Brexit and UK signalling
Automated testing and SSI data
ETCS testing and maintenance
ERTMS TESTING AND MAINTENANCE

ERTMS: from verification and validation to operation and maintenance
Maurizio Palumbo
ERTMS Solutions, Belgium

A system is a combination of interacting and integrated elements, subsystems, or assemblies that accomplish a defined objective. These elements include products, processes, people, facilities, services, and other support functions.

Systems Engineering (SE) is an interdisciplinary approach for the realisation of successful systems, by developing a final product that meets the customer needs, goals and objectives.

Thanks to its nature, an ERTMS re-signalling project is a perfect example of a safety critical system development, whose realisation, from concept to operations, can be managed following the rigorous approach defined in the ‘V-model’ for railway applications.

Introduction: the ERTMS system development lifecycle

A system development methodology refers to the framework used to structure, plan, and control the process of developing a safety critical system, e.g. an ERTMS/ETCS railway signalling programme.

The ERTMS systems development lifecycle presents and describes the activities to be performed (and the results that must be produced) during each phase of the product development.

The term ‘V’ comes from the shape of the diagram (figure 1), which is split into the two main macro-phases ‘design’ (left side, during which the main concept will be specified and translated into system requirements) and ‘Integration and Verification’ (right side, where the system parts are recomposed and the correctness of each of them, and the static and dynamic aspects of interfaces between them, is verified).

In more detail the purpose of the Integration and Verification phase is:

• Completely assembling the elements to make sure they are compatible with each other.
• Demonstrating that the aggregated elements perform the expected functions and meet measures of performance/effectiveness.
• Detect defects/faults related to design and assembly activities by submitting the aggregated elements to focused V&V actions.

However, what’s the difference between the concepts of verification and validation? Engineers usually struggle to correlate the two process and same terms often refer to different meanings.

Verification proves that a manufactured product for any part of the system model within the system structure conforms to the build requirements. In other words, the purpose of the verification process is to confirm that the specified design requirements are fulfilled by the system. This process also provides the information required to perform the remedial actions that correct the non-conformances in the finished system.

Validation is the confirmation, through the provision of objective evidence, that the stakeholder’s requirements for a specific intended use or application have been fulfilled. This is shown in figure 2. A validated system is therefore able to accomplish its intended final use, goals, and objectives (i.e. meet stakeholder requirements) in the intended operational environment. A validation action applied to an engineering element includes the following aspects:

Figure 1 – The V-cycle for railway applications.
• Identification of the element on which the validation action will be performed.
• Identification of the reference that defines the expected result of the validation action.
• Any engineering element can be validated using a specific reference for comparison.

According to these definitions, from a process perspective, the verification and validation may be similar in nature, but the objectives are fundamentally different. From an engineering point of view, it is essential to confirm that the realised product is in conformance with its design specifications (did we build it right?), whereas from a customer point of view, the interest is in whether the end product will do what the customer intended (did we build the right thing?).

Moreover, it is important to understand the iterative nature of these activities, which can be repeated in each stage of the system life-cycle, to provide progressive evidence of requirements satisfaction (and remedial actions against nonconformities) during the product development. This is shown in figure 3.

Once the system has been validated and delivered to the final user for operations, arranging and ensuring efficient and effective maintenance is the most challenging task to be carried out, because of the high effort required in terms of time and costs.

A railway service or asset needs to be highly reliable, therefore the equipment must be kept in good working condition and regular maintenance is essential to achieve this goal.

For these reasons, innovative maintenance solutions for railway systems, as well as integration of maintenance into operation, are constantly studied and developed to ensure a better management of the railway infrastructure and rolling stock.

**Testing and commissioning**
As part of the verification and validation process, methods for ensuring that the system contains the functionality specified must be developed.

There are many methods for validating functionalities and determining if the system reacts in the expected way, but testing is the most common and efficient one, therefore, to validate the requirements, test plans are written that contain multiple test cases; each test case is based on one system state and tests some functions based on a related set of requirements.

On the total set of test cases, each requirement must be tested at least once, and some requirements will be tested several times because they are involved in multiple systems in varying scenarios and in different ways.

**Case study 1: ERTMS trackside/onboard on-site testing on the Thameslink ETCS line**
Although many solutions, such as laboratory replications of the real environment and/or systems simulators, can be adopted by the ETCS suppliers to perform an early-stage and iterative verification process, the closer the ERTMS system is to its design maturity, the more important will be the need to test the solution in the field by performing on-site tests, to ensure the correct integration of the ERTMS trackside and on-board subsystem and, thus, the effectiveness of the whole solution.

History taught the ERTMS market that this activity can be quite challenging, and expensive in terms of time and cost, due to:

• The restricted time-range available to the ETCS supplier, to access the track for on-site test sessions and its related cost (often, tests can be performed only during night time).
• The time required to analyse the results of each test case, due to the different sources of information to be integrated to detect any failure (DMI, RBC data, air-gap data, lineside signals, drivers’ operations, etc.).

For these reasons, Network Rail decided to look for solutions to hasten and automate this process, with the purpose of avoiding any potential project delays that could happen due to the issues listed above.

