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Deliverable D3.8

Stand Alone System Requirements Specification for Fail-Safe Train Positioning

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Authors

Author(s)	**CAF Investigación y Desarrollo (CAF I+D)** Iban Lopetegi
Contributor(s)	

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1 Executive Summary

The European Union Agency for Railways (ERA) defined different mid and longer term strategic challenges related to the ERTMS specifications roadmap in [3]. The objective was to identify the optimal balance between (a) ERTMS Specification stability on one side and (b) their evolution (enhancements and errors) and ERTMS products on the other side, while safeguarding interoperability in the most economical way. In particular, ERA [3] states that *"The strategic challenges linked to the evolution are mainly linked to developments which support the need for* ***further capacity increase*** *and to developments that* ***decrease the overall life cycle costs*** *of the ERTMS implementations.".* Furthermore, ERA has also recognized the satellite positioning as one of the main key elements of the future signalling system/concept aimed at allowing "*Potential reduction in* ***deployment*** *and* ***maintenance*** *of* ***balises*** *and* ***improved performance*** *due to* ***more accurate odometry****;"*

Previous projects focusing exclusively in GNSS, such as GSA STARS [4], have shown that the use of GNSS only it is not sufficient neither for performance reasons nor for safety reasons. As a consequence, GNSS shall be combined with other sensors to ensure a more accurate safe odometry subsystem than the existing one. In order to set clear targets for the Stand Alone Fail Safe Train Positioning, EUG members have provided valuable user requirements specification [1] which has been the source of the following system requirements specification.

2 Table of Contents

3 Abbreviations, Acronyms and Definitions

Abbreviations/Acronyms/Definitions	Description
Absolute Position	Absolute position refers to a position that defines the train location unambiguously. For instance, an absolute position can be given by WGS84 coordinates but it can also be given by a track identifier and the travelled distance within a specific track.
Confidence Interval	It refers to a range of values so defined that there is a specified probability that the value of a parameter lies within it.
RCA	Reference CCS Architecture
MTBF	Mean Time Before Failure

4 Background

The present document constitutes the first issue of WP3s Deliverable D3.8 “System Requirement Specification”. The Deliverable D3.8 is part of the framework of the Project titled “Enhancing railway signalling systems based on train satellite positioning, on-board safe train integrity, formal methods approach and standard interfaces, enhancing traffic management system functions” (Project Acronym: X2Rail-2; Grant Agreement No 777465).

5 Objective / Aim

The X2Rail-2 D3.8 defines the system requirements specification of the Stand Alone Fail-Safe Train Positioning system. This document is using as an input the EUG defined user requirements for a localisation system that is related to safety purposes [1]. In particular, the requirements specified for this system only focus on the train front end targeted to safety related systems.

6 General Description

6.1 Introduction

6.1.1 This document defines the system requirements specification for a fail-safe train positioning system as understood by X2RAIL2-WP3 stream 2. The document defines the high level requirements for a stand-alone train positioning system regardless of the technology used by the final implementation. Documents such as RCA [2] and Mission Profiles from EUG members [1] have been used as reference source of information.

6.1.2 The following document defines a new approach within X2RAIL2-WP3. The work carried out in [9] reflects the concept of the virtual balise whereas this documents aims to locate the train with better performance values than currently required one.

7 Functional Requirements

7.1 Main Requirements Specification

7.1.1 Fail-safe train positioning shall provide an absolute position of the front of the train.

7.1.2 Note: Current ETCS on board unit uses balises to obtain a relative position that is reported to the trackside. It is therefore the trackside that can place the train in an absolute location based on its track knowledge and act consequently. The objective of the train positioning is the other way around, where the train is able to self-locate where the use of balises is an adequate measure to overcome the difficulties in track discrimination.

7.1.3 Fail-safe train positioning shall discriminate track.

7.1.3.1 Note: Track discrimination in ETCS is currently guaranteed by the balise reading and by track circuits. In the proposed system, the train needs to be track discriminative as it is in baseline 3 of ETCS specification.

7.1.4 Fail-safe train positioning shall provide a confidence interval relative to the train's front position.

7.1.5 If the train's track is known, the confidence interval shall be defined only by determining the longitudinal confidence interval of the train.

7.1.6 If the train's track is not known, the confidence interval shall be defined using a horizontal plane in the same reference system the absolute position is provided, where the real position of the train must be contained with the required probability.

7.1.6.1 Note: the horizontal plane that defines the confidence interval could be defined in different manners. Although a typical method for defining such horizontal plane is to define the radius of a circle, the requirement leaves open to the final implementation to define the most appropriate method.

