European Global Navigation Satellite Systems Agency

ERSAT GGC

WP1 – ERSAT GGC Summary Results

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Prague, 26 November 2019

Agenda

In the morning:

- Main Project Objectives
- Project WBS and List of Main Deliverables
- Project Challenges

In the afternoon:

- Main Reached Results & Closing Remarks

Rationale for the 1st Objective

1

- **ESA 3InSat Project (2012 – 2015)**: A demonstration project to develop, test and verify a new ERTMS based system with the **SIL 4 train localization function** and the GNSS Positioning technology.

2

- **Roy Hill Project (2012 – 2017): SIL 4** ERTMS L2 based System with **Virtual Balises only**. The line (350 km) is in commercial service since beginning 2017.

3

- Due to the positive obtained results, STS supported the setup of initiatives aimed to the definition and the development of a **standard** and **interoperable** ERTMS solution based on the **VB concept**.

Main Project Objectives (cont.)

Rationale for the 1st Objective

ERSAT-EAV (GSA), SBS Feasibility Study (ESA), RHINOS (GSA), DB4Rail (ESA)

NGTC-WP7 (EU) investigated the GNSS Positioning into ERTMS by applying the **Virtual Balise concept**. A preliminary functional and a **safety analysis** was carried out

STARS (GSA) investigated how to fill the **gap** between ERTMS safety needs and EGNSS services, through the **railway environment characterization**

Roughly all ERTMS Suppliers

Rationale for the 1st Objective

... In the meantime ...

ERTMS Longer Term Perspective (ERA Report, Dec. 2015)

- "Use of **early implementers**: operational feedback of new function in an early implementation project; A common integrated project between the early implementers and the ERA for the development of the main contributors should be established and enforced by a strong commitment to get an interoperable solution."

RFI – Game Changer of Satellite Positioning

- To act as **early implementer**, it created the **ERSAT Program**.

Main Project Objectives (cont.)

1st ERSAT-GGC Main Objective

Enhanced ERTMS Specification and Architecture (WP 2)

New funct. blocks;

New interfaces (e.g. GNSS SIS, Augmentation, ...);

Signaling mitigation for coping with new hazards;

Specification of Funct. and Non Funct. Tests

...

Safety and Hazard Analysis of the Enhanced ERTMS Architecture (WP 3)

Assessment of the Enhanced ERTMS architecture (WP 5.1)

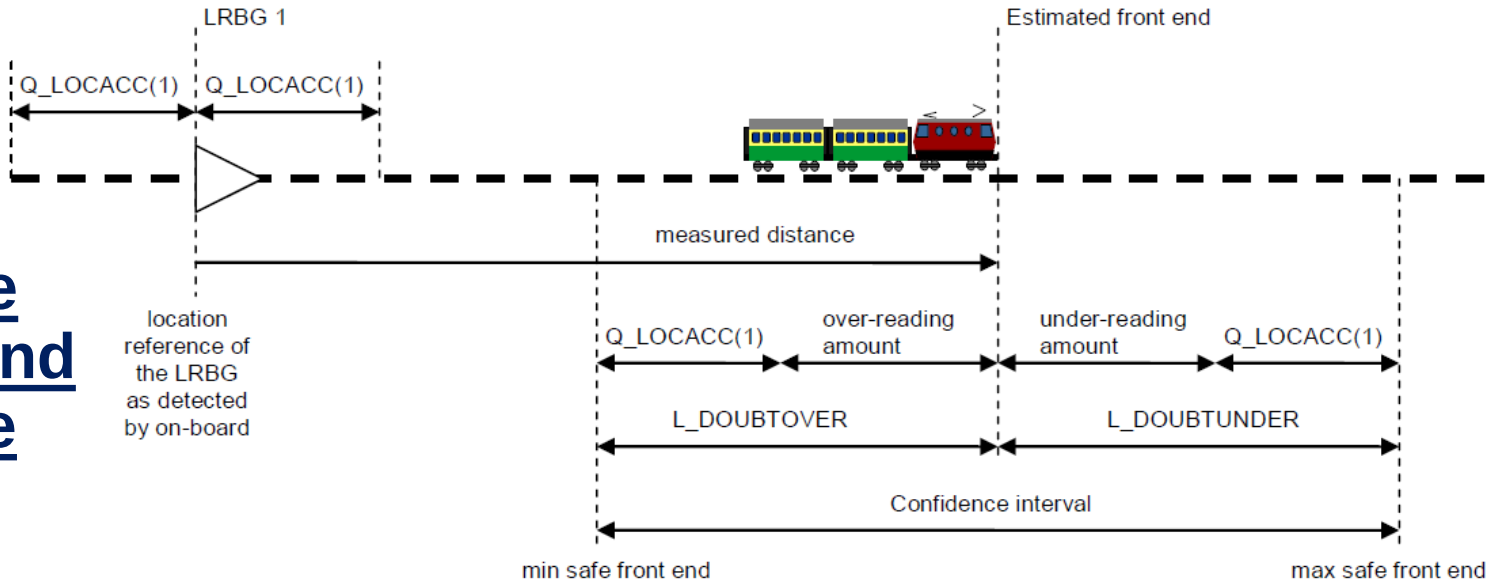
Safety Analysis of the Enhanced ERTMS Architecture

GNSS Quantitative Study for ERSAT GGC project

Independent assessment of the enhanced ERTMS architecture by two Notified Bodies

Main Project Objectives (cont.)

