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LOCALISATION WORKING GROUP (LWG)

Railways Localisation System
High Level Users' Requirements

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0a-0g		Internal review of TLG	GR
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1	28/01/2019	Update after January 19 NPMs meeting	DC, GR

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1 List of References and Acronyms

References

PERSPECTIVE	Report on ERTMS Longer Term Perspective, 18/12/2015
RCA_WP	18C044 White Paper Reference CCS Architecture Based on ERTMS
[SS041]	Performance Requirements for Interoperability - Subset-041v. 3.2.0
[SS091]	Safety Requirements for the Technical Interoperability of ETCS in Level 1 and 2 - Subset-091v. 3.6.0
[RCA]	RCA Architecture V0.5

Acronyms

ATO	AUTOMATIC TRAIN OPERATION
BG	BALISE GROUP
CAPEX	CAPITAL EXPENDITURE
CBA	COST BENEFIT ANALYSIS
CER	COMMUNITY OF EUROPEAN RAILWAYS
CMD	COLD MOVEMENT DETECTOR
CR	CHANGE REQUEST
EC	EUROPEAN COMISSION
EIM	EUROPEAN RAIL INFRASTRUCTURE MANAGER
EUG	ERTMS USERS GROUP
ERA	EUROPEAN RAIL AGENCY
LS	LOCALISATION SYSTEM
LRBG	LAST RELEVANT BALISE GROUP
MOL	MOBILE OBJECT LOCATOR
NPM	NATIONAL PROGRAMME MANAGERS
OPEX	OPERATIONAL EXPENDITURE
PL	PERSON LOCATOR
PSL	PERSON SUPERVISOR AND LOCATOR
RCA	REFERENCE CCS ARCHITECTURE
SIL	SAFETY INTEGRITY LEVEL

SoM	START OF MISSION
TLG	TRAIN LOCALISATION GROUP
TLS	TRAIN LOCALISATION SYSTEM
VL	VEHICLE LOCATOR

2 Scope of the document

2.1.1.1 The purpose of this document is to define railways localisation high level user's requirements in a technology neutral manner.

2.1.1.2 Users' requirements are intended to address the following functionalities to be developed according to an incremental approach:

a) Enhancement (accuracy and cost effectiveness) of onboard odometry for ERTMS application; the scope of the document is to make current ERTMS odometer requirements clearer and better performing to fulfil present and future operational users' needs, without impact on the existing ERTMS onboard architecture or on the ERTMS working principles

b) Vehicle locator (VL); the scope of the document is to define high level users' requirements of an independent Vehicle Locator (VL) able to provide the actual position of the vehicle and the track occupation or only a part of it (only the front position). Other vehicle dynamic data will also be provided to different consumers (e.g. EVC, TMS, passengers information, …)

c) Mobile object locator (MOL); the scope of the document is to define high level users' requirements of a system able to localise mobile objects that can interact with the railway environment. It can be used for multiple use cases like tagging an obstacle, a crane, a train-end, a wagon or coach, a door that swings on the track, etc.

d) Person locator (PL); the scope of the document is to define high level users' requirements related to the locationing of persons on the surroundings of the track. The management of these information to block a track or to defend (warn) persons along the track (PSL function) is out of the scope of this specification

2.1.1.3 Functionalities b), c) and d) of 2.1.1.2 refer to the functional blocks defined in the [RCA] document.

2.1.1.4 According to [RCA], the VL, MOL and PL are interfaced with the Mobile Object Transactor which processes the received localisation information.

2.1.1.5 Chapter 4, 5, 6 and 7 of the document define the high level users' requirements related respectively to functionalities a), b), c) and d) described in 2.1.1.2.

3 Problems description

3.1 Introduction

3.1.1.1 The current version of this document only addresses issues affecting ERTMS operation with reference to point a) of 2.1.1.2.

3.2 ERTMS domain

3.2.1.1 In the ERTMS domain train localisation is identified as the actual speed and distance to a reference point along the track (the LRBG) with an associated confidence interval.

