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Rail to Digital automated up to autonomous train operation

D21.2 – System requirements of ASTP system

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09	15/05/2025	Update after External and MCP reviews:

		- [REQ: FP2-ASTP-SRS-067] & [REQ: FP2-ASTP-SRS-068]: correction of the reference frame: from train true speed/acceleration to ASTP true speed/acceleration - Minor upgrade of the Executive Summary and the conclusion - Update of the requirement traceability matrix

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EXECUTIVE SUMMARY

Generalities

The challenge of WP21 Advanced Safe Train Positioning system requirements of the project R2DATO is to provide Absolute Safe Train Positioning solutions with more accurate position and speed, which will provide possibilities of optimising headway as well as energy train control assistance (ATO), allowing energy saving and densification of trains with less trackside equipment

The Technical Enabler 2 ASTP focuses on the development of a modular and scalable Advanced safe train positioning (ASTP) system. It serves all CCS (and non-CCS) functions such as ATP, ATO, ATS/TMS, TCMS, applications of RU in the train or on trackside. This work package deals with following objectives:

- Identify common high-level user needs and system capabilities of ASTP
- Analysis of required system performance for the ASTP system

The TRL level associated with the documents produced in this WP is 6.

The results of WP21 will be provided in two deliverables:

- D21.1 – Operational Requirements and System Capabilities of ASTP System (Use Cases).
- D21.2 – System requirements of ASTP system.

To be noticed that WP21 was held in two steps:

The first final versions of D21.1(v12) and D21.2 (v05) raided several open issues.

A process of clarification of the identified open issues was launched and was formalised in the form of several Technical Notes (available as an appendix in D21.1). Since most of the open issues where related to the overall CCS-OB architecture or specification (out of WP21 scope), WP21 could only provide the members points of view and proposals without considering the open issue closed. Only the System Pillar, with a broader scope of work, is able to take the right decisions to definitely close the identified open issues.

The current version of D21.2 is part of this second phase considering the results of the open issues clarifications process.

D21.2 content

The deliverable D21.1 contains the operational requirements and provides high level analysis focusing on ASTP.

The present document, D21.2, is the formalisation in the form of requirements of the analysis carried out in deliverable D21.1 also adding requirements related to the state of the art related to safe onboard electronic equipment.

Also, to avoid any documentary quality issue, D21.2 does not include any a copy or extract from D21.1 but makes explicit reference to the necessary paragraphs, including any definitions or concepts required.

As a result, this document cannot be considered as a stand-alone document, and must absolutely integrate D21.1 to be fully understood.

Maturity of the requirements

The set of requirements defined in the present document were generated considering the state of the art and the agreed perimeter at the time of writing where several uncertainties were present, particularly regarding functional allocation and performance requirements.

A process of clarification of the identified open issues, generating several technical notes (available as an appendix in D21.1) has been carried out. Even if some open issues were solved, several of them are still under discussion and can be classified as:

- Unstable user needs (for example perception or ATO).
- Undefined (and/or unagreed) embedded CCS architecture.
- Undefined (and/or unagreed) functional allocation between embedded CCS components.
- Cross-disciplinary work in progress on the definition of the Digital map (definition and handling).
- Availability and definition of supporting information provided to the ASTP.
- Real need from the ASTP in term supporting information.
- Technology readiness of the sensors and techniques used to achieve the performance requested within the safety objectives.

Since several open issues still need to be tackled by the System Pillar, the set of requirements may not be used for an industrial project (in the scope of ERTMS) without considering the future sector agreements.

ABBREVIATIONS AND ACRONYMS

1D	One dimension
3D	Three dimensions
ASTP	Advanced Safe Train Positioning
ATO	Automatic Train Operation
ATO-OB	Automatic Train Operation On-Board
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
CBTC	Communication based train control
CCS	Control Command and Signalling
CCS-OB	Control Command and Signalling On-Board
CI	Confidence interval
CMD	Cold Movement Detection
EB	Emergency Braking
EGNOS	European Geostationary Navigation Overlay Service
ETCS	European Train Control System
ETRS89	European Terrestrial Reference System 1989
EoA	End of Authority
ERTMS	European Rail Traffic Management System
ESA	European Space Agency
EUSPA	European Union Agency for the Space Programme
FRMCS	Future Railway Mobile Communication System
FFFIS	Form Fit Functional Interface Specification
GNSS	Global Navigation Satellite System
ID	Identification
LRBG	Last Relevant Balise Group
IMU	Inertial Measurement Unit
MA	Movement Authority
MAACI	Max Accepted Acceleration Confidence Interval
MAAU	Max Accepted Acceleration Underestimation
MAAO	Max Accepted Acceleration Overestimation