Rationale for the 2nd Objective



Train Confidence Interval with **Physical Balise** = **F**(Location Accuracy of LRBG, Odometer Accuracy, Physical Balise Detection Error)

Where:

- Location Accuracy of LRBG is a **Static Configuration** Value
- Physical Balise Detection Error **<= 1 m**

Rationale for the 2nd Objective

Train Confidence Interval with **Virtual Balises** = **G**(Location Accuracy of Last Relevant Virtual BG, Odometer Accuracy, Virtual Balise Detection Error)

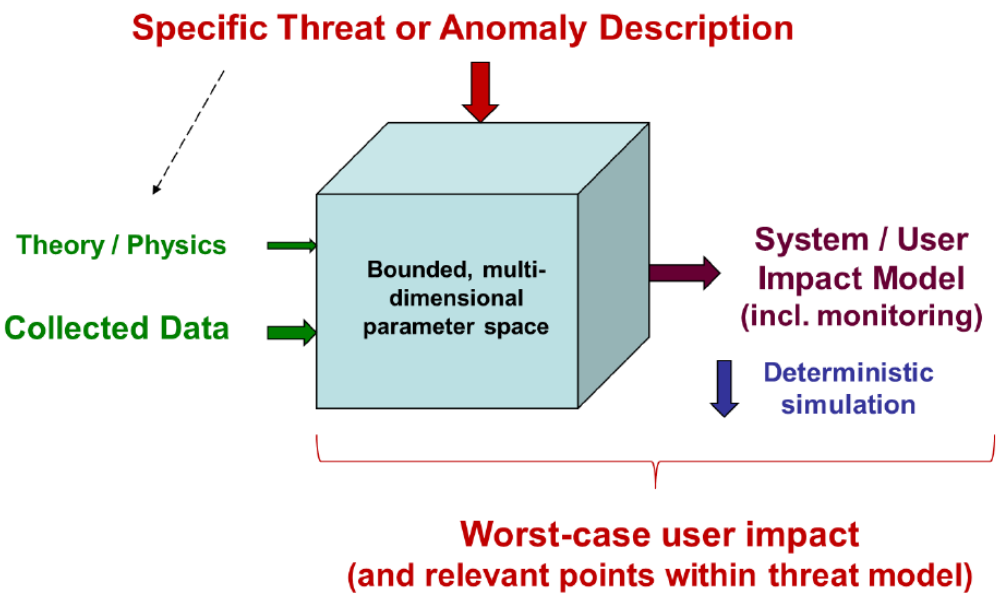
Where:

Location Accuracy of Last Relevant Virtual BG, still defined as a **Static Configuration** Value, defines the **nominal** maximum location accuracy (e.g. 99%) of a Virtual BG.

Virtual Balise Detection Error **is the best estimation of the detection error dynamically computed at the VB Detection time.**

Rationale for the 2nd Objective

VB Location, with the **required inaccuracy confidence interval** =
Best Estimation of the VB Location +/- Virtual Balise Detection Error

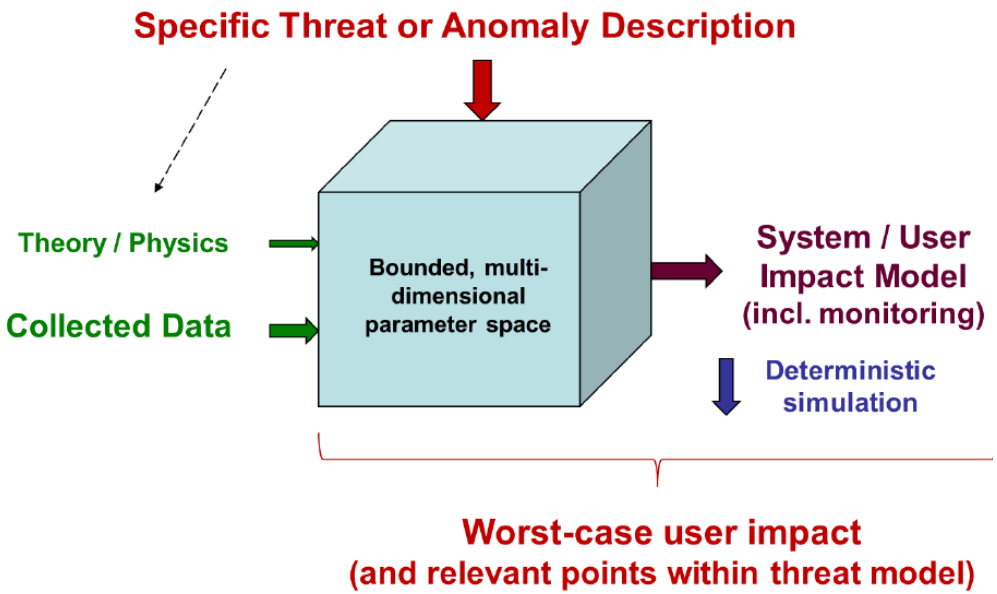


RHINOS D11.1 – Description of the comparable efforts in Aviation

The inaccuracy confidence interval must bound errors under **anomalous** and **nominal conditions**. To bound errors for anomalous conditions, specific "**Threat Models**" are normally defined and developed for each faulted or anomalous condition that is of non-negligible probability and may lead to unbounded errors exceeding the wished limits.