7.1.7 Fail-safe train positioning shall calculate train's front position with a maximum confidence interval of +/-10 meters within speed intervals from zero to 40km/h, 40km/h included. For

speeds greater than 40km/h and lower or equal to 500 km/h the confidence interval shall be equivalent to a distance run in one second [1].

7.1.8 The following graph is a representation of the maximum travelled distance confidence interval value in meters. Notice that just at 40km/h there is a small discontinuity due to the definition of the requirement at 40km/h.

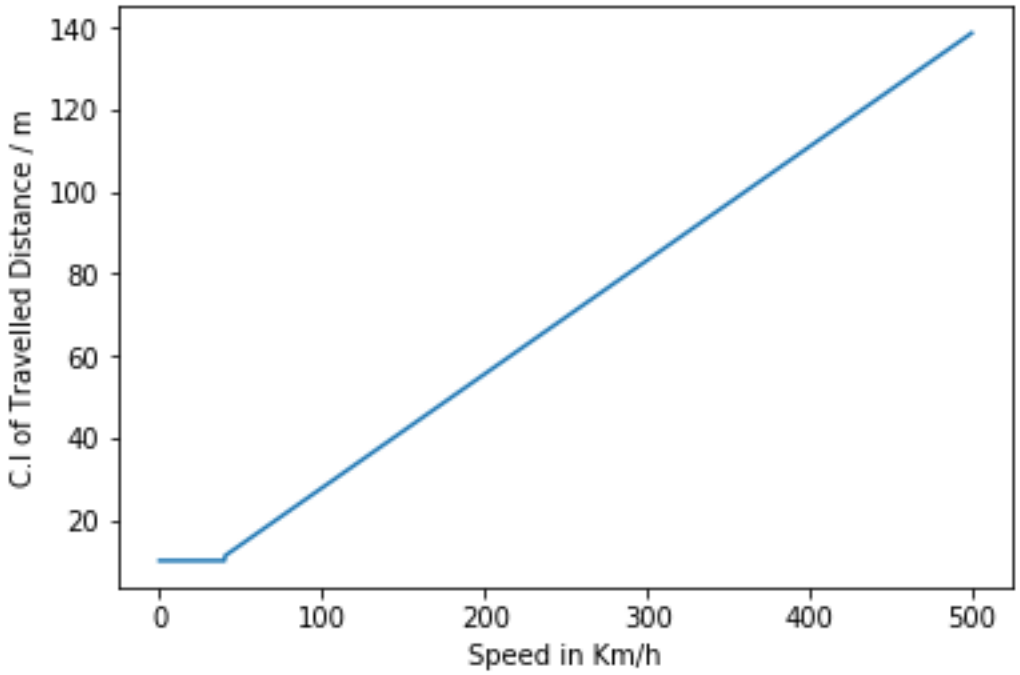

Figure 1 Maximum confidence interval representation for travelled distance.

7.1.9 Both, train absolute position and speed shall be able to be consumed by local subsystems and remote subsystems within the on-board unit.

7.1.9.1 Note: Although a fail-safe train positioning system may be running on an existing framework, it shall provide an interface to external subsystems in order to be modular and flexible in future architectures.

7.1.10 Fail safe train positioning shall provide train's speed

7.1.10.1 Note: Speed value is referred to a scalar value not a vector

7.1.11 Fail-safe train positioning shall provide the confidence interval to the train's speed.

Fail safe train positioning shall calculate train's speed with a maximum confidence interval of +/- 2km/h for speed lower than 30km/h, and then increasing linearly up to 12km/h at 500km/h [1].

