European Global Navigation Satellite Systems Agency

ERSAT GGC

WP2 - Enhanced ERTMS Specification and Architecture

Hitachi Rail STS

ERSAT GGC Final Event

Praha, November 26th 2019

WP2 Organization and participants

WP2 - Enhanced ERTMS Specification and Architecture

WP2 Tasks

- WP 2.1 - Consolidation of the Enhanced ERTMS Reference Architecture with Multiple Augmentation Sub Systems
- WP 2.2 - Specification of Functional and Non Functional Tests

WP2 Participants

Hitachi Rail STS (WP leader)

RFI	CEDEX	Italcertifer
Trenitalia	INECO	Bureau Veritas Italia
ADIF	Radiolabs	
SNCF	DLR	

WP2 Key Objectives

- **Review and consolidation of the Enhanced ERTMS Functional Architecture**, suitable for the introduction of the **GNSS technology** and the **Virtual Balise (VB) concept**, and of the IP based Public Mobile Radio Networks

- **Work jointly with the WP3, devoted to the Hazard Analysis**, in order to integrate the safety requirements and to formalize the new Enhanced Architecture in view of the assessment performed by the Notified Bodies within WP5

- **Definition and development of the Functional and Not Functional Test Specification**, to be used for the verification of the new ERTMS systems obtained by the instantiation of the above consolidated Enhanced ERTMS Functional Architecture

WP2 Challenges (1/2)

Define an architecture capable of:

- Being integrated in the ERTMS evolution without any major change
- Granting the backward compatibility with the existing ERTMS systems
- Avoiding implementation constraints

Provide an answer to the safety concerns related to the VB, such as:

- How to manage the GNSS variable accuracy within the ERTMS framework
- How to protect the system against the cross-talk

WP2 Challenges (2/2)

Identify how the operativity of the ERTMS systems would be affected by the introduction of the VB concept

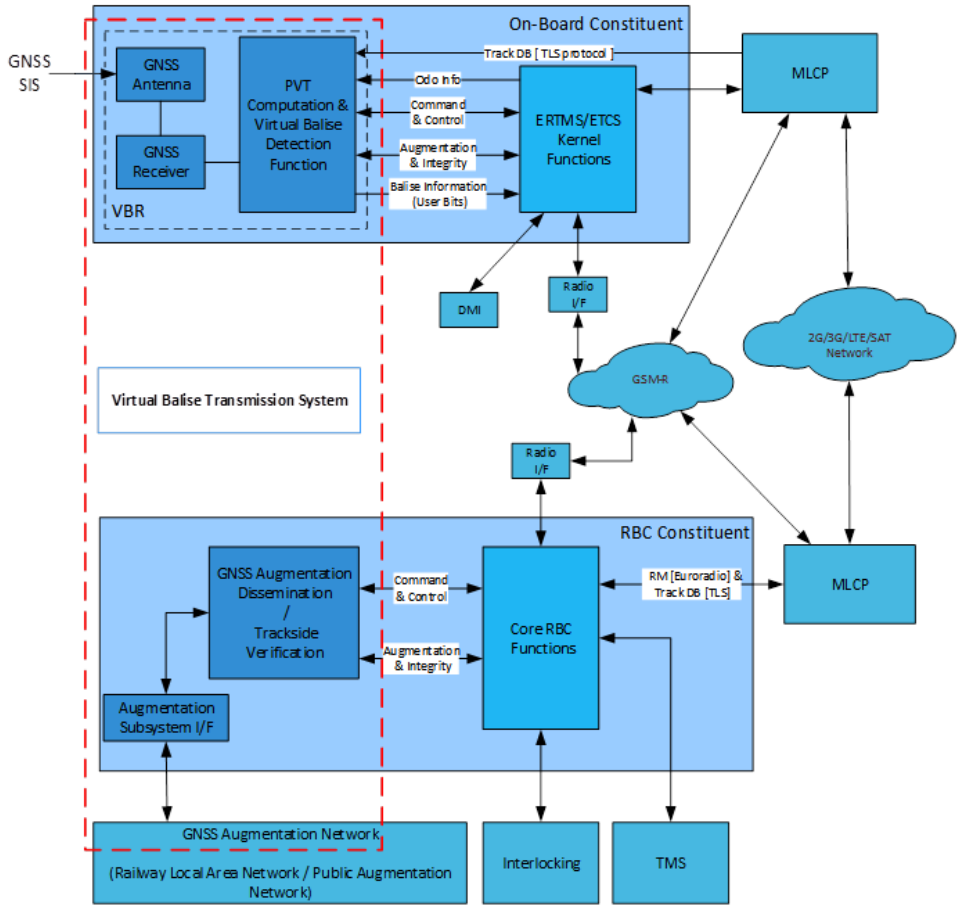
- Analyse the ERTMS Operational Scenarios in order to define which are the scenarios affected
- Define operational solutions in order to minimize the scenarios affected and the impact of the changes