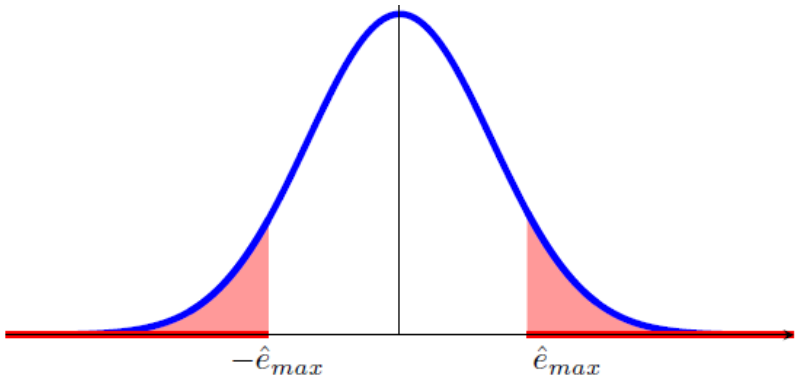
Rationale for the 2nd Objective

VB Location, with the required inaccuracy confidence interval =
Best Estimation of the VB Location +/- Virtual Balise Detection Error



RHINOS D11.1 – Description of the comparable efforts in Aviation

GNSS Position Integrity in Urban Environment: A Review of Literature
Ni Zhu, Juliette Marais, David Betaille, Marion Berbineau - IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS



Negligible Systematic Errors, Random Errors only, Error Distribution is a Centered Gaussian, the red zone represents the target integrity risk

Rationale for the 2nd Objective

To reduce the residual risks that:

- the identified **GNSS Positioning Algorithms for railways**, and
- the defined **Fault Detection** and **Exclusion Algorithms**, and
- the identified **Threat Models** and the related **Fault Injection simulation environment**, and
- the **configuration values** proposed for **not being too much conservative**

might NOT bounds the errors under some specific local phenomena conditions in some specific railway track areas

THE A PRIORI SURVEY HAS BEEN PROPOSED AS A FURTHER TEMPORARY MITIGATION FOR THE FIRST PILOT LINES

Main Project Objectives (cont.)

2nd ERSAT-GGC Main Objective

Track Survey and Track Classification (WP 4)

- Definition of the Track Area Classification Process;
- Specification and Development of the Classification Toolset;
- Track Survey Execution and Data Collection;
- Evaluation of data and Integration of the Toolset in CEDEX, DLR, RINA and RFI Laboratories

Assessment of the Survey Process for Classifying the Track Areas (WP 5.2)

Assessment of the related Toolset (WP 5.3)

- Independent assessment of the classification process
- Independent assessment of the classification toolset

Demonstration (WP 6)

