

1. PUBLISHABLE SUMMARY

List of Beneficiaries

No	Name	Short name	Country	Project entry month	Project exit month
1 (Coordinator)	CENTRO DE ESTUDIOS E INVESTIGACIONES TÉCNICAS	CEIT	Spain	1	42
2	ERTMS SOLUTIONS SPRL	ESOL	Belgium	1	42
3	FRAUNHOFER	FRAUNHOFER IIS	Germany	1	42
4	NOTTINGHAM SCIENTIFIC LTD.	NSL	UK	1	42
5	ASOC. DE ACCION FERROVIARIA	CETREN	Spain	1	42
6	UNIVERSITY OF GLASGOW	UGLA	UK	1	42
7	INTEGRASYS	INTEGRASYS	Spain	1	42
8	PHIDANI SOFTWARE SPRL	PHIDANI	Belgium	1	42

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Summary description of project objectives

EATS project DoW identifies the objectives of this project. It aims at progressing the ETCS on-board equipment laboratory testing and the use satellite positioning technologies together with other technologies into ERTMS.

The main research paths of the EATS project are aligned with the two main objectives. On the one hand is the improvement of the current laboratory for testing the on-board ETCS equipment (EATS_LAB). EATS_LAB will help to define the required tools to further test the system focusing on safety and including more realistic tests for the wireless links. On the other hand is the definition of the Smart Train Positioning System (STPS) to be integrated into the ETCS on-board equipment (EATS_GNSS). The STPS is based on satellite positioning and wireless technologies employed as Location-Based Services (LBS) that should help to overcome current limitations of the migration to ETCS level 3. Both the research lines are also connected and share the same three phase methodology:

1 – Requirements definition

EATS_LAB is focused on the implementation of the ETCS on-board Golden Reference Model (GRM), identification of the wireless communications of the on-board ETCS in order to test the system in a realistic environment, definition of the faults to be injected to the on-board ETCS equipment in order to test its safety level and the development of the testing laboratory model architecture proposal.

EATS_GNSS is centred on the requirements definition for STPS, such as functional requirements, RAMS requirements, architecture regarding number of antennas and its location on the train's roof, test setup requirements and finally identification of the required mechanism for standardisations and certification in the field of GNSS and ETCS.

2 – Implementation

EATS_LAB is focused on the implementation and verification of the proposed laboratory tools for ETCS testing, namely, Wireless Communication emulators that will introduce the realistic effect in the air-gaps, Saboteurs that will inject faults to be to the on-board ETCS equipment in order to test its safety level and the required tools for STPS laboratory testing.

EATS_GNSS is centred on the implementation and verification of the key parts of the STPS such as the positioning algorithms based on the multi-constellation GNSS and wireless technologies (UMTS, GRM-R) and the information fusion, the prototype to determine AOA by means of GSM-R, the definition of the integration of the STPS within the on-board ETCS and the implementation of the scenarios for the STPS positioning algorithms to be carried out in WP7.

3 – Validation

EATS_LAB is focused on the validation of the tools implemented in the previous phase. For that, first the integration of the tools into the ETCS laboratory model developed will be carried out. After that, the validation of the wireless communications emulators and the calibration of the saboteurs will be covered. Finally, a proposal to contribute to the standards will be done.

EATS_GNSS is centred on the validation of the positioning algorithms and the AOA determination prototype, as well as the verification of the RAMS requirements of the STPS. Moreover, an analysis of the STPS integration into the on-board ETCS system will be carried out. Further, a proposal to contribute to the standards will be done.

Finally, dissemination is also a key objective of the project. Dissemination activities are considered across seven levels: Worldwide level with a web page, dissemination to the main stakeholders in railway, dissemination to the industry, courses for professionals and students, contributions to technical journals and international congresses, contribution to the standards and analysis of the commercial exploitation of the outcomes of the project.