Define how a new system implementing the Enhanced Architecture would be tested

- Define the modification to the laboratory environment necessary to test the new systems
- Identify through a differential approach the tests to be added to the existing ERTMS test suites, with the objective to minimize the impact on the current test procedures

Work performed WP2.1

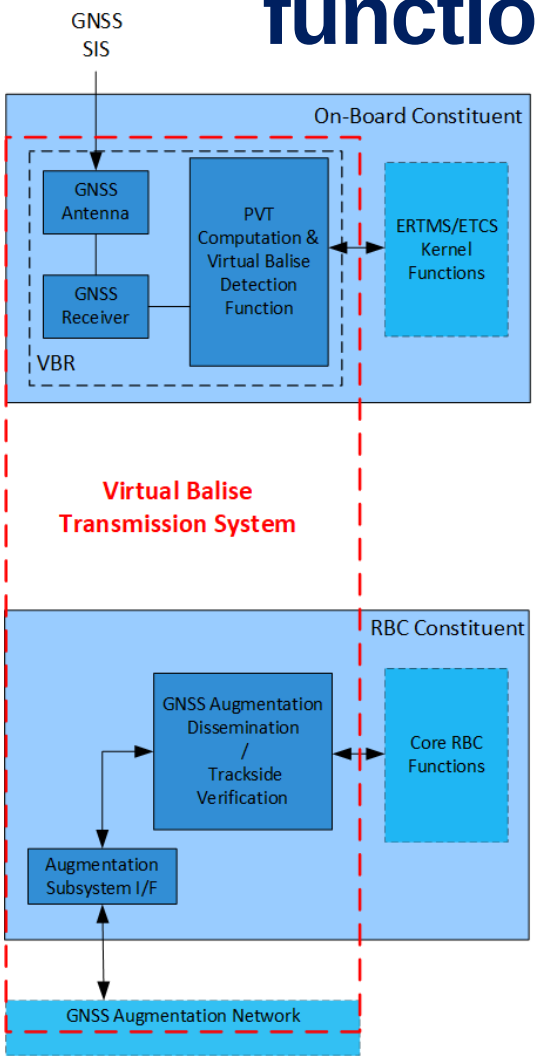
Consolidation of the VB concept



The first step of ERSAT GGC WP2 has been the development and the consolidation of the VB concept defined in the previous R&D projects