- Field Demonstration of the Process & Toolset

3rd ERSAT-GGC Main Objective

Dissemination and Exploitation

Dissemination plan

Public website

Project leaflets

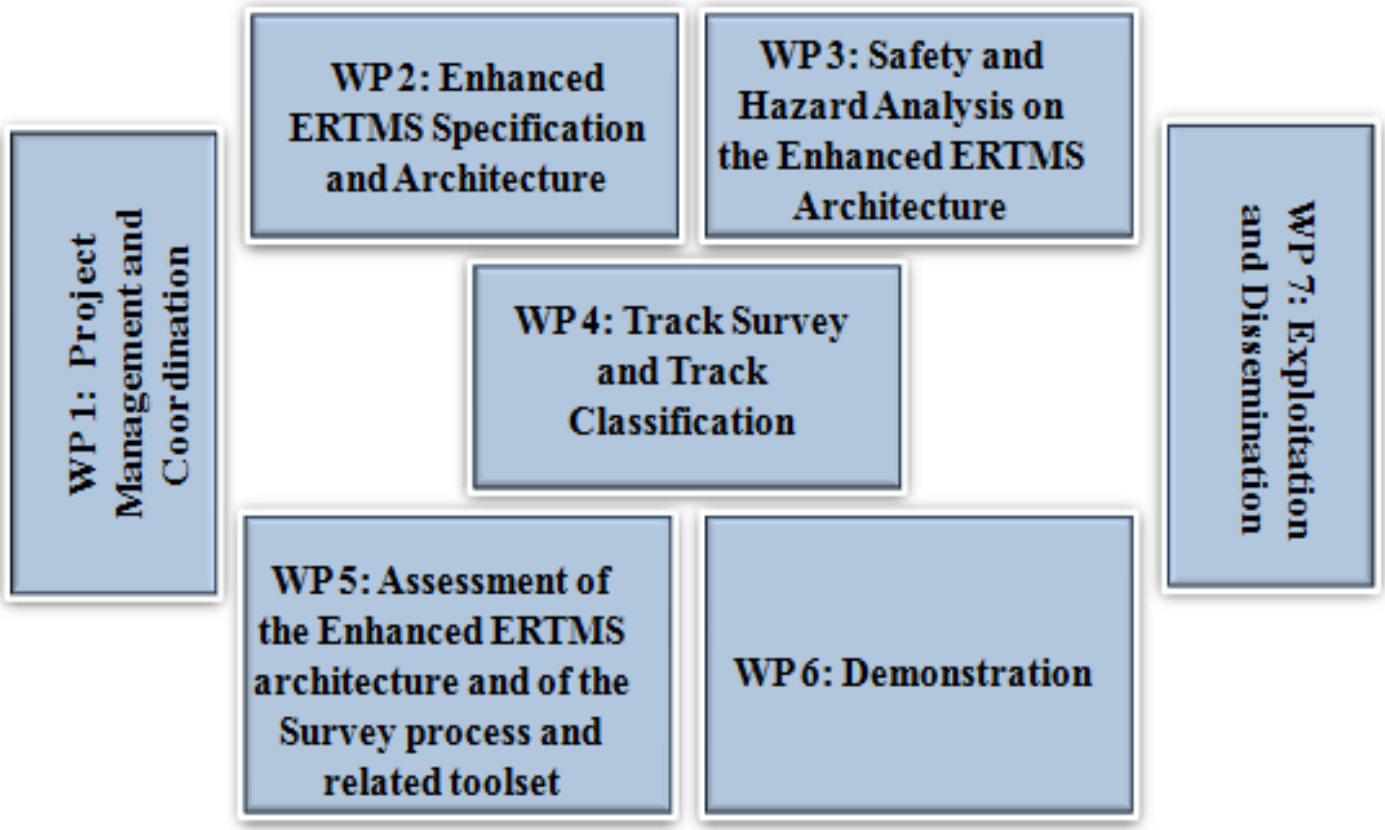
Exploitation actions

Project WBS and List of Main Deliverables

Project WBS and List of Deliverables

ERSAT-GGC WBS

WP1: RFI
WP2: STS
WP3: RINA-C
WP4: DLR
WP5: BVI
WP6: RDL
WP7: UNIFE



Project WBS and List of Deliverables (cont.)

List Of Deliverables associated with 1st Main Objective

Del. #	Deliverable name	WP #	Short name of lead participant	Type	Dis. level
D2.1	Enhanced Functional ERTMS Architecture Capable of using GNSS and Public Radio TLC Technologies	2	STS	R	PU
D2.2	Functional and Not Functional Test Specification	2	STS	R	PU
D3.1	Safety Analysis of ERSAT ERTMS Application over GNSS	3	RINA-C	R	PU
D3.2	GNSS Quantitative Study for ERSAT GGC Project	3	RINA-C	R	PU
D5.1	Assessment report of the enhanced functional ERTMS architecture	5	BVI/ITCF	R	PU

Project WBS and List of Deliverables (cont.)

List Of Deliverables associated with 2nd Main Objective

Del. #	Deliverable name	WP #	Short name of lead participant	Type	Dis. level
D4.1	Procedure Specification Document	4	DLR	R	CO
D4.2	Technical Specification of Survey Toolset	4	DLR	R	CO
D4.3	Prototype Implementation of the Survey Toolset	4	DLR	DEM	CO
D4.4	Measurement Campaign Report	4	DLR	R	CO
D4.5	Process Execution Report	4	DLR	R	PU
D5.2	Assessment report of the survey process	5	BVI/ITCF	R	PU
D5.3	Assessment report of the related toolset	5	BVI/ITCF	R	CO
D6.1	Track Survey Execution Report	6	RDL	R	PU
D6.2	Field Data Analysis Report	6	RDL	R	PU

Project WBS and List of Deliverables (cont.)

List Of Deliverables associated with 3rd Main Objective

Del. #	Deliverable name	WP #	Short name of lead participant	Type	Dis. level
D7.1	Dissemination Plan	7	UNIFE	R	CO
D7.2	Project Website	7	UNIFE	DEC	PU
D7.3	Project Leaflet	7	UNIFE	DEC	PU
D7.3	Project Leaflet – Updated	7	UNIFE	DEC	PU
D7.4	Dissemination and Exploitation Report	7	UNIFE	R	PU

Project Challenges

Project Challenges

WP 2

Definition and Analysis of the ERTMS Operational Scenarios

- Critical review with RFI, RINA-C, NoBos

WP 2,
WP 3,
WP 5

Verification of the Enhanced ERTMS Functional Architecture

- Common Interpretation of the New Hazards
- Identification of the mitigations
- Successful completion of the qualitative and quantitative Safety Analysis

Project Challenges (cont.)