MAPCI	Max Accepted Position Confidence Interval
MAPU	Max Accepted Position Underestimation
MAPO	Max Accepted Position Overestimation
MASCI	Max Accepted Speed Confidence Interval
MASU	Max Accepted Speed Underestimation
MASO	Max Accepted Speed Overestimation
N/A	Not Applicable
OCORA	Open CCS On-board Reference Architecture
R2DATO	Rail to Digital automated up to autonomous train operation
RAMS	Reliability, Availability, Maintainability and Safety
REACH	Registration, Evaluation, Authorization and restriction of Chemicals
RoHS2	Restriction of Hazardous Substances 2
RU	Railway Undertaking
SIL4	Safety Integrity Level 4
STM	Specific Transmission module
TCMS	Train Control and Monitoring System
TSI	Technical Specification for Interoperability
THR	Tolerable Hazard Rate
V&V	Verification & Validation
WGS84	World Geodetic System 1984
WP21	Work package 21 of the R2DATO project

Please refer to additional acronyms defined in SUBSET-023 [2].

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1 INTRODUCTION

This document represents the deliverable D21.2 – System Requirements of ASTP System of task 21.2 which is part of work package WP21 Absolute Safe Train Positioning operational needs of the R2DATO project.

The main goal of task 21.2 is to define a set of requirements derived from D21.1[1] Operational Requirements and System Capabilities of ASTP System.

It is to be noted that D21.1[1] defines the functional definition of the ASTP system and therefore, the functional definition is not redefined in D21.2.

1.1 DEFINITIONS

All definitions are available in § 2 of D21.1.

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

1.2 METHODOLOGY

Requirements are defined as follows:

[REQ: FP2-ASTP-SRS-XXX]: *title of the requirement*

[category]: Identification of the category of the requirement using one of the following tags:

- FR: functional Requirement.
- NFR: non-functional Requirement.
  - NFR-RAMSS: Non-functional Requirement related to Reliability, Availability, Maintainability, Safety or Security.
  - NFR-ENV: Non-functional Requirement related to environmental constraints.
  - NFR-PERFO: Non-functional Requirement related to performance constraints.
  - NFR: Generic non-functional Requirement.

[Requirement]: Core of the requirement.

[Rational]: Rational content.

[V&V method]: Assumption on the Verification and Validation method.

[Safety assumptions]: Assumptions on the safety relevancy of the requirement provided by the specification team. Those assumptions must be challenged by the RAMS team and shall not be considered for granted.

[traceability]: Traceability towards D21.1: Operational needs and system capabilities of an ASTP system [1].

[END REQ]

2 OPERATIONAL AND FUNCTIONAL REQUIREMENTS

2.1 ASTP PROVIDING DATA

[REQ: FP2-ASTP-SRS-072]: *Providing data to users*

[category]: FR.

[Requirement]: ASTP shall provide all available data to each user after its initialisation stage respecting the specified transmission periodicity.

[Rationale]: The ASTP shall be considered as a data provider. ASTP does not have any action on the train. Available data must be understood as data that can be processed by the ASTP withing the required THR. For example, ASTP may struggle to calculate a position but can still calculate the speed. In this case ASTP shall provide the speed.
For transmission periodicity, refer to FP2-ASTP-SRS-072.

[V&V method]: Verification / testing

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §7.2.1.1.1

[END REQ]

[REQ: FP2-ASTP-SRS-073]: *Unavailable data (internal safety process faults)*

[category]: FR.

[Requirement]: If ASTP is unable to produce a data respecting the safety requirements (THR) because ASTP cannot guarantee safe operation due to internal safety process faults (for ex: safe computer failure, self-testing KO etc): ASTP shall not provide any information to the users.

[Rationale]: ASTP is providing safety related data that shall not be used by users if not in accordance with the specified THR to reach the overall safety objectives. In this case, the ASTP can be considered in failure mode.

[V&V method]: Verification / testing

[Safety assumptions]: ASTP shall guarantee not to send data that do not achieve the awaited THR.

[traceability]: D21.1 §9.3.2.1.2

[END REQ]

[REQ: FP2-ASTP-SRS-083]: *Unavailable data (insufficient information)*

[category]: FR.

[Requirement]: If ASTP is unable to produce a data respecting the safety requirements (THR) because ASTP does not contain sufficient information to guarantee safe results (one or several sensor failure or unavailability): ASTP shall provide a default invalid value for the data concerned and shall provide all other data as specified.

[Rationale]: ASTP is providing safety related data that shall not be used by users if not in accordance with the specified THR to reach the overall safety objectives. To be noticed that this requirement is only valid for the data related to safety. For example, if ASTP cannot provide a position with a SIL4 confidence interval, the confidence interval will be provided with a default invalid value, but the estimated position can still be provided to all users that do not need a safe position.

