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Satellite application for train control systems: The Test Site in Sardinia

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ABSTRACT

This paper deals with the program for the introduction and exploitation of space technologies based on the ERTMS/ETCS (European Railways Train Management System/European Train Control System) architecture bundling the EGNOS-GNSS infrastructures in the train control system, in order to improve performance and enhancing safety, reducing the investments on the railways circuitry and its maintenance. These solutions can be successfully applied for local and regional lines and low traffic lines, where the issue for a railroad enhanced service, requires increasingly financing to maintain and improve infrastructure. In order to assess the performance and validate the space technologies in a real railways environment, a special focus will be dedicated to the case of the regional lines in Sardinia where is a plan to deploy a Test Site.

1. Context

This paper summarizes a roadmap for the introduction in a Trial site in Sardinia (Italy) of the satellite localization for ERTMS within the ongoing ESA 3InSat project (2012–2014) and the ongoing definition of the application of ERTMS with satellite for positioning and also for train data communication (ERSAT Project (Protocollo di Intesa, 2013; The Capabilities of Space-Based GNSS Technologies, 2012; The use of GNSS for railway applications, 2012).

Two big European ongoing initiative from two European Commission Department (respectively DG Move and DG Enterprise) could have a merging benefit. ERTMS/ETCS (EGNOS and Galileo, 2012; A Roadmap for the Adoption of Space Assets for Train Control Systems, 2012; The Capabilities of Space-Based GNSS Technologies, 2012) for standardization and interoperability of command and control train systems in Europe leaded by ERA and Galileo the next European satellite constellation for localization and services leaded by ESA and GSA.

The ERTMS Memorandum of Understanding signed the 12 avril 2012 between the main railway stakeholder outline the general strategy for the application. In Fig. 1 is described a Railway standardized application by two EC project: Galileo and ERTMS.

Multi-constellation architecture GNSS offers a higher degree of flexibility facilitating the world wide adoption of the satellite-based localization systems in the ERTMS–ETCS ecosystem. Nevertheless, the availability of an augmentation network for satellite localization is of paramount importance to reduce the Protection Level (PL)[1] according to the railway safety target at system level.

Safety and dependability requirements for Railway application (CENELEC Standards 5012X) and their allocation to the train Location Determination System (LDS) based on any GNSS are to be fulfilled and demonstrate on the field for the ERTMS/ETCS safety targets.

This demonstration could be reach from employment in the trial site of several GNSS multi- constellation GPS (American), GLONASS (Russian), in the future Galileo (European), Beidou (Chinese) and by the utilization of local augmentation network (Aunetwork) including the wide-area EGNOS service for improvement of the safety integrity and reduction of the GNSS position error confidence interval.

For train-track data communication satellite positioning and hybrid (satellite-terrestrial) TLC networks are assumed to be in-

Abbreviations: ASI, Agenzia Spaziale Italiana; CTC, centralized traffic circulation; DG, direction generale; EGNOS, European Geostationary Navigation Overlay Service; ERA, European Railway Agency; ERTMS, European Railway Traffic Management System; ERSAT, ERTMS satellite; ESA, European Space Agency; ETCS, European Train Control System; GEO, geostazionary; GNSS, Global Navigation Satellite Subsystem; GSA, Galileo Supervision Agency; IP, internet protocol; LDS, Location Determination System; L2, Level 2 ERTMS/ETCS; L3, Level 3 ERTMS/ETCS; PL, Protection Level; RAMS, Realability Availability Maintenability Safety; RBC, Radio Block Center; RFI, Rete Ferroviaria Italiana; SLA, Service Level Agreement; TLC, telecommunication; UIC, Union International Chemin de Fer.

[1] The PL is a statistical bound of the horizontal (or vertical) train position error computed so as to guarantee that the probability of the absolute horizontal (or vertical) position error exceeding said number is smaller than or equal to the target integrity risk.

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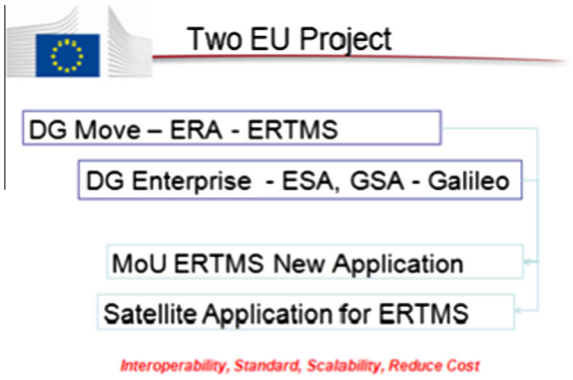

Fig. 1. A railway standardized application by two EC project.

cluded in the application as an alternative of the traditional TLC means which are part of the ERTMS (European Railways Train Management System) architecture in order to reduce the investments on the railways circuitry and its maintenance. Since an important market demand is originated by these regional-local line upgrades as well as "rural" and low traffic lines that represent all together about 50% of the existing railway length in Europe, a cost-effective ERTMS solution has been recognized as a necessary technology improvement of the basic ERTMS ecosystem. The satellite-based localization and the IP-based communications have been already identified as the key technologies to be adopted by the ERTMS in its evolving path in general and especially to satisfy the needs of the local and regional lines.