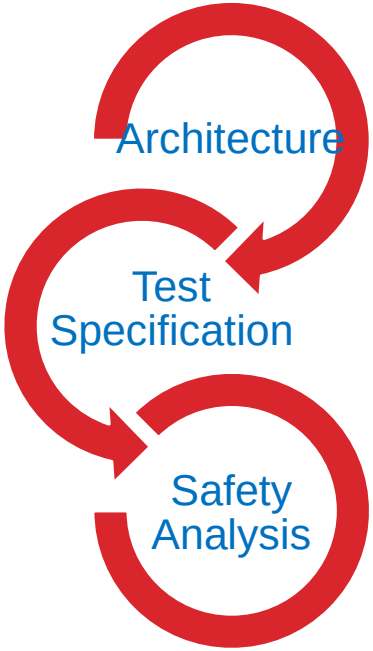
WP 4,
WP 5,
WP 6

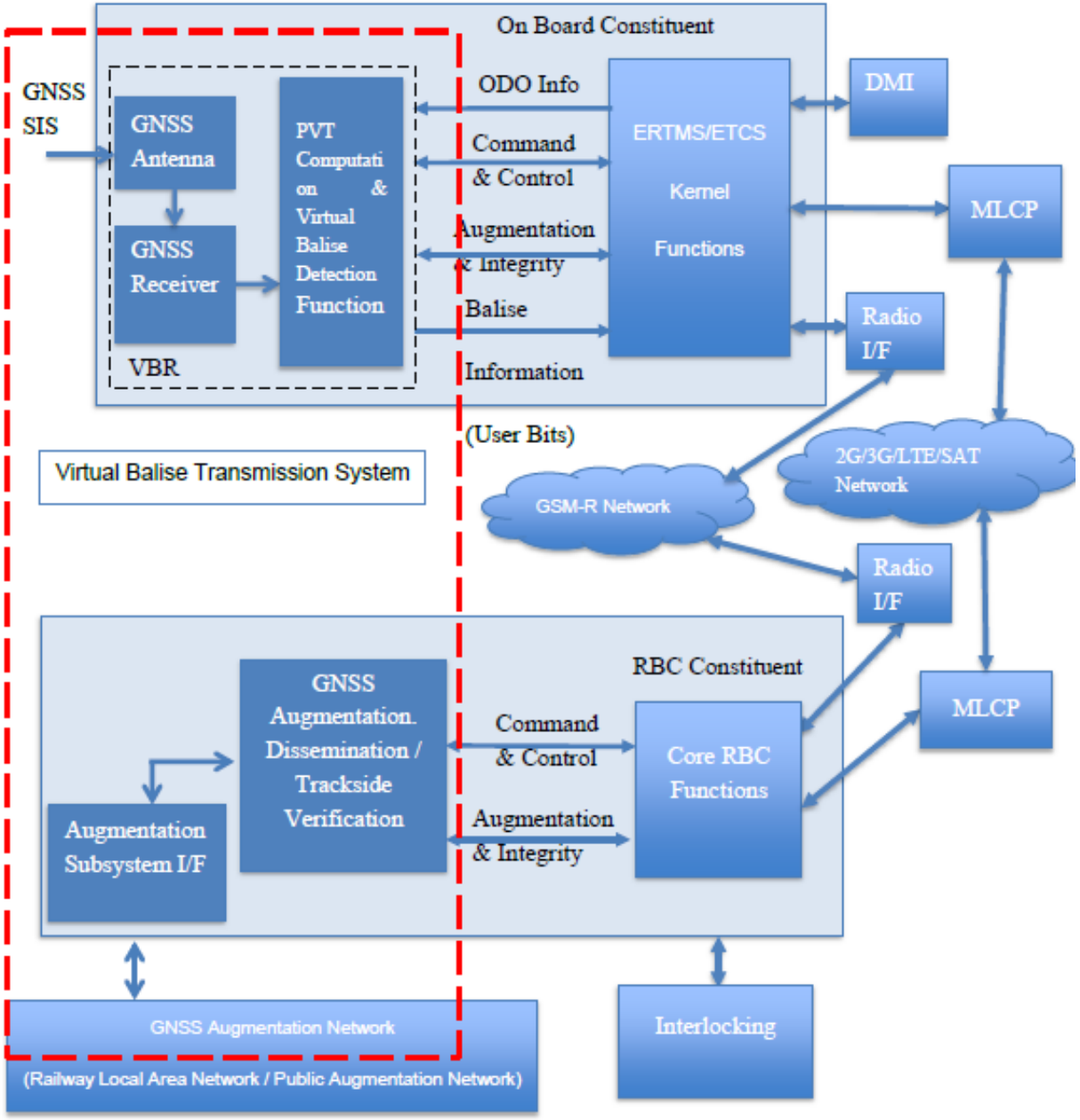
Classification Process & Toolset

- **Complexity initially underestimated**: many topics require further R&D activities
- **Lack of the Railway MOPS** introduces further complexity (e.g. parametric process and many configuration parameters);
- **Tight Schedule -** A two phases process has been defined and Phase 2 has only been outlined. Phase 2 is expected to carry out a continuous monitoring of the already classified track areas to detect a degradation of the performance indexes.