[V&V method]: Verification / testing

[Safety assumptions]: ASTP shall guarantee not to send data that do not achieve the awaited THR.

[traceability]: D21.1 §9.3.2.1.2

[END REQ]

[REQ: FP2-ASTP-SRS-001]: *Confidence interval variations*

[category]: FR.

[Requirement]: Only if safety is granted (fulfilment to the safety requirements), the occurrence of sudden variation (e.g., sudden increase of the confidence interval while the train is following a braking curve) or loss of ASTP localisation information by a safety relevant consumer due to the lack of valid data (e.g., lack of message, data is too old, etc.) leading to a brake intervention (service brake or emergency brake) shall be less than 2*10-6/h (one brake intervention per year for a fleet of 10 trains operated during 14 hours per day)

[Rationale]: Three use cases are identified:

- In the case the sudden increase of the train front end position confidence interval is greater than the distance travelled, the train minimum safe rear end can be seen as going backwards. Therefore, in moving block area, the following train can then trigger brake intervention or trip mode if the two trains are close to each other.
- In the case the sudden increase of the train front end position underestimation is larger than the distance to a target (EOA, speed decrease …), the train can trigger brake intervention.
- In the case the sudden increase of the speed underestimation is larger than the margin to the speed curve, the train can trigger brake intervention or trip mode instead of adapting its speed.

The confidence interval increase can be counterbalanced by slowing down the train (lower traction or service braking).

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §4.1.1.4.11 / D21.1 §4.1.2.4.1 / §8.1.1.1.2

[END REQ]

2.2 ASTP LIFE CYCLE

[REQ: FP2-ASTP-SRS-075]: *ASTP life cycle*

[category]: NFR-RAMSS.

[Requirement]: ASTP life cycle shall be at least 30 years.

[Rationale]: D21.1 §4.1.2.4.5

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §4.1.2.4.5

[END REQ]

2.3 1D LOCALISATION

[REQ: FP2-ASTP-SRS-002]: *1D localisation dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the ASTP 1D position:

Data	Unit / resolution	Range	Safety assumption	default invalid value
Reference location id	N/A	[0;2^{32}-2]	Safety related	2^{32}-1
Position qualifier	N/A	0 Reverse 1 Nominal 2 Unknown	Safety related	Unknown
Estimated distance	Cm (0.01m) / 1 cm	[0; 2^{32}-2]	Safety related (used to define the max/min train safe front end)	2^{32}-1
Underestimation of the estimated distance	Cm (0.01m) / 1 cm	[0; 2^{32}-2]	Safety related	2^{32}-1
Overestimation of the estimated distance	Cm (0.01m) / 1 cm	[0; 2^{32}-2]	Safety related	2^{32}-1
Track edge id	N/A	[0; 2^{32}-2]	Safety related if no trackside train detection is available	2^{32}-1
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Safety related (safe time management)	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 1: 1D localisation dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.2:

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1.

[V&V method]: Verification.

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-001.

[END REQ]

2.4 1D SPEED

[REQ: FP2-ASTP-SRS-003]: *1D speed dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the ASTP 1D speed:

data	Unit / resolution	Range	Safety assumption	default invalid value
Movement direction	N/A	0 Reverse 1 Nominal 2 Unknown	Safety related	Unknown
Estimated ASTP speed	0.1km/h | 0.1km/h	[0;6000]	Safety related (used to define the max safe speed)	6001
Underestimation ASTP speed	0.1km/h | 0.1km/h	[0;6000]	Safety related	6001
Overestimation ASTP speed	0.1km/h | 0.1km/h	[0;6000]	Safety related	6001
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Safety related (safe time management)	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 2: 1D speed dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.3:

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification.

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-002

[END REQ]

2.5 1D ACCELERATION

[REQ: FP2-ASTP-SRS-004]: *1D acceleration dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the ASTP 1D acceleration:

data	Unit / resolution	Range	Safety assumption	default invalid value
Estimated ASTP acceleration	0.01m/s^2 | 0.01m/s^2	[-1000;1000]	Safety related (used to define the max safe acceleration)	1001
Underestimation ASTP acceleration	0.01m/s^2 | 0.01m/s^2	[-1000;1000]	Safety related	1001
Overestimation ASTP acceleration	0.01m/s^2 | 0.01m/s^2	[-1000;1000]	Safety related	1001
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Safety related (safe time management)	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 3: 1D acceleration dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.4:

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification.