In Fig. 2 is described in particular the Italian railway network infrastructure specialization with regional lines extended for the 44% of the network.

2. ERTMS and satellite for rail regional lines: Pilot line in Sardinia

Just in a regional line in Sardinia (Italy) is planned to deploy in the next two years a Pilot Line, in order to assess the performance and validate the space technologies in a real railways environment.

This Test Range, one of the first in Europe, will have a length of about 50 km and is conceived to allow the validation of the key building blocks such as the satellite localizator, the augmentation network and the TLC network without using dedicated railway TLC network as the GSM-R. Furthermore the Test Range will be able to test and validate the new satellite-based train control system in the ERTMS environment with the aim to maintain an interoperable train control system. In Fig. 3 is shown the ETCS Driver Machine Interface, key component for interoperability to be maintained as it is, the unique interface for the driver also in this new ERTMS satellite application.

In Fig. 4 is described the general ERTMS/ETCS concept to localize the train using an Eurobalise Group and the train odometry of the train. For satellite localization the concept of real eurobalises group is replaced by virtual balise group. The accuracy of satellite GNSS constellation finalized in the next 3 years is expected to be 1 m adopting also Galileo (The certification within 3InSat Gino DI Mabro Italcertifer, 2012; CompRail XII, 2010). However in tunnel longer than 2 km the accuracy must be guarantee by train odometry.

By bundling the European leading edge satellite technologies of the EGNOS infrastructures, with the indisputable leadership on the train management systems legitimated by technological achievements in safety of the ERTMS, the challenge is to guarantee the evolutionary roadmap of ERTMS by preserving the highest safety and reliability values already achieved since its introduction in Europe with a cost-efficiency solution for a fast deployment on the regional and global railways infrastructures.

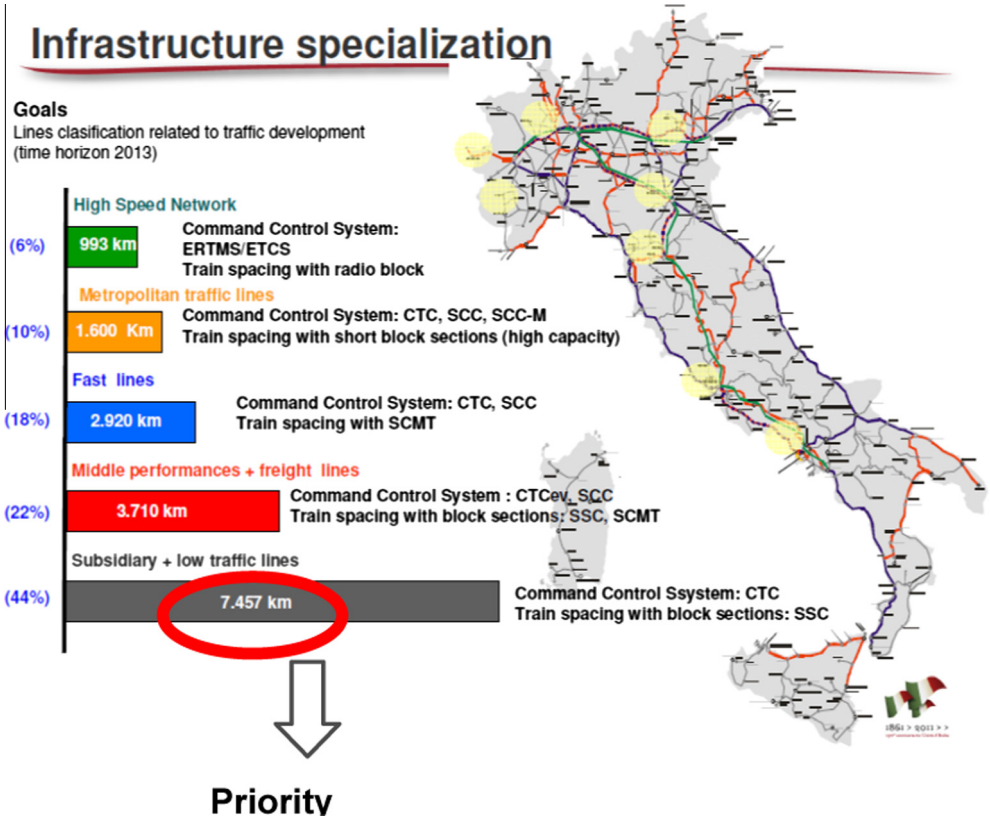

Fig. 2. The Italian rail networks specialization.