Work performed WP2.1

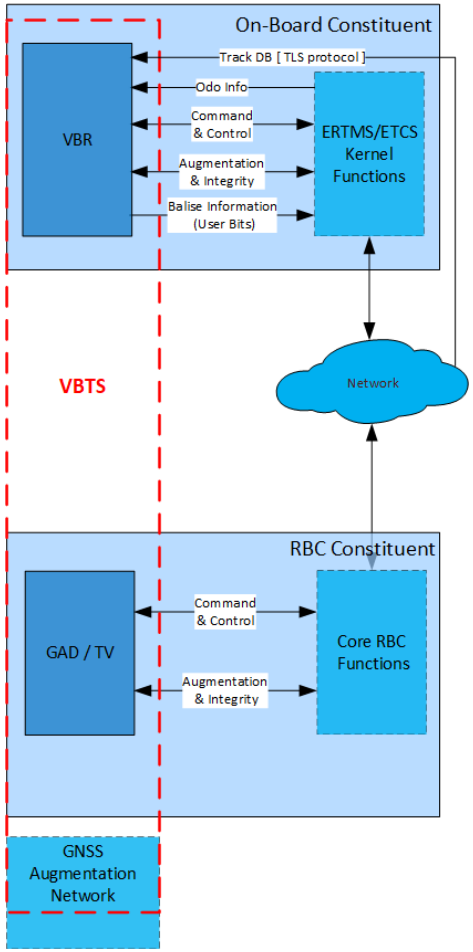
Virtual Balise Transmission System functional blocks definition



- **GNSS receiver function**
  - Provide GNSS SIS and diagnostic data to the PVT block
- **PVT Computation and Virtual Balise Detection function**
  - Computation of the position of the train and detection of Virtual Balises into the on-board track description
  - Provision of the related balise information to the ERTMS/ETCS kernel
  - Delivery of the VBs in the correct sequence and protection against cross-talk
  - Self-diagnostics and start-up tests
- **GNSS Augmentation Dissemination / Trackside Verification**
  - Dissemination of the augmentation information to the VBR
  - Trackside verification and timely generation of alarms

Work performed WP2.1

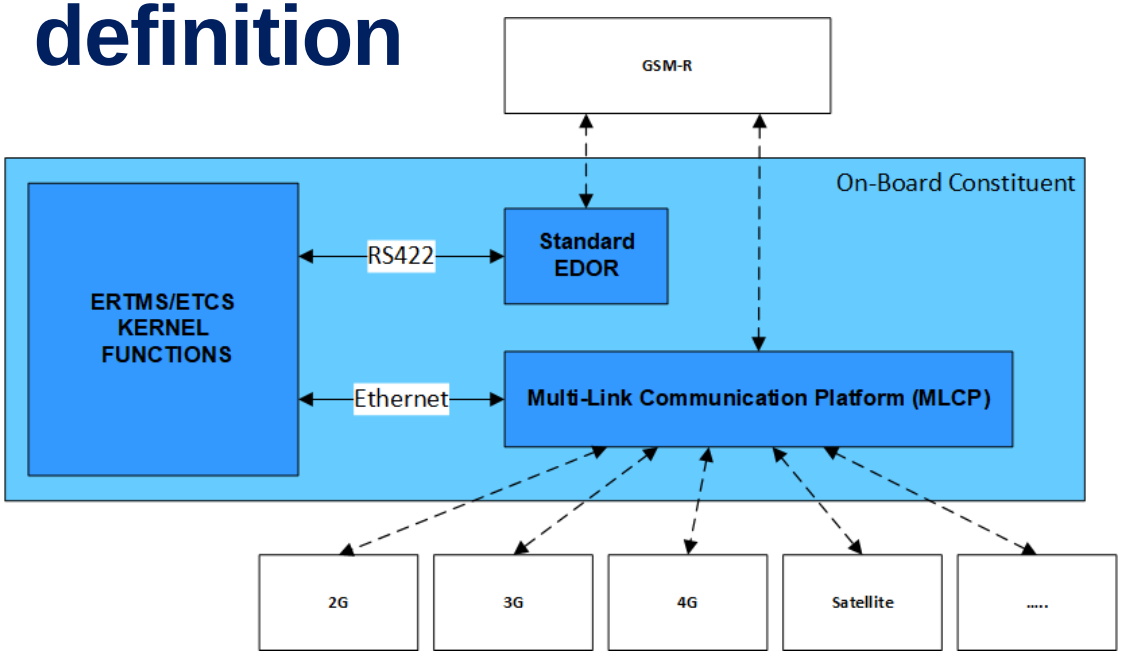
Virtual Balise Transmission System interfaces definition