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-003

[END REQ]

2.6 3D POSITION

[REQ: FP2-ASTP-SRS-005]: *3D location dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the ASTP 3D position:

data	Unit / resolution	Range	Safety assumption	default invalid value
3D Position: latitude	Degree | 1E-7°	[-900 000 000; +900 000 000]	Not safety related	+900 000 001
3D Position: longitude	Degree | 1E-7°	[-1 800 000 000; +1 800 000 000]	Not safety related	+1 800 000 001
3D Position: Altitude over WGS 84 ellipsoid	Cm (0.01m) / 1 cm	[-50000; +884800]	Not safety related	+884801
3D Position uncertainty		Covariance matrix of the 3-axis coordinates	Not safety related	0 on each value
Coordinate system	N/A	0 WGS84 1 Other	Not safety related	1 Other
Track edge id	N/A	$[0;2^{32}-2]$	Not safety related	$2^{32}-1$
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Not safety related	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 4: 3D location dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.5:

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification.

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-004

[END REQ]

[REQ: FP2-ASTP-SRS-006]: *3D location coordinate system reference*

[category]: FR.

[Requirement]: ASTP 3D position shall use the *World Geodetic System WGS84* .
The reference coordinate system shall be identified through the “Coordinate system” data.

[Rationale]: GNSS positioning and GNSS augmentation is referenced to WGS84.
If another reference coordinate system, as ETRS89, is used, translations will be needed.
These translations are not in the scope of ASTP and need to be exported.
Since reference coordinate systems can diverge with time due to tectonic movements, a periodic verification between the reference coordinate of the map and WGS84 need to be performed.
This verification is not in the scope of ASTP and need to be exported.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-004 / §2.1.1.1.4

[END REQ]

[REQ: FP2-ASTP-SRS-085]: *3D location and track bounding*

[category]: FR.

[Requirement]: ASTP 3D position shall be track bounded. If ASTP cannot determine on which track the ASTP reference point is, the ASTP 3D position may be track unbounded and the track edge id shall be set to default invalid value.

[Rationale]: Unless catastrophic event, the train is always on tracks. Due to this reason, it is more relevant to provide a 3D track bounded position.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-004

[END REQ]

2.7 3D VELOCITY

[REQ: FP2-ASTP-SRS-007]: *3D velocity dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the 3D train velocity:

data	Unit / resolution	Range	Safety assumption	default invalid value
3D Velocity: X axis	0.1m/s | 0.1m/s	[-1700;1700]	Not safety related	1701
3D Velocity: Y axis	0.1m/s | 0.1m/s	[-1700;1700]	Not safety related	1701
3D Velocity: Z axis	0.1m/s | 0.1m/s	[-1700;1700]	Not safety related	1701
3D Velocity uncertainty		Covariance matrix of the 3-axis coordinates	Not safety related	0 on each value
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Not safety related	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 5: 3D velocity dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.6.

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification.

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-005

[END REQ]

2.8 3D ACCELERATION

[REQ: FP2-ASTP-SRS-008]: *3D acceleration dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the 3D train acceleration:

data	Unit / resolution	Range	Safety assumption	default invalid value
3D Acceleration: X axis	0.01m/s^2 | 0.01m/s^2	[-1000;1000]	Not safety related	1001
3D Acceleration: Y axis	0.01m/s^2 | 0.01m/s^2	[-1000;1000]	Not safety related	1001
3D Acceleration: Z axis	0.01m/s^2 | 0.01m/s^2	[-1000;1000]	Not safety related	1001
3D Acceleration uncertainty		Covariance matrix of the 3-axis coordinates	Not safety related	0 on each value
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Not safety related	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 6: 3D velocity dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.7.

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification.

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-006

[END REQ]

2.9 ATTITUDE (ROTATIONAL ANGLES)

[REQ: FP2-ASTP-SRS-009]: *3D attitude dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the 3D train attitude:

data	Unit / resolution	Range	Safety assumption	default invalid value
Yaw	Degree | 1E-4°	[0-3 600 000]	Not safety related	3 600 001
Pitch	Degree | 1E-4°	[0-3 600 000]	Not safety related	3 600 001
Roll	Degree | 1E-4°	[0-3 600 000]	Not safety related	3 600 001
Attitude uncertainty		Covariance matrix of the 3-axis coordinates	Not safety related	0 on each value
Yaw angular rate	Degree/s | 1E-4°/s	[0-3 600 000]	Not safety related	3 600 001
Pitch angular rate	Degree/s | 1E-4°/s	[0-3 600 000]	Not safety related	3 600 001
Roll angular rate roll	Degree/s | 1E-4°/s	[0-3 600 000]	Not safety related	3 600 001
Angular rate uncertainty		Covariance matrix of the 3-axis coordinates	Not safety related	0 on each value
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Not safety related	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 7: 3D attitude dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.8.

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification.