Work performed and main results achieved

The EATS project is broken down into eight work packages (WPs) that will lead to the achievement of the ultimate goals of the project. All the tasks for the period from 1st April 2014 to 30th September 2015 described in Annex I (Description of Work) have been completed into the period and the deliverables have been sent as planned. Following, the activities of the WP1, WP2, WP3, WP4, WP5, WP6, WP7 and WP8 carried out in this period are briefly described:

WP1: Coordination and management

This work package deals with all the management aspects of the project and the monitoring of the progress towards the ultimate objectives, identifying shortcomings and recommending remedial action

when necessary. Only CEIT has resources in this first work package that is dedicated to the management activities. Therefore, CEIT, as project coordinator, has the main responsibilities in such matters: administrative, financial, legal and IPR activities. The technical management with tasks review and generic progress review meetings are also CEIT's responsibilities.

WP2: Requirements and architecture definition of the test setup for the on-board ERTMS/ETCS level 1,2&3

This work package has been completed in the 2nd period with the update of the ETCS on-board model with the baseline 3 ETCS kernel (EVC) based on ESOL'S EFS (ERTMS Formal Specs.) (T2.1). This has been done following the Advisory Board's proposal. The model has been developed in such way as to manage the information that will send/receive the kernel to/from ODO, RADIO, BTM, LTM, DMI, TIU and JRU. Moreover, the virtual laboratory (EATS_LAB) has been completed and a list of scenarios has been build (T2.4). This will allow to test the model developed and to introduce the tools developed in WP4. Moreover, different scenarios can be simulated in order to see the behaviour of the system. This WP has been completed and the 1st milestone (MS1) has been closed.

WP3: Smart train Positioning System (SPTS) requirements, architecture and test requirements definition

This WP and its corresponding milestone (MS2) has been completed in the 1st period, therefore there was no activity in the 2nd period.

WP4: Design, implementation and verification of testing tools

In this work package the laboratory tools to test the ETCS/ERTMS on-board equipment have been defined and developed. The wireless communication emulators have been developed in T4.1. For BTM and LTM physical laboratory architecture has been proposed and implemented (physical BTM, physical LTM), on the other hand for STPS, the simulated GNSS and WCT channels have been developed for the simulation platform to be developed in T5.4. In T4.2 the faults to be injected by the saboteurs have been defined and the saboteurs have been developed: DMI – INT, BTM – INT, BTM, LTM – INT, LTM, TIU – INT, ODO – INT. Finally, in T4.3 together with T5.3, a proposal for integrating the STPS into the EATS_GRM and EATS_LAB has been proposed and implemented. Once all the tasks of the work package have been completed the corresponding milestone (MS3) has been reached.

WP5: Design and implementation of the STPS for ETCS level 3

In this work package, the positioning algorithms related to GNSS, WCT (GSM-R and UMTS), STPS Hybrid Algorithm (for each coach of a train) and STPS Core Data Fusion (combination of individual coach hybrid solutions) have been designed and implemented (T5.1). Moreover, the algorithms have been partially validated separately by the design groups. On the other hand the different blocks of the AOA determination prototype have been designed and fabricated (T5.2). Finally, the integration of the STPS into the EATS laboratory defined in T2.4 and the on-board unit reference model developed in T2.1 has been defined and validated (T5.3). Additionally, apart from the STPS integration with the laboratory and the on-board reference model done together with T4.3, RAMS requirements, a high-level RAMS analysis for STPS components has been introduced based on the output from an initial HAZOPS study to inform the development of Fault Trees (T5.3). Finally a simulation platform for the positioning algorithms of the STPS has been developed (T5.4).

WP6: Verification of the STPS for ETCS level 3

In T6.1, the validation of algorithms developed in T5.1 is being done by means of the simulation platform developed in T5.4. The scenarios for the first stage of the validation have been developed and the first tests have been carried out. On the other hand, the validation of the AOA estimation prototype blocks have been carried out and the integration of the blocks has been started in T6.1. The RAMS analysis of the STPS subsystem has been started by means of defining the strategy to be taken and starting some of the

activities such as PHA, FTA, Safety Case and FMEA (T6.2). Finally, a strategy for employing the EATS_LAB for the analysis of the integration of STPS into ERTMS on-board unit has been defined in T6.3; this included the generation of common scenarios for STPS and for EATS_LAB.