Main Reached Results & Closing Remarks

Reached Main Results & Closing Remarks





Reached Main Results & Closing Remarks (cont.)

In particular,

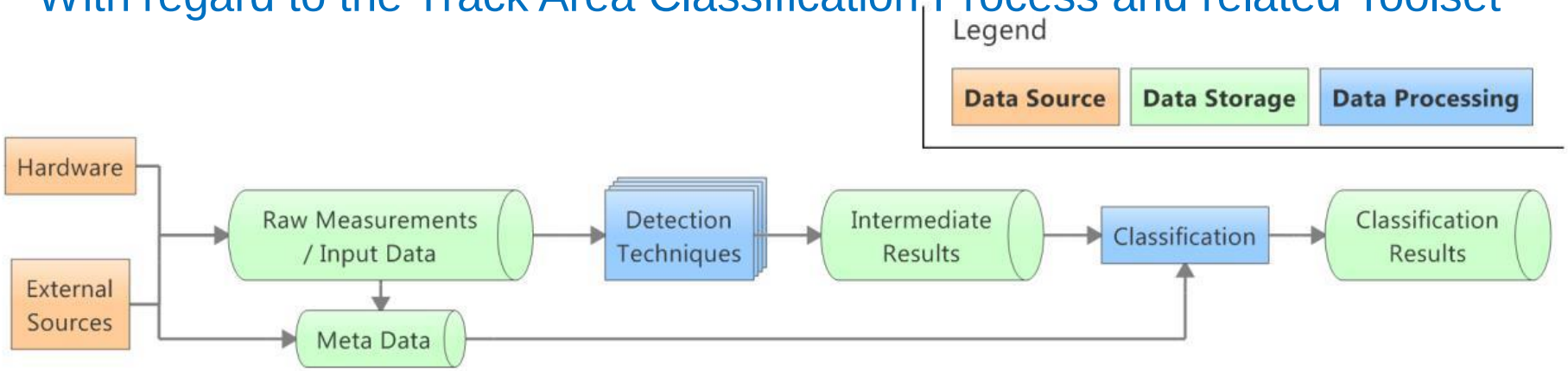
- The safety analysis have been developed on the basis of Railway best practices for the Risk Management, such as the **Common Safety Method** (CSM) and the **CENELEC EN 50126**;

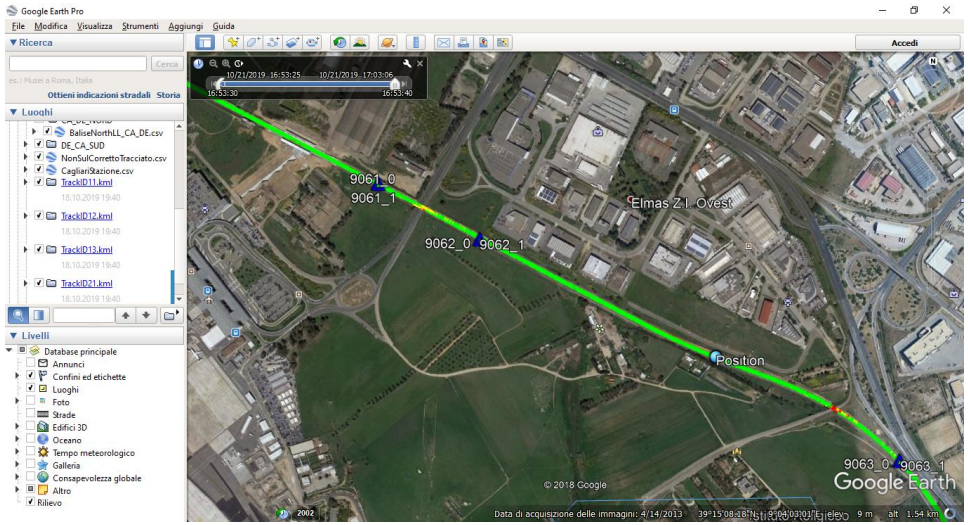
- The Qualitative Safety Analysis has adopted the **Failure Mode, Effects, and Criticality Analysis (FMECA)** approach, in general accordance with the "MIL-STD-1629A:1980 – Procedures for performing a failure mode, effects and criticality analysis";

- The **Fault Tree Analysis** is based on the ETCS Core Hazard THR top-down apportionment for the hazard rates of the UNISIG grouping of constituents, as already performed in **SUBSET-091** and **SUBSET-088 Part 3**, and introduces the VBTS functions within the grouping of constituents (i.e., Onboard, Trackside and Transmission Subsystem).

Reached Main Results & Closing Remarks (cont.)

With regard to the Track Area Classification Process and related Toolset





Examples of results (Italy on the left, Spain on the right)

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Reached Main Results & Closing Remarks (cont.)