- **Commands & Control (On-Board)**
  - Management of the VBR equipment, diagnostics
- **Commands & Control (RBC)**
  - Position initialization and verification of DB version, track route discrimination, ERTMS/ETCS train localization and position validation
- **Augmentation & Integrity (On-Board & RBC)**
  - Dissemination of the augmentation information to the On-Board, verification of the VBR information/integrity
- **Odometry Information**
  - Used for odometer stamping and cross-checks
- **Balise Information**
  - Standard Balise user bits and dynamic accuracy
- **Track DB**

Work performed WP2.1

Radio communication system definition



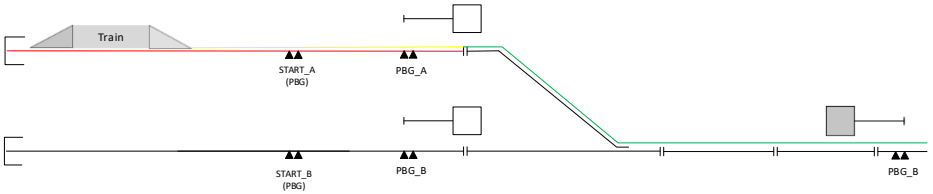
- Using multiple public networks and intelligent routing
- Possibility to interwork with legacy GSM-R network
- Use of Euroradio to guarantee safety/interoperability requirements
- Multi-Link Communication Platform to guarantee QoS suitable for railway domain

Work performed WP2.1

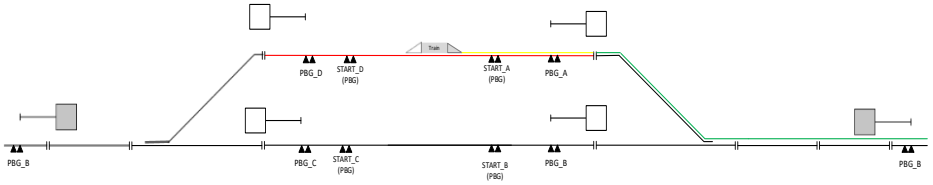
Operational Scenarios definition 1/2

1) **Identification of the Scenarios affected by the introduction of the VBR using an incremental approach**

- **Start of Mission from Terminal Station**



- **Start of Mission from Intermediate Station**



- **Start of Mission from Line**

2) **Analysis of the selected Operational Scenarios**

3) **Analysis of the techniques to further reduce the impact of the introduction of the VB to the ERTMS operativity**

Work performed WP2.1

Operational Scenarios definition 2/2

Formalization of the Operational Scenarios identified

5.4.1 TERMINAL RAILWAY STATION

Rationales:

a. Each platform belonging to a Terminal Railway Station is equipped with two physical BGs:
   - One BG aligned with the starting signal
   - One BG placed near and in rear of the starting signal
b. The EVC and RBC have established a new communication session, as explained in § 5.3.
c. The conditions of freedom of the Route in advance of the train position (i.e. the departure route is correctly set and locked within the station) are satisfied.
d. [Assumption] The VBR has successfully completed the update of the Track DB.

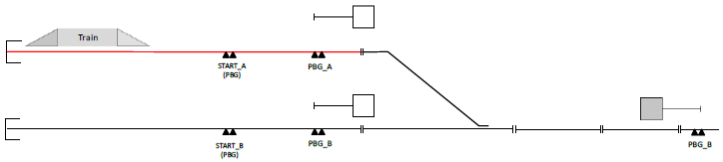


Figure 5 : Terminal Station - SoM with Q_Status "known"

Events:

1. The EVC sends the Start of Mission Position Report message [Msg157], including the information on the stored position (Q_STATUS = 1);
2. RBC receives the SOM Position Report message [Msg157] and checks that:
   - No PR variables have Unknown value
   - The LRBG of the PR is included in the RBC configuration
3. The reference BG of the PR received is located in advance of the Min Safe Front End (MinSFE) of the train.
4. RBC regards the SoM PR as valid, and the GAD/TV sends to the VBR the information to select the track in not ambiguous way (or an equivalent information which defines the platform) to the VBR, where the train is localised.