7.1.12 The following graph is a representation of the maximum speed confidence interval.

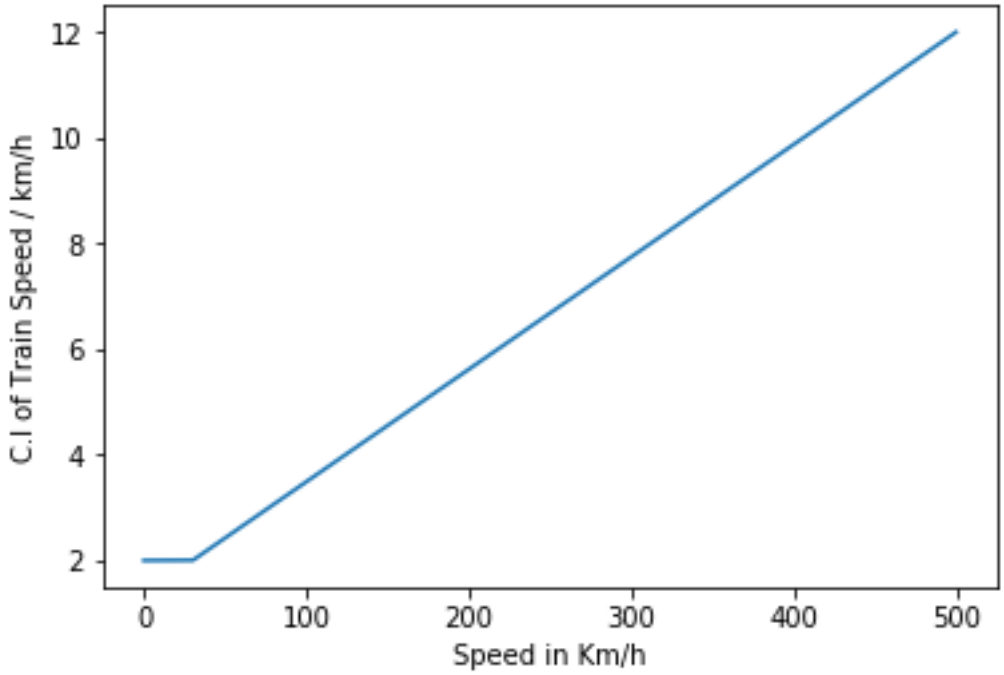

Figure 2 Maximum confidence interval representation for speed.

7.1.13 Both, train absolute position and speed shall be calculated continuously, at a minimum rate of 70ms, during a mission (see 7.2 for mission requirements).

7.1.13.1 Note that the defined minimum rate only applies to the calculation and publication of the data within the internal communication system of the train, such as Multifunction Vehicle Bus (MVB) or Ethernet Communication Network (ECN).

7.2 Mission Profile

7.2.1 Fail Safe Train Positioning shall be active when the system is powered-on, i.e. train main battery is switched on, which it shall be considered as an operational demand rate of not more than 18 hours per day.

7.3 Operational Conditions

7.3.1 The requirements defined in 7.1 shall be met on every European rail physical environment including (the list does not have to be considered exhaustive) tunnels, forests, mountains, underground stations, presence of metal masses around rail.

7.3.2 Functions defined in 7.1 shall be met on every European rail meteorological environment including (the list does not have to be considered exhaustive) high rail temperature and

low adherence conditions such as the presence of ice, snow, leaves; for what it concerns, EN50155:2017 applies.

8 Non Functional Requirements

8.1 Safety Requirements

8.1.1 The functionalities to calculate and provide a train absolute position and its confidence interval shall be SIL4 compliant.

8.1.2 Fail Safe Train Positioning shall provide positioning and speed, as defined in section 7, with a SIL 4 compliant interface to other train subsystems.

8.1.3 The functionalities to calculate and provide a train speed and its confidence interval shall be SIL4 compliant.

8.1.4 The system shall be SIL4 compliant as defined by [5].

8.1.5 The system shall be SIL4 compliant as defined by [6] or by [7].

8.1.6 Any communication channel used by the system shall be compliant with [8].

8.2 Reliability Requirements

8.2.1 The system shall meet a minimum material reliability of 20000 hours for the train absolute position and speed calculation functions.

8.2.2 The system shall meet a MTBF of 60000 hours for the train absolute position and speed calculation functions.

9 References

[1] 19E100_MissionProfiles_2 – Mission profiles defined by EUG members
[2] Reference CCS Architecture
[3] ERA, Report ERTMS Longer Term Perspective, 18/12/2015.
[4] STARS project. D5.1 - State of the art of EGNSS projects for the rail application, STR-WP5-D-IFS-033 (IFSTTAR – 21/03/17).
[5] EN 50129: 2018 Railway Applications - Communications, signaling and processing systems – Safety related electronic systems for signaling
[6] EN 50128: 2010 Railway Applications - Communications, signaling and processing systems – Software for rail control and protection systems
[7] EN 50657: 2017 Railways Applications - Rolling stock applications - Software on Board Rolling Stock
[8] EN 50159:2011 Railway Applications - Communications, signaling and processing systems – Safety related communication in transmission systems
[9] X2R2-WP3-D-ANS-034-09_-_System_Requirement_Specification_of_the_Fail-Safe_Train_Positioning_Functional_Block