List of Publications

- Rihab Hmida, Amaury Flancquart, Juliette MARAIS, "**FPGA implementation of a video-based system for GNSS reception characterization along a railway line**", Accepté à 4th International Conference on Railway Technology: Research, Development and Maintenance, 3-7 September 2018 | Sitges, Barcelona, Spain
- Juliette Marais, Rihab Hmida, Amaury Flancquart, Salvatore Sabina, Massimiliano Ciaffi, "**Video-based classification of railway track areas for GNSS-based virtual balise solutions in the ERSAT GGC project**", ION-ITM, January 29-February 1, 2018, Reston, Maryland
- M. Ciaffi, J. Marais, G. Emmanuele, O. Garcia Crespillo, A. Coluccia, A. Vennarini, S. Sabina, S. A. Kazim, D. Gerbeth, M. Caamano, A. Neri, E. Razzano, F. Senesi, "**Classification of Railway tracks for applying enhanced ERTMS/ETCS Solutions Based on GNSS positioning technologies**", WCRR 2019 - Interactive Poster Session, Tokyo, oct.
- Omar Garcia Crespillo, Juliette Marais, Andriy Konovaltsev, Salvatore Sabina, Alessia Vennarini, Andrea Coluccia, Elena Razzano, Antonio Aguila, Francesco Ranauro, Alessandro Neri and Massimiliano Ciaffi, "**Local GNSS Threat Detection Methods for Virtual Balise Placement in Railway Applications**", ITST 2018", Lisbonne, Octobre 2018

Reached Main Results & Closing Remarks (cont.)

List of Publications

- Joaquín Peinado (Adif), José Bueno (CEDEX), "**Campaña de pruebas y experimentación en la línea 528 Almorchón-Alhondiguilla**", 10 Congress Innovation Ferroviaria, Oct. 24th – 25th 2019, Merida (Spain)
- C. Wullems, F. Sperandio, M. Basso, S. Sturaro, S. Sabina, "**A Preliminary Apportionment of Safety Targets for Virtual Balise Detection using GNSS in Future Evolutions of ERTMS**", ITST 2018, Lisbonne, October 2018.
- Alessandro Neri, Pietro Salvatori, Cosimo Stallo, Andrea Coluccia, "**A Multi-sensor Autonomous Integrity Monitoring Approach for Railway and Driver-less Cars**", ION GNSS+ 2018, Miami, September 2018
- P. Salvatori, C. Stallo, A. Coluccia, A. Neri, F. Rispoli, "**An Integrity Monitoring Algorithm Design Based on Code Double Differences for Rail GNSS Augmentation Network**", 2018 IEEE 4th International Forum on Research and Technology for Society and Industry (RTSI)

Reached Main Results & Closing Remarks (cont.)

Dissemination

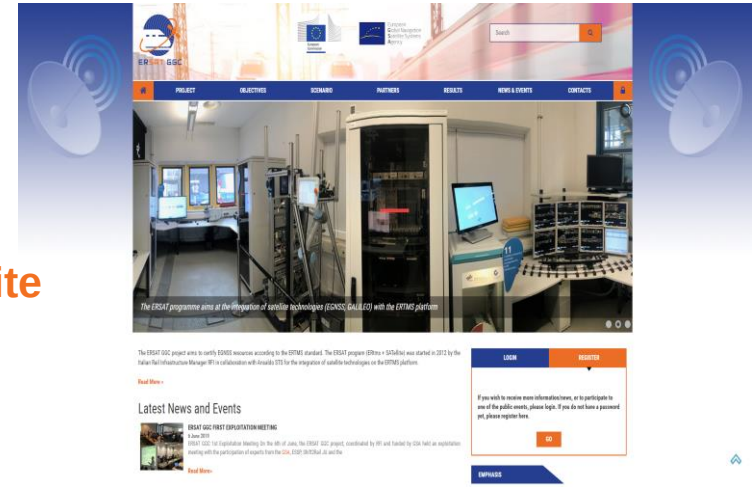
Dissemination of the project through different channels: website, social media, publications and events/conferences.

Technical Publications

Brochures

Events/Congress/Conference

Website



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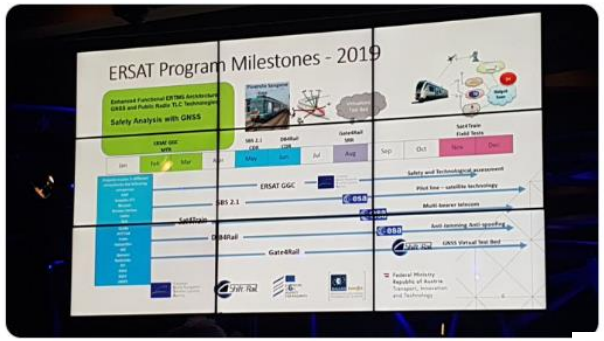
Reached Main Results & Closing Remarks (cont.)