3.2.1.2 Train localisation determination in the ERTMS/ETCS context is currently a weak point [PERSPECTIVE] because of low reliability/performance implying:

- impact on safety (e.g. when release speed is given by trackside the activation of train trip functionality is delayed as longer as the accuracy is lower since emergency brake is triggered by min safe front end)
- impact on operation such as:
    - delays due to unexpected brakings
    - difficulty to approach a target
    - loss of capacity, increase of headways due to the increase of the confidence interval (on high density applications relying on moving block or fixed virtual block)
- impact on direct costs such as:
    - high cost of maintenance due to device failures and to premature wearing because of unexpected brakings
    - high cost of maintenance due to odometry recalibration
    - need to raise the density of balises generating high CAPEX and OPEX

4 Enhancement of onboard Odometry for ERTMS application, users' requirements

4.1 General targets

4.1.1.1 Solutions to improve ERTMS odometry performance shall work under all rail operational conditions, such as:

- slip and slide
- from standstill until maximum speed

Rationale:

a solution is needed under all operational conditions and it has to include events reasonably foreseeable in normal operation;

the difference between nominal and degraded situations shall be clearly defined: slip/slide (voluntary or not) events are normal conditions in the railway environment; they should belong to the nominal conditions of odometry.

4.1.1.2 Solutions to improve ERTMS odometry performance shall work under all rail environmental conditions, such as:

- all weather conditions
- all type of loco environment
- all types of Rail infrastructure (e.g. tunnels, bridges, with or without catenary, concrete track, ballast track, etc.)
- all types of physical environments such as station areas surrounded with high buildings, forests, etc.

Rationale:

a solution is needed under all railways environmental conditions;

the difference between nominal and degraded situations shall be clearly defined: e.g. presence of leaves or snow on the track are examples of normal conditions in the railway environment.

4.1.1.3 Solutions to improve ERTMS odometry performance shall not reduce safety integrity according to current ERTMS standard.

Rationale:

current ERTMS standard on safety [SS091] has to be kept as valid.

4.1.1.4 Solutions to improve ERTMS odometry performance shall be sustainable that is a positive business case shall be demonstrated along the life cycle in a global perspective, encompassing railway undertakings and infrastructure managers.

Rationale:

it has to be demonstrated that solutions to improve odometry performance will bring benefit in global term along its life cycle considering CAPEX, OPEX,

reliability/availability/maintainability, reset/calibration, capacity improvement and train delays decrease, possibly compared with existing solutions in operation performing the same functionalities; the positive business case estimation should be determined starting from the current driving costs railways need to reduce.

4.1.1.5 Solutions to improve ERTMS odometry performance shall provide efficient mechanism to reset/calibrate/periodically correct data to keep train position information within accuracy targets during the mission.

Rationale:

maintenance activity for reset/calibrate *is costly and is sensitive action regarding introduction of errors, manual calibration should be avoided; reset/calibrate/periodically correct data mechanism have to be defined to fulfil accuracy targets.*

4.1.1.6 Solutions to improve ERTMS odometry performance shall be able to self-diagnose when accuracy targets are not fulfilled and the relevant mitigation/measure shall be identified, provided that safety is not affected.

Rationale:

ERTMS needs odometry error determination to calculate the train confidence interval.

4.2 Performance targets

4.2.1.1 ERTMS odometry availability shall be improved.

Rationale:
compared to sensors currently in use, improvements are expected without compromising safety needs;
this includes possible reduction of physical kits/device trackside and onboard.

4.2.1.2 ERTMS odometry accuracy shall be improved.

Rationale:
with reference to ERTMS standard [SS041] § 5.3, improvements are expected without compromising safety needs;
this includes reduction of distance-related error as well as the possibility to increase the number of recalibration with a limited number of physical trackside kits (e.g. balises).

5 Vehicle locator user's requirements

5.1 Introduction

5.1.1.1 The vehicle localisation has to be defined as the position of the train along the track or only a part of it (only the front position) and its possible additional dynamic variables (e.g. speed, acceleration, yaw, …) including the relevant uncertainties. The vehicle localisation will consider the track that is being occupied by the vehicle.

5.1.1.2 Users requirements defined in the current document are allocated to the Vehicle Locator (VL) to be intended as the logical function able to provide a continuous train localisation.

5.1.1.3 The context the VL refers to is the control command and signalling (CCS) domain having ERTMS/ETCS as the control command system including functions envisaged by the ERTMS long term perspective ("game changers") and also considering the evolution of the Reference CCS Architecture ref. [RCA_WP]).