After careful consideration, Network Rail’s choice fell on the ERTMSCamCorder, an on-site testing tool enabling full and synchronised record, replay, and report of all trackside and on-board systems.
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onboard data needed during the test and commissioning phase of a rail project. The user interface is shown in figure 4.

The system, made by two cameras (one records the DMI, the other one records the track), a laptop (installed on-board) and an EVC/JRU communication sniffer, ensures the user can record each test session with the purpose of storing its data in a shared database and hastening the post-test analysis required to correct any malfunctions.

In relation to that, Jonathan Hayes, head of systems integration at Network Rail for the Thameslink project recently said:

"We have very limited access to the track, and we occasionally miss DMI features that we are looking for. The ERTMSCamCorder allows us to record that during the test sessions and replay that in the office. It also allows us to do very rapid analysis if we’ve got a problem."

Operation and maintenance

Maintenance on the railway is defined as the process of preserving the assets along the track or related to vehicles, but there are different approaches to maintaining a railway asset:

Corrective maintenance

This is a task performed to identify, isolate, and resolve a fault so that a failed equipment can be replaced or restored to an operational condition within the tolerances or limits established for in-service operations. With this approach, no actions are taken to prevent a fault, since the only way to detect it is waiting for an equipment to fail.

Preventive railway maintenance

This is a task regularly performed to monitor the status or the conditions of a railway equipment, to lessen the likelihood of it failing. An approach like this allows the infrastructure managers to recognise the bad health of an asset, so that a preventative action can be taken before a failure, ensuring a better reliability of the whole system.

Predictive railway maintenance

Predictive maintenance techniques are designed to help determine the condition of in-service equipment to predict when it is going to fail, therefore it is not a matter of likelihood, but a highly detailed forecast is ensured. This approach promises cost savings over routine or time-based maintenance, because tasks are performed only when warranted.

Case study 2: Eurobalise maintenance on the ETCS Belgian network

Part of any ERTMS trackside installation, the Eurobalises are transponders placed between the rails of a railway, they serve as ‘beacons’ giving the train an exact location, as well as transmitting signalling information to the ETCS-fitted trains.

All networks that operate ETCS are starting to put in place systematic measurement of the Eurobalises, to maintain them in an effective way. Nowadays, there are several tools available on the market to perform Eurobalise maintenance, and many Eurobalises vendors currently supply to their customers a portable ‘suitcase’, enabling them to read and optionally reprogram the Eurobalises (figure 5). This unit is essentially a stripped-down OBU, with antenna and instrumented BTM function only, together with a battery, a small user interface and a casing making it fit to use in the field.

Clearly, these human portable tools are not the best if you plan to assess the whole network composed of thousands of kilometres of balise equipped lines. It is commonly accepted that a couple of engineers can, with such a tool, only check 10 to 15 balises per day, maximum.

Aware of the limitations of the previous solutions, the ERTMS market started to ask for instruments specifically designed to automate Eurobalises measurements, to enable diagnostic of any issue with these balises, including degradations.

Condition-based monitoring of Eurobalises enables the network operators to replace the Eurobalises before they break, avoiding costly train delays and corrective maintenance interventions, by getting a preventative report of the balise signal quality.
An example of the new tools currently available on the market, presented at the latest TRAKO Fair in Gdansk (Poland) and awarded with the Józef Nowkuński prize, thanks to the added value in innovation and advanced technology brought by its product for maintenance of railway assets, is the BaliseLifeCheck, currently adopted by the Belgian railway infrastructure manager, Infrabel, to constantly check the health of the balises (National and ETCS) installed on the track throughout Belgium.

The BaliseLifeCheck is a moving laboratory, to be installed on a measurement or commercial train, automating the balise maintenance.

The system is equipped with an ETCS antenna, producing detailed signal quality information when it passes over a Eurobalise, and a laptop with embedded software able to compare the actual values with the Subset-036 and Subset-085 standardised parameters (figure 6).

Any risk of deviation with these Subsets (and hence, possible future failures of the systems, which might cause, notably, unavailability of the track), can be identified in real-time, before the failure occurs.

**Collaborative approach**

A ERTMS re-signalling project will require a rigorous approach to its system development including verification, validation, and maintenance arrangements. This will include new ways of carrying out these requirements. In the testing and commissioning stage a ERTMS trackside-onboard integration process using the ERTMSCamCorder provides one solution. To maximise the availability of the system a condition-based monitoring approach to the Eurobalises will enable these to be replaced before they fail. This will avoid train delays and corrective maintenance interventions. These tools will also provide the asset manager a comprehensive data set in order to manage a ERTMS system throughout its life.

**About the author ...**

Maurizio Palumbo is a computer engineer with specific expertise in systems engineering, railway signalling and ERTMS/ETCS. He has solid international experience, thanks to his involvement in three ERTMS schemes (Italy, Denmark, and UK), a CBTC project (London, UK) and collaborations with some of the most significant railway signalling organisations, including Alstom, Thales, Network Rail, London Underground. He currently lives in Brussels, where he works as business developer at ERTMS Solutions.

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Figure 5 – Eurobalise reading ‘suitcase’.

Figure 6 – Eurobalise signal envelope shown against subset thresholds.