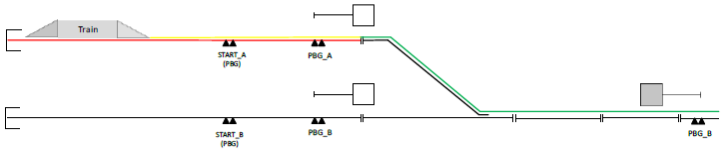


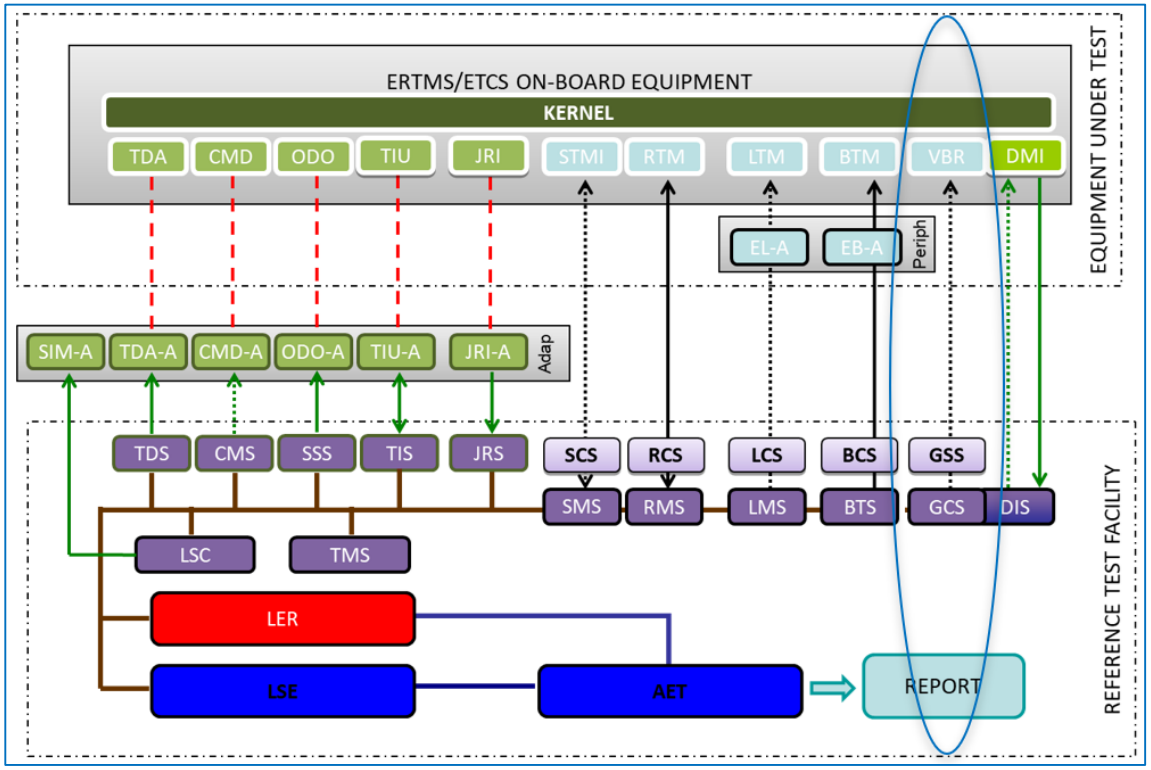
Figure 6 : Terminal Station - First Movement Authority with LS (or OS) mode profile

Work performed WP2.2

Analysis of the Lab environment

- **Definition of a possible On-Board test architecture to be used in order to validate a new system implementing the new Architecture**