5.1.1.4 TLS output may be also used by consumers different from CCS.

5.2 General targets

5.2.1.1 VL shall work under all rail operational conditions, such as:

- Slip and slide
- From standstill until maximum speed

Rationale:

a VL solution is needed under all operational conditions and it has to include events reasonably foreseeable in normal operation;

the difference between nominal and degraded situations shall be clearly defined: slip/slide (voluntary or not) events are normal conditions in the railway environment; they should belong to the nominal conditions of the VL.

5.2.1.2 VL shall work under all rail environmental conditions, such as:

- all weather conditions
- all type of loco environment
- all types of Rail infrastructure (e.g. tunnels, bridges, with or without catenary, concrete track, ballast track, etc.)
- all types of physical environments such as station areas surrounded with high buildings, forests, etc.

Rationale:

A VL solution is needed under all railways environmental conditions;

the difference between nominal and degraded situations shall be clearly defined: e.g. presence of leaves or snow on the track are examples of normal conditions in the railway environment.

5.2.1.3 VL shall be interoperable, independent from applications and interchangeable. External interfaces shall be completely standardised and open to be used by other systems.

Rationale:

VL external interfaces have to be defined to avoid vendor lock-in and to provide train positioning information to different consumers;

the interface between VL and the Mobile Object Transactor has to be standardised to guarantee interoperability.

5.2.1.4 VL shall be sustainable that is a positive business case shall be demonstrated along the life cycle in a global perspective, encompassing railway undertakings and infrastructure managers.

Rationale:

it has to be demonstrated that VL will bring benefit in global term along its life cycle considering CAPEX, OPEX, reliability/availability/maintainability, reset/calibration, capacity improvement and train delays decrease, possibly compared with existing solutions in operation performing the same functionalities; the positive business case estimation should be determined starting from the current driving costs railways need to reduce.

5.2.1.5 VL shall provide train position information (and additional dynamic parameters) continuously to consumers having different needs in terms of integrity (confidence associated to the uncertainty), accuracy (uncertainty) and respond time.

Rationale:

the kind of data and their format have to be defined starting from an analysis to be performed at system level to fulfil the needs of the different consumers and having in mind the overall functionalities envisaged;

possible examples (list to be considered nor mandatory neither exhaustive) of consumers of VL output are:

- *ERTMS/ETCS*
- *TMS (which also needs info from source different from train to determine track occupancy)*
- *Passengers information system*
- *ATO*

5.2.1.6 VL safety integrity shall be determined according to the safety relevance of consumers using VL output.

Rationale:

safety integrity of VL depends on the consequences a wrong train position information would have on VL consumers.

5.2.1.7 VL reliability/availability/maintainability shall be determined considering the overall architecture (all consumers using VL output).

Rationale:

to be considered the impact of reliability/availability of VL on all the consumers.

5.2.1.8 VL security shall be ensured.

Rationale:

robust security process for VL shall be considered in relation to the overall RCA architecture.

5.2.1.9 VL shall provide train position information (and additional dynamic parameters) using reference coordinates to allocate the train along the track in a way to fulfil the different consumer's needs.

Rationale:

the reference coordinates have to be defined to fulfil the needs of the different consumers.

5.2.1.10 VL shall provide efficient mechanism to reset/calibrate/periodically correct data to keep train position information (and additional dynamic parameters) within accuracy targets during the mission.

Rationale:

maintenance activity for reset/calibrate *is costly and is sensitive action regarding introduction of errors, manual calibration should be avoided; reset/calibrate/periodically correct data mechanism have to be defined to fulfil accuracy targets.*

5.2.1.11 VL shall be able to self-diagnose when accuracy targets are not fulfilled and the relevant mitigation/measure shall be identified in a way that safety is not affected.

Rationale:

self-diagnostic capability is necessary to minimise maintenance activities and consequences the failure of accuracy targets would have on VL consumers.

5.2.1.12 VL capability to predict situation where VL is failing to fulfil accuracy targets and the relevant mitigation/measure shall be described.

Rationale:

predictability capability is necessary to minimise the consequences the failure of accuracy targets would have on VL consumers.

5.3 Performance targets

5.3.1.1 When compared to the current ERTMS localisation as jointly performed by balises and odometry, the VL shall bring significant improvements in availability.