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-007

[END REQ]

2.10 ODOMETER INFORMATION

[REQ: FP2-ASTP-SRS-010]: *Odometer information dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the Odometer information to satisfy STM requirements:

data	Unit / resolution	Range	Safety assumption	default invalid value
Estimated distance travelled	cm / 1 cm	[-2^{31}; 2^{31}-2]	Safety related (used to define the max/min train safe front end)	2^{31}-1
Estimated distance max	cm / 1 cm	[-2^{31}; 2^{31}-2]	Safety related	2^{31}-1
Estimated distance min	cm / 1 cm	[-2^{31}; 2^{31}-2]	Safety related	2^{31}-1
Estimated train speed	0.1m/s | 0.1m/s	[0;1700]	Safety related (used to define the max safe speed)	1701
Maximum train speed	0.1m/s | 0.1m/s	[0;1700]	Safety related	1701
Minimum train speed	0.1m/s | 0.1m/s	[0;1700]	Safety related	1701
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Safety related (safe time management)	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

Table 8: Odometer information dataset

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.9.

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification / testing

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-008 / §4.1.2.4.4.1

[END REQ]

2.11 VIRTUAL REFERENCE LOCATION

[REQ: FP2-ASTP-SRS-086]: *Virtual Reference Location dataset provided by ASTP*

[category]: FR.

[Requirement]: ASTP shall provide the following data concerning the Virtual Reference Location

Data	Unit / resolution	Range	Safety assumption	default invalid value
Reference location id	N/A	[0;2^{32}-2]	Safety related	2^{32}-1
Region ID	N/A	[0;2^{32}-2]	Safety related	2^{32}-1
Orientation	N/A	0 Reverse 1 Nominal 2 Unknown	Safety related	Unknown
Validity timestamp	Depending on the selected technique	Depending on the selected technique	Safety related (safe time management)	Depending on the selected technique
Function status	N/A	0 Non-available 1 Available	Not safety related	Non-available

[Rationale]: Definitions of the dataset are defined in D21.1 § 7.1.10.

Note: to avoid any documentary quality issue, D21.2 does not include any copy or extract from D21.1

[V&V method]: Verification / testing

[Safety assumptions]: Assumptions on the safety relation for each data of the dataset are provided in the dataset definition.

[traceability]: ASTP_SF-009

[END REQ]

2.12 TIME AND REAL TIME MANAGEMENT BETWEEN DATA PROVIDERS AND DATA USERS

[REQ: FP2-ASTP-SRS-011]: *ASTP time synchronisation*

[category]: FR.

[Requirement]: ASTP, ASTP data provider and ASTP data users shall use a common time synchronisation technique compatible with the safety requirements in accordance with the EN50159 [19] standard. If available, the chosen technique shall be the one defined in the future TSI.

[Rationale]: ASTP is deeply linked to real time or pseudo real time applications. All data providers or data users shall share the same time management techniques with a common reference. The time management for CCS-OB is defined in the subset 147 [10] published in the CCS TSI 2023 and shall be favoured. To be noticed that time synchronisation can rely on a common safe absolute clock or on a relative delta clock check between the two connected components.

[V&V method]: Verification.

[Safety assumptions]: Related to safety, undetected or unmanaged delays may lead to feared events.

[traceability]: ASTP_SF-201

[END REQ]

2.13 FUNCTION STATUS INFORMATION

[REQ: FP2-ASTP-SRS-013]: *ASTP dataset Function status*

[category]: FR.

[Requirement]: For each dataset and independently, ASTP shall manage the system information status as following:

- If the dataset does include a safe confidence interval (1D localisation, 1D speed, 1D acceleration and estimated distance travelled since power-on)
  - Function status = Dataset available: if all data of the dataset is available
  - Function status = Dataset unavailable: if one data of the dataset is unavailable, including the CI.
- If the dataset does not include a safe confidence interval (3D localisation, 3D velocity, 3D acceleration and attitude)
  - Function status = Dataset available: if all data are available.
  - Function status = Dataset unavailable: if one data of the dataset is unavailable.

If the ASTP is not providing data at the defined rate (refer to FP2-ASTP-SRS-034 and FP2-ASTP-SRS-035), the affected datasets are considered unavailable during this time.

[Rationale]: This requirement is related to the performance requirements defined in § 3.1 .
To be noticed that safety is the main concern and is the ASTP cannot generate the data within the defined THR, the data shall not be provided (refer to FP2-ASTP-SRS-073).

	Confidence interval size < accuracy objectives	Confidence interval size > accuracy objectives	Confidence interval is not calculated or provided
Value is included in the confidence interval within the defined THR: YES	Best performance in safety	Potential capacity issues (delays to EB). Unavailability, no safety issues	Emergency braking, train stops. Unavailability, no safety issues
Value is included in the confidence interval within the defined THR: NO	! Safety issue, not acceptable !	! Safety issue, not acceptable !	