Omar G. Crespillo @OmarGCrespillo · 13 nov.
@EU_GNSS presenting the roadmap and next steps activities of European GNSS in Rail, including **#ERSAT_GGC** project, during the #space4rail event at @esa.

Juliette Marais @marais_juliette · 19 mars
#SpaceInRail **#ERSAT_GGC** is an important project now in the process in the ERSAT program

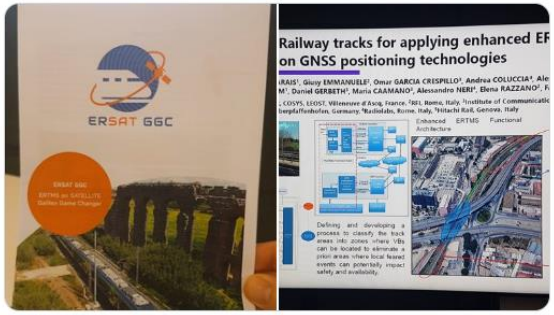


European GNSS Agency @EU_GNSS · 27 juin
#EGNSS & #rail :
#Galileo and European Rail Traffic Management System #ERTMS are perfect complementary assets that together can considerably reduce rail operational costs. How? Check what the #ERSAT project is doing in this field!

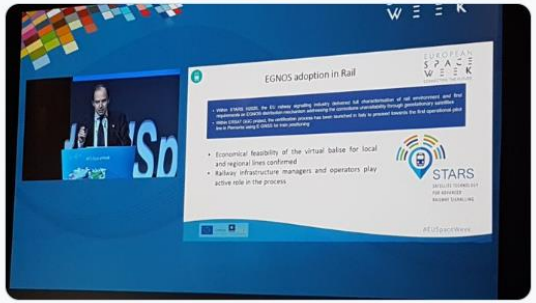
gsa.europa.eu/newsroom/news/...

#EUrail #UseGalileo

Juliette Marais @marais_juliette · 30 oct.
#ERSAT_GGC project is presented this morning (now!) in IP_07 session of #WCRR2019 #Tokyo, seminar room 1. #GNSS for #ERTMS/#ETCS solutions



Juliette Marais @marais_juliette · 5 déc. 2018
#EUspaceweek **#ERSAT_GGC** and #STARS #rail projects are on the floor in the presentation of GG. Calini from @EU_GNSS !



UNIFE The RAIL IND. @UNIFE · 27 mars 2018
#ERSAT GGC aims to fill the last but fundamental gap before putting into service the ERSAT by enabling @ERTMS to use satellite services bit.ly/2GgHD7b .

Meet us at the UNIFE C04 stand at @TRA_Conference

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Reached Main Results & Closing Remarks (cont.)

Juliette Marais @marais_juliette · 19 mars
M. Ciaffi from RFI presents the #ERSAT ecosystem: #ERTMS #Satellite in its **#ERSAT_GGC** presentation @EU_GNSS #SpaceInRail

Juliette Marais @marais_juliette · 3 déc. 2018
#EUSpaceWeek #GNSS #Rail session. Let's share the progresses of ongoing projects. Starting with M. Ciaffi and **#ERSAT_GGC** project

Juliette Marais @marais_juliette · 30 oct.
#WCRR2019 G. Ridolfi #RFI: **#ERSAT_GGC** goal is to build a track area classification process based on the presence of #GNSS local permanent threats for #ERTMS use. Funded by @EU_GNSS. More info: ersat-ggc.eu

Ineco @Ineco_es · 13 juil. 2018
José Conrado, jefe de área de Desarrollo I+D+i de @Adif_es, es el encargado de continuar la jornada, explicando el Proyecto **#ERSAT** (#ERTMS + #Satélite) y las pruebas a realizar de este estándar en las líneas de @Adif_es #AgoraERTMS

Exploitation

Exploitation of the project through effective communication with key stakeholders of rail and space sectors

Date: **6th June 2019**

External Participants: **GSA, ESA, ESSP,CAPRESE/STEMS S2R JU**

Time	Topic	Responsible
10:00 – 10:15	Welcome	M. Ciaffi S. Sabina
10:15 – 10:45	STEMPS presentation	T. Richardson
10:45 – 11:15	CAPRESE presentation	T. Richardson
11:15 – 11:45	Virtual Balise Detection Algorithms Suitable for Guaranteeing an a-priori Predictable Trackside Signalling Design Analysis	S. Sabina
11:45 – 12:15	Roundtable	all
12:15 – 12:30	**Break**	
12:30 – 13:00	WP2 Presentation "Enhanced ERTMS Specification and Architecture"	F. Pognante S. Sabina
13:00 – 13:30	WP3 Presentation "Safety and Hazard Analysis of the Enhanced ERTMS Architecture"	F. Sperandio S. Sturaro
13:30 – 14:15	**Lunch**	
14:15 – 14:30	WP5 Presentation "Assessment of the Enhanced ERTMS architecture and of the Survey process and related toolset"	A. Basili
14:30 – 15:00	Roundtable	All
15:00 – 15:15	Wrapping up	M. Ciaffi S. Sabina

Thank You for having listened