Rationale:

compared to sensors currently in use, improvements are expected without compromising safety needs;

this includes reduction of physical kits/device trackside and onboard.

5.3.1.2 When compared to the current ERTMS localisation as jointly performed by balises and odometry, the VL shall bring significant improvements in accuracy.

Rationale:

compared to sensors currently in use, improvements are expected without compromising safety needs;

this includes reduction of distance-related error as well as the possibility to increase the number of recalibration with a limited number of physical trackside kits (e.g. balises).

5.3.1.3 The VL shall be track-selective.

Rationale:

as the VL encapsulates the complete localisation function, it also has to centralise the logic for track-selectivity which means to be also able to distinguish a diverging track from a straight track over a switch.

6 Mobile object locator user's requirements

6.1 General targets

6.1.1.1 The Mobile Object Locator (MOL) shall provide continuously position information (and additional dynamic parameters) of different kinds of mobile devices e.g. wagons, coaches, working machinery with the goal to protect them against possible converging objects/trains

Rationale:

Any object suitable to occupy a piece of track means a potential risk to the operation. Locating these objects to protect other moving objects in the tracks is responsibility of the MOL.

6.1.1.2 MOL shall work under all rail operational conditions, such as:

- vibrations
- from standstill until maximum speed

Rationale:

a MOL solution is needed under all operational conditions and it has to include events reasonably foreseeable in normal operation;

the difference between nominal and degraded situations shall be clearly defined.

6.1.1.3 MOL shall work under all rail environmental conditions, such as:

- all weather conditions
- all type of wagon/coach environment
- all types of Rail infrastructure (e.g. tunnels, bridges, with or without catenary, concrete track, ballast track, etc.)

- all types of physical environments such as station areas surrounded with high buildings, forests, etc.

Rationale:

A MOL solution is needed under all railways environmental conditions;

the difference between nominal and degraded situations shall be clearly defined.

6.1.1.4 MOL shall be interoperable, independent from applications and interchangeable. External interfaces shall be completely standardised.

Rationale:

MOL interfaces have to be defined to avoid vendor lock-in and to provide object positioning information to the Mobile Object Transactor;

the interface between MOL and the Mobile Object Transactor has to be standardised to guarantee interoperability.

6.1.1.5 MOL shall be sustainable that is a positive business case shall be demonstrated along the life cycle in a global perspective, encompassing railway undertakings and infrastructure managers.

Rationale:

it has to be demonstrated that MOL will bring benefit in global term along its life cycle considering CAPEX, OPEX, reliability/availability/maintainability, reset/calibration, capacity improvement possibly compared with existing solutions in operation performing the same functionalities; the positive business case estimation should be determined starting from the current driving costs railways need to reduce.

6.1.1.6 MOL safety integrity shall be determined according to the use of the information provided and the possible additional provisions envisaged.

Rationale:

safety integrity of MOL depends on the consequences a wrong object position information would have and on the presence of possible additional provisions to be considered (e.g. train detection systems).

6.1.1.7 MOL reliability/availability/maintainability shall be determined considering the possible additional provisions envisaged.

Rationale:

to be considered the impact of reliability/availability of MOL on the overall architecture.

6.1.1.8 MOL security shall be ensured.

Rationale:

robust security process for MOL shall be considered in relation to the overall RCA architecture.

6.1.1.9 MOL shall provide object position information (and additional dynamic parameters) using reference coordinates to allocate the object along the track.

Rationale:

the reference coordinates have to be defined.

6.1.1.10 MOL shall provide efficient mechanism to reset/calibrate/periodically correct data to keep object position information (and additional dynamic parameters) within accuracy targets.

Rationale:

maintenance activity for reset/calibrate *is costly and is sensitive action regarding introduction of errors, manual calibration should be avoided; reset/calibrate/periodically correct data mechanism have to be defined to fulfil accuracy targets.*

6.1.1.11 MOL shall be able to self-diagnose when accuracy targets are not fulfilled and the relevant mitigation/measure shall be identified in a way that safety is not affected.

Rationale:

self-diagnostic capability is necessary to minimise maintenance activities and consequences of MOL failures.

6.1.1.12 MOL capability to predict situation where MOL is failing to fulfil accuracy targets and the relevant mitigation/measure shall be described.