[V&V method]: Verification / Testing.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §8.2

[END REQ]

2.14 MAINTENANCE

[REQ: FP2-ASTP-SRS-014]: *Event memory managed by ASTP*

[category]: FR.

[Requirement]: ASTP shall manage a time stamped event memory to log all events related to ASTP behaviour (no achievement of the requirements) or environmental event detected by the ASTP sensors (for example: uncommon vibration, spoofing event).

[Rationale]: The event memory will ease the ASTP own maintenance and the onboard or trackside maintenance. The memory needs to manage the data for a minimum time of on month.

[V&V method]: Verification / testing

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-203 / D21.1 §4.1.1.4.8 / §8.3.1.1.4 / § 4.1.1.2

[END REQ]

2.15 START OF MISSION (INITIALISATION)

[REQ: FP2-ASTP-SRS-017] : *Standalone initialisation*

[category]: FR.

[Requirement]: ASTP, from the train power on, shall initialise itself and provide the outputs with no human supervision.

[Rationale]: D21.1 §9.2

[V&V method]: Verification / Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 /§ 7.2.1.1.4

[END REQ]

[REQ: FP2-ASTP-SRS-018]: *Initialisation with valid information*

[category]: NFR-PERFO.

[Requirement]: After the ASTP is powered-on, it shall fulfil entire operational capability in less than 1 minute when:

- Initial position is known (e.g., last known position is saved before ASTP is switched-off) AND

- Track edge id is known (e.g., last track edge id is saved before ASTP is switched-off) AND
- CMD indicates no train movement since the train was powered off

[Rationale]: Refer to D21.1 §7.2. When the 3 defined conditions are fulfilled, the initial position is considered valid.

[V&V method]: Verification / Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 / §5.2.1.1.2 / § 7.2.1.1.1 / § 7.2.1.1.2 / § 7.2.1.1.4

[END REQ]

[REQ: FP2-ASTP-SRS-019]: *Initialisation without valid information*

[category]: NFR-PERFO.

[Requirement]: After the ASTP is switched-on, it shall fulfil entire operational capability in less than 5 minutes when:

- Initial position is unknown (e.g., last known position is not saved before ASTP is switched-off)
  OR
- Track edge id is unknown (e.g., last track edge id is not saved before ASTP is switched-off)
  OR
- CMD indicates a train movement during the train is powered off.

After this delay, in case ASTP is unable to fulfil entire operational capability, [FP2-ASTP-SRS-020] shall apply.

[Rationale]: Entire operational capability shall be understood as all datasets are available as defined in [REQ: FP2-ASTP-SRS-013]. If one of the 3 defined conditions is fulfilled, the initial position is considered invalid. To be noticed that depending on the sensor data set, this requirement may be unachievable. The train will need to move in specific mode as on sight or staff responsible to acquire a first safe position (for example by reading an eurobalise). Moving a train always require speed and travelled distance.

[V&V method]: Verification / Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §5.2.1.1.2 / §5.2.1.1.3 / § 7.2.1.1.2 / § 7.2.1.1.4

[END REQ]

[REQ: FP2-ASTP-SRS-020]: *Initialisation under degraded mode*

[category]: FR.

[Requirement]: In case the ASTP cannot reach full operational capability after the system is powered on (e.g., weak GNSS signal), estimated speed and travelled distance since the ASTP is powered on shall always be provided.

[Rationale]: Refer to D21.1 §7.2. If the train will need to move in specific mode as on sight or staff responsible to acquire a first safe position (for example by reading an eurobalise), speed and travelled distance are needed.

[V&V method]: Verification / Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §5.2.1.1.5 / § 7.2.1.1.3 / § 9.2.1.1.2

[END REQ]

[REQ: FP2-ASTP-SRS-084]: *CMD behaviour*

[category]: FR.

[Requirement]: ASTP shall consider that the CMD indicate a train movement when the train is powered off only if the train movement exceeds a threshold.

[Rationale]: This behaviour is defined in subset 26 [3]. The usual value of the threshold equal 2m. The ASTP algorithms need to consider this behaviour especially for the confidence interval calculation.

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §11.5.1.1.2

[END REQ]

2.16 TRACK SELECTIVITY

[REQ: FP2-ASTP-SRS-021]: *Track edge ID*

[category]: FR.

[Requirement]: ASTP shall provide the track edge ID of the track segment where the ASTP reference point position is estimated.

[Rationale]: Since ASTP provide only information related to the ASTP reference point, each user can derive its necessary dataset using the track edge ID and the 1D position for example. ASTP does not need to identify all possible track edge ID considering the 1D position underestimation and overestimation.

