication function is a key requirement for IL development, therefore, the validation process for this function will be used here as an example of the process for the CPD. The IL communication function requirements were determined in the IN2RAIL and X2RAIL projects. These requirements for communication consist of: (1) Connect consumer and provider; (2) Support of Different Transport/Application Layer (OSI) Protocols; (3) HTTP oriented; (4) Routing; (5) Route to correct provider; (6) Dynamic end-point handling; (7) Message queuing; (8) Service registration; (9) Service discovery; (10) Configuration Control; (11) Message integrity.

The test scenarios will be designed and generated including consideration of the key use cases of the IL for communication purposes identified in D8.1 of IN2RAIL. The test scenarios are organised into three test groups which are listed below:

| **Test group** | **Tested use case (communicated content)** |
|---|---|
| Way side communication | • Train position reports;<br>• Route setting/ route state;<br>• Automatic train operation (ATO);<br>• Environmental conditions; |
| Railway undertaking specific communication | • Timetable change request from Railway Undertaking (RU);<br>• Management of major disturbances; |
| Maintenance management | • Maintenance management |

The involved entities inside CPD for testing include IL, train position provider, possession management, passenger information system, interlocking control, operator's workstation, ATO, etc. Within each test scenario, testing data (e.g. train positions, route info, timetable and etc.) will be generated by its corresponding entities and fed into the CPD and response of the CPD to each test case is recorded and analysed with respect to the designed performance indicators and evaluate whether the developed system is able to satisfy the proposed requirements.

## III. CONCLUSIONS

In this paper, we introduce the main objectives of OPTIMA project and their technical challenges. The architecture of the communication platform developed by OPTMIA project is illustrated, and we discuss the approach to generating performance indicators for the Traffic Management Communication Platform Demonstrator from the requirements. The validation process for the communication function is shown as example in this paper of the full testing process for the Communication Platform Demonstrator to be developed in OPTIMA.

## REFERENCES

[1] Shift2Rail, "Shift2Rail Multi Annual Action Plan (MAAP)," Shift2Rail Joint Undertaking, 2015.