Rationale:

predictability capability is necessary to minimise the consequences of MOL failures.

6.2 Performance targets

6.2.1.1 When compared to the current objects locator, the MOL shall bring improvements in availability (or at least the same level of availability).

Rationale:

compared to device currently in use, improvements are expected without compromising safety needs;

this includes reduction of physical kits/device trackside and onboard.

6.2.1.2 When compared to the current objects locators, the MOL shall bring significant improvements in accuracy/resolution.

Rationale:

compared to device currently in use, improvements are expected without compromising safety needs.

6.2.1.3 The MOL shall be track-selective.

Rationale:

as the MOL encapsulates the complete localisation function, it also has to centralise the logic for track-selectivity which means to be also able to distinguish a diverging track from a straight track over a switch.

7 Person locator user's requirements

7.1 General targets

7.1.1.1 Person Locator (PL) shall be able to locate people working in the surroundings of the track with the goal to protect them against possible converging objects/trains.

Rationale:

any moving object in the tracks can be dangerous for people working in the surrounds of the tracks. PL is responsible for locating people providing the information to protect them (defence mechanisms such as to block a track or to defend/warn persons along the track is out of the scope of this specification).

7.1.1.2 PL shall work under all rail environmental conditions, such as:

- all weather conditions
- all types of Rail infrastructure (e.g. tunnels, bridges, with or without catenary, concrete track, ballast track, etc.)
- all types of physical environments such as station areas surrounded with high buildings, forests, etc.

Rationale:

a PL solution is needed under all railways environmental conditions.

7.1.1.3 PL shall be interoperable and interchangeable. External interfaces shall be completely standardised.

Rationale:

PL interfaces have to be defined to avoid vendor lock-in and to provide person positioning information to the Mobile Object Transactor;

the interface between PL and the Mobile Object Transactor has to be standardised to guarantee interoperability.

7.1.1.4 PL shall be sustainable that is a positive business case shall be demonstrated along the life cycle in a global perspective with comparison with existing provisions in use.

Rationale:

it has to be demonstrated that PL will bring benefit in global term along its life cycle considering CAPEX, OPEX, reliability/availability/maintainability, reset/calibration, capacity improvement compared with existing solutions in operation performing the same functionalities; the positive business case estimation should be determined starting from the current driving costs railways need to reduce.

7.1.1.5 PL safety integrity shall be determined according to the use of the information provided and the possible additional provisions envisaged.

Rationale:

safety integrity of PL depends on the consequences a wrong object position information would have and on the presence of possible additional provisions to be considered.

7.1.1.6 PL reliability/availability/maintainability shall be determined considering the possible additional provisions envisaged.

Rationale:

to be considered the impact of reliability/availability of PL on the overall architecture.

7.1.1.7 PL security shall be ensured.

Rationale:

robust security process for PL shall be considered in relation to the overall RCA architecture.

7.1.1.8 PL shall provide person position information using reference coordinates to allocate the person along the track.

Rationale:

the reference coordinates have to be defined.

7.1.1.9 PL shall provide efficient mechanism to reset/calibrate/periodically correct data to keep person position information within accuracy targets.

Rationale:

maintenance activity for reset/calibrate *is costly and is sensitive action regarding introduction of errors, manual calibration should be avoided; reset/calibrate/periodically correct data mechanism have to be defined to fulfil accuracy targets.*

7.1.1.10 PL shall be able to self-diagnose when accuracy targets are not fulfilled and the relevant mitigation/measure shall be identified in a way that safety is not affected.

Rationale:

self-diagnostic capability is necessary to minimise maintenance activities and consequences of PL failures.

7.1.1.11 PL capability to predict situation where PL is failing to fulfil accuracy targets and the relevant mitigation/measure shall be described.

Rationale:

predictability capability is necessary to minimise the consequences of PL failures.

7.2 Performance targets

7.2.1.1 When compared to the current person locator, the PL shall bring improvements in availability (or at least the same level of availability).

Rationale:

compared to device currently in use, improvements are expected without compromising safety needs;

this includes reduction of physical kits/device trackside.

7.2.1.2 When compared to the current person locators, the PL shall bring significant improvements in accuracy/resolution.

Rationale:

compared to device currently in use, improvements are expected without compromising safety needs.