[V&V method]: Verification / Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-001

[END REQ]

2.17 COMMON INTERFACE REQUIREMENTS

[REQ: FP2-ASTP-SRS-023]: *FFFIS between ASTP and providers/users*

[category]: FR.

[Requirement]: ASTP, user equipment and provider equipment shall comply with the FFFIS to be defined in the future TSI iteration.

[Rationale]: Most of the interfaces between ASTP and provider/user will be defined in future relevant standards. Supplier specific mechanisms shall be avoided. If data is transferred through a communication interface, EN50159 [19] shall apply.
To be noticed that this requirement is not related to ASTP internal sensors.

[V&V method]: Verification / Lab test.

[Safety assumptions]: Related to safety. The FFFIS shall guarantee the data integrity.

[traceability]: D21.1 §5.2.4.1.3

[END REQ]

2.18 DATA ACQUISITION REQUIREMENTS (SUPPORTING INFORMATION)

To be notice that the requirement defined in this chapter refer to the supporting information that may be available and provided to ASTP to achieve the requested requirements.

It shall be understood that:

1) The supporting information proposed by WP21 is only a proposal to the design teams and shall not be considered as mandatory.

2) The design teams shall only use the needed supporting information to fulfil the requirements in term of safety and performance.

3) Less (no) supporting information will ease development, RAMS analysis, integration, reduce costs etc and shall be favoured.

4) For each used supporting information, the design team shall provide the requested exported constraints especially focusing on safety.

5) The list of supporting information is deeply linked to CCS-OB architecture and may evolve.

6) Availability, safety requirements and quality of the supporting information shall not be taken for granted and every needed supporting information shall be exhaustively analysed especially toward safety.

7) If a supporting information is needed, ASTP shall use the format and interface defined by the future standardised CCS-OB. A specific mechanism is to be avoided or considered as an internal component of ASTP.

8) If the design team identify a need toward a supporting information not identified by WP21, a request can be addressed to the system engineers to embed the needed supporting information (exported constraint, change request etc)

2.18.1 Augmentation

[REQ: FP2-ASTP-SRS-024]: *Augmentation data acquired by ASTP*

[category]: FR.

[Requirement]: If available onboard and needed by ASTP to achieve requirements, augmentation data shall be acquired in accordance with the future TSI.

[Rationale] : Augmentation data must enhance GNSS localisation information. Furthermore, involving augmentation must result in faster accurate localisation estimation after the start-up of ASTP.
Augmentation data is not limited to GNSS and could be supporting information such as temporary slippery conditions (rail friction coefficient) that can be regarded by the sensors and/or fusion logic to improve the overall performance.
To be noticed that EGNOS is considered as one of the most interesting augmentation data to be used.
To be noticed that a supplier specific augmentation mechanism must be avoided.
Refer to D21.1 § 7.1.13.
To be noticed that FRMCS is identified as a key enabler to acquire augmentation. Signal in Space may be an alternative for low density line if FRMCS is not available on the whole line by may be out of the scope of ETCS.

[V&V method]: Verification.

[Safety assumptions]: Related to safety only if augmentation data is used to improve safety.

[traceability]: ASTP_SF-103

[END REQ]

2.18.2 Cold Movement

[REQ: FP2-ASTP-SRS-025]: *Cold Movement data acquired by ASTP*

[category]: FR.

[Requirement]: If available onboard and needed by ASTP to achieve requirements, Cold Movement information shall be acquired in accordance with the future TSI.

[Rationale]: Cold Movement Detector information can be standardised to be shared with several onboard users.
To be noticed that a supplier specific external Cold Movement Detection mechanism must be avoided.
Refer to D21.1 § 7.1.17.

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: ASTP_SF-109

[END REQ]

2.18.3 Train Routing Information

[REQ: FP2-ASTP-SRS-027]: *Train routing information acquired by ASTP*

[category]: FR.

[Requirement]: If needed by ASTP to achieve requirements, ASTP shall acquire the train routing information (Movement Authority, journey profile or switch information etc) in accordance with the present TSI or the future updates.

[Rationale]: This information is seen useful to fetch the required map data for the train path ahead and to validate the determined position by the ASTP against track selectivity, e.g., at start-up after vehicle has moved during power-off mode (degraded mode). It might also be used to determine track selectivity, e.g., if the vehicle position is known prior to passing a switch point and to decide whether it turned left or right.
Future TSI may also include an explicit definition of the switch point positions.

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: ASTP_SF-102

[END REQ]

2.18.4 Eurobalise Telegram

[REQ: FP2-ASTP-SRS-028]: *Eurobalise Telegram acquired by ASTP*

[category]: FR.

[Requirement]: If needed by ASTP to achieve requirements, ASTP shall acquire the Eurobalise Telegram in accordance with the present TSI or the future updates.