WP7: Verification, integration and validation of the EATS ETCS laboratory

During the second period the integration of the laboratory tools developed in T4.1 (Wireless Communication Emulators) and T4.2 (Saboteurs) into the laboratory developed in T2.4 and reference model developed in T2.1 has been completed. Moreover, the strategy for the tests employing the Wireless Communication Emulators and Saboteurs foreseen for T7.2 and T7.3 has been defined.

WP8: Dissemination and exploitation

In the first part of the project, most of the 7 activities considered by this WP have been started, with the exception of the contribution to standards and the commercial exploitation analysis, as these require the final outcomes of the project and will be addressed at the end of the project. Dissemination activities have been carried out individually: Congress and journal papers, courses for professionals, dissemination to the industry and updating of the EATS website.

Expected final results

The call answered by this project (SST.2012.5.2-4. Innovation and standardization in the field of signalling to accelerate a European Train Control System rollout) expounded the need of employing laboratory testing for ETCS in order to reduce costs to put system into service and the need of including GNSS in ERTMS in order to increase the capacity of the lines by reducing costs.

Currently European Train Control System (ETCS) rollout is a major concern for the railway sector. Equipment for ETCS level 1 and 2 typically follows a long process before being put into service due to interpretation variations in the specification and certification procedures requiring long and expensive field-testing. In addition, migration from ETCS level 2 to 3 has not been implemented due to technical challenges in providing adequate location and integrity information from the train. EATS aims to address these two situations through the following mechanisms:

1. Advancing in testing for reducing time and effort in the verification and certification process

EATS will propose innovative laboratory tools providing a model of the on-board ERTMS system. An on-board ERTMS Golden Reference Model (ERTMS-GRM) will be developed to describe the on-board ERTMS equipment behaviour. This will include behaviour for ETCS levels 1, 2 and 3. It will include modelling the dynamic behaviour of the air-gap communication and will allow fault injection for safety assessment.

These innovations are intended to help certification laboratories and Notified Bodies to assess ERTMS on-board equipment for any scenario and to eliminate interpretation differences which lead to wasted effort. This will lead to reduced laboratory and field-testing certification processing time and cost.

2. Enhancing safety and availability of the on-board Smart Train Positioning System (STPS)

EATS will propose a novel positioning system based on the combination of different techniques which have been shown to provide benefit in other industrial sectors and exploit unique features of the railway and the train. RAMS analysis and laboratory testing are foreseen to verify the proposed technical solution. This will be a step forward towards ETCS level 3 that minimizes trackside costs and maximizes track capacity.

3. Contribution to standards for ETCS laboratory testing, ETCS level 3 and GNSS based positioning.

The results obtained from the first two objectives susceptible of being standardised will be proposed to be included in the corresponding standards. This includes the enhanced tools for laboratory testing and the STPS with the use of GNSS for Railway Safety Critical Systems.

4. Dissemination of the results to the main stakeholders in the European railway industry.

A dissemination plan has been defined that includes 7 levels: worldwide level, scientific community, industry, educational world, railway companies, standardization bodies, and exploitation).

Potential impact and use

EATS will be proposed for the call SST.2011.5.2-4 "Innovation and standardization in the field of signalling to accelerate a European Train Control System rollout". The work program states that the aim of the research shall be able to facilitate the introduction of the ETCS. EATS is clearly aligned with this objective because the research activities are focused on two high level objectives:

Points of the expect impact of the call SST.2012.5.2-4	EATS expected impact
<i>Faster roll-out of ERTMS and reduction of cost for the certification and authorization to put equipment into service.</i>	EATS aims to the reduction of time and effort during the verification and certification by means of an advance laboratory testing strategy (on-board ERTMS Golden Reference Model to eliminate interpretation divergences, fault injection testing techniques for the safety assessment, and emulation of dynamic behaviour of wireless interfaces)
<i>Improved possibilities to make use of lab-testing in connection with the validation of ETCS</i>	
<i>Clarification about the possibilities and ways to use satellite-based positioning in the context of ETCS, if necessary in connection with other techniques.</i>	EATS will increase availability of train positioning system for ETCS/ERTMS level 3 by means of the STPS that includes GNSS in connection with other techniques such as: <ul style="list-style-type: none"> - Other sources of information (UMTS, GSM-R) - Multi-antenna assembly to reduce the effect of propagation paths - Algorithm fusion based on 1D algorithm, TOA, TDOA, and AOA. - Correction of estimated position by means of multi-receiver individual information with known spatial separation.

Table 1-1: EATS impact related to the call SST.2012.5.2-4

The impact of EATS is directly applied to the ETCS supply chain. Depending on the role the impact of the EATS' High Level Objective (HLO) number 1 (Enhanced laboratory) or number 2 (STPS) might differ. The following table summarizes the impact at the identified levels.

Actor	Role	Examples	Relevance of EATS High Level Objective #1	Relevance of EATS High Level Objective #2
ETCS Equipment Manufacturers	Certify ETCS equipment prior to installation on trains	Siemens, Thales, Ansaldo, Alstom	Use of ERTMS-GRM would provide more comprehensive assessment of on-board ETCS, including interfaces through Lab testing. Reduce development, testing and certification costs.	Increasing awareness of the potential performance of alternative positioning solutions may help in development of future offerings. With no immediate change to the ETCS interface specification, this is unlikely to be of interest to equipment manufacturers in

Actor	Role	Examples	Relevance of EATS High Level Objective #1	Relevance of EATS High Level Objective #2
				the short term. It is anticipated that this will be verified through a questionnaire.
ERTMS Testing Labs	Test interoperability of on-train and trackside equipment prior to installation	CEDEX, DLR, MULTITEL	Use of ERTMS-GRM could reduce ambiguity in certification process, making it more straightforward to demonstrate requirements are met. Help to complete ETCS specification for fault definition and testing procedures. Reducing demands for real-life (on train) testing. Shift of testing from track to lab would benefit labs, any significant simplification in testing regime leading to less lab time overall may ultimately reduce revenues though.	Introducing new STPS component and interface to ETCS would lead to further testing procedures and requirements needing verification.
Rolling Stock Manufacturer	Supply locomotives, carriages, freight trucks, bogies	Siemens, Bombardier, Alstom, CAF	ERTMS-GRM in-house or in contracted lab could reduce effort in verification and integration of ETCS equipment. Manufacturers need ETCS certified stock for operations on designated ERTMS lines.	Future-proofing products for evolutions of positioning solutions could be a value-add for locomotives and carriages.
Rail Operator	Operating rail services	First Group, Virgin Trains, RENFE, DB, SNCF	Increased capacity and efficiency of operations through ERTMS adoption.	Possible operational benefits through other applications enabled through STPS.
Railway Infrastructure Manager	Maintain rail tracks, signaling, bridges, tunnels, level crossings, some stations	Network rail, ADIF, RFF, DB Netz	Reduced maintenance costs from ERTMS adoption, particularly Level 3, if trackside infrastructure is reduced. Increased revenues from TOCs if capacity is increased.	General trend of moving from positioning based on trackside infrastructure toward greater "intelligence" on train has potential to reduce maintenance costs.
Rolling Stock Operating Company	Owens and maintains locomotives and carriages leased to TOCS	Angel Trains, Porterbrook, HSBC, Alpha Trains	Perhaps not relevant if UK structure is not widely followed – perhaps more "future-proofed" units would increase longevity of stock	

Table 1-2: Rail Industry Actors and Potential Impact of EATS Results

Project logo and website



<http://www.eats-eu.org/>