- **Impact limited to the introduction of 2 new modules:**



- **GNSS Signal Simulator**
  - **Providing GNSS raw data directly to the VBR antenna connector**

- **Geographical Coordinates Simulator**
  - **Generating the geographical coordinates according to the current position on the track**

Possibility to inject faults according to the test scenario

Work performed WP2.2

Test suite definition 1/2

Selection and analysis of the available Test Suites

- Identification of the available test suites and selection of those affected by the introduction of the VB concept
- By following a differential approach, identification of the additional tests to be added to the existing test suite

Selection of the classes of tests

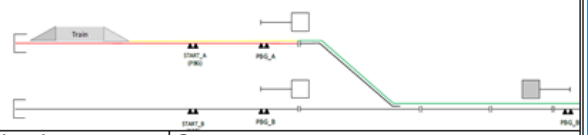
1. The Operational Scenarios determined within the WP2 identify how the VB introduction affects the operation of the ERTMS systems and allow to select **a class of test to prove that there are no hazard in the scenarios**
2. From the safety/availability perspective, the VB differs from the physical balise by its variable and potentially lower accuracy and by the need to know the track routes, therefore **a class of tests assesses the robustness of the system against cross-talk** and threats related to accuracy and update of the VBR information

Work performed

WP2.2

Test suite definition 2/2

Formalization of the Test Cases

TEST CASE DESCRIPTION			
	Code	Version	Title
Test Case	SoM1	01	SoM in L2 with known position. Train is in a terminal station.
Baseline applicable	Baseline 3		
Test case author	…		
Test Objective(s)	The aim of this test case is to verify that the SoM procedure is performed correctly and that the RBC sends the MA with Shifted location reference to the EVC: ▪ An On-Sight (OS) or a Limited Supervision (LS) profile up to the first signal in advance of the train ▪ Full Supervision MA from the first signal in advance of the train up to the last virtual signal where the FS conditions are all fulfilled		
Diagram			
Starting conditions	Level	2	
	Mode	SB	
	Train Speed (km/h)	0 Km/h	
	Additional starting conditions	▪ Each platform belonging to a Terminal Station is equipped with two physical BGs, one BG aligned with the starting signal and one BG placed near and in rear of the starting signal. ▪ The conditions of freedom of the Route in advance of the train position are satisfied. ▪ The VBR has successfully completed the update of the Track DB.	

Sequence of OTC		Checkpoints		
Step	Description	Interfaces	Description of what to be tested at the interface	OK?
1	The driver validates or introduces the Driver ID.	DMI(O)		
		DMI(I)	DRIVER ID	
		JRU		
2	The establishment of a communication session is initiated by the EVC.	DMI(O)	Safe radio connection "Connection Up"	
		DMI(I)		
		JRU	Message 155 Message 32 Message 159	

Project findings and next steps (1/2)

The Enhanced ERTMS Functional Architecture and the Virtual Balise concept, defined in the previous R&D projects, have been extended and enriched with:

- A thorough analysis on the impact of the VB concept on the operation of the ERTMS systems, which demonstrated to be limited to a small subset of scenarios
- The definition of a possible test architecture and test suite to verify the new enhanced architecture

In collaboration with the WP3 which performed the **Hazard Analysis of the proposed Architecture**, the project answered to the possible concerns about the safety and the availability of the Enhanced Architecture, which demonstrated to be robust and reliable

Project findings and next steps (2/2)

An **independent assessment has been performed** within the WP5 in order to guarantee the full compliance of the new Enhanced Architecture with all applicable standards and norms

The work performed within the project can be used as a possible input for the **evolution of the ERTMS roadmap** through both the introduction of the train positioning based on the GNSS System and the Public Radio TLC Technologies

In particular, **the Hazard Analysis and the Safety Assessment** performed on the Enhanced Architecture is expected to **pave the way of the certification process for a first operational deployment** on a Pilot Line selected by RFI

Thank you for your attention!