[Rationale]: Refer to D21.1 §7.1.15.
Depending on the algorithms used, balise information can be used as an absolute reference location (e.g., also in combination with digital map information) and reduce/reset the confidence interval (Subset-026-3.6.4.2.2 [3]).
This information is also useful to validate the determined position by the ASTP against the matching physical reference position.
To be noticed that no standard interface with the balise reader is yet defined. ASTP may acquire the balise telegram from the balise reader or from ETCS.

[V&V method]: Verification / testing.

[Safety assumptions]: Related to safety if eurobalises telegram are used to produce safety related data.

[traceability]: ASTP_SF-107

[END REQ]

2.18.5 Map Data

[REQ: FP2-ASTP-SRS-029]: *Map Data acquired by ASTP*

[category]: FR.

[Requirement]: If available onboard and needed by ASTP to achieve requirements, ASTP shall acquire the Map Data in accordance with the future TSI.

[Rationale]: Refer to D21.1 §7.1.11.
The Digital Register will be a common source for several users. The future TSI will define standard interfaces toward the digital map.
Work Package 27 is specifically dedicated to Map Data specification.

[V&V method]: Verification / testing.

[Safety assumptions]: Related to safety if Map data are used to produce safety related data.

[traceability]: ASTP_SF-101

[END REQ]

2.18.6 Static ASTP Configuration

[REQ: FP2-ASTP-SRS-032]: *Static ASTP configuration*

[category]: FR.

[Requirement]: If centralised at the train level, ASTP shall acquire its static configuration from the common onboard configuration data storage component. Otherwise, specific static configuration information shall be managed as an internal component of ASTP.

[Rationale]: refer to D21.1 §7.1.14.
Static configuration may include sensor positioning definition, the ASTP reference location and other specific parameters. Static configuration data shall allow to achieve the specified performance without compromising system safety.

[V&V method]: Verification / testing.

[Safety assumptions]: Related to safety if static train configuration is used to produce safety related data.

[traceability]: ASTP_SF-105

[END REQ]

2.18.7 Last Relevant Reference Location

[REQ: FP2-ASTP-SRS-033]: *LRRL acquired by ASTP*

[category]: FR.

[Requirement]: ASTP shall use the Last Relevant Reference Location provided by ETCS.

[Rationale]: refer to D21.1 §7.1.16.
To be noticed that 1D position can refer to LRBG but may also refer to other localisation references. In this case, the backward compatibility with ETCS L2 is not achievable.

[V&V method]: Verification / testing.

[Safety assumptions]: Related to safety if LRRL is used to produce safety related data.

[traceability]: ASTP_SF-108

[END REQ]

3 NON-FUNCTIONAL REQUIREMENTS

3.1 PERFORMANCE REQUIREMENTS

3.1.1 Common performance requirement

[REQ: FP2-ASTP-SRS-034]: *ASTP dataset time validity*

[category]: NFR-PERFO.

[Requirement]: ASTP dataset time validity shall not exceed 200 ms when transferred to users.

[Rational]: Time validity shall be understood as the dataset define a value corresponding to a state not older than 200 ms when outputted by ASTP. Sensors delays, time to process the fusion algorithms etc shall be considered. Present day odometry time validity usually goes from 200 ms to 500 ms.

[V&V method]: Lab test.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §4.4.1

[END REQ]

[REQ: FP2-ASTP-SRS-035]: *ASTP dataset transmission period*

[category]: NFR-PERFO.

[Requirement]: ASTP dataset transmission periodicity shall comply with the users' needs.

User need	Maximum transmission period	Assumption on the user	Assumption on the dataset needed
Very high	25ms	ATO with a 50ms cycle	1D localisation / 1D speed / 1D acceleration
High	50ms	Perception	3D attitude
Normal	100ms	ATP with a 200ms cycle	1D localisation / 1D speed / 1D acceleration
Low	1000ms	others	All

Table 9: transmission period dataset

[Rational]: No common need is identified. Assumptions on the user needs shall be confirmed.

[V&V method]: Lab test.

[Safety assumptions]: not related to safety.

[traceability]: D21.1 §4.4 / §5.2.4

[END REQ]

3.1.2 1D Location

[REQ: FP2-ASTP-SRS-036]: *ASTP computed confidence interval toward the estimated ASTP position performance*

[category]: NFR-PERFO.

[Requirement]: The computed ½ confidence interval (Underestimation of the estimated distance and Overestimation of the estimated distance) toward the ASTP reference position provided by ASTP shall not exceed (absolute value):

- 60m in areas with negligible constraints whatever is the train operation (cruising, accelerating, standstill etc).
- 60m in areas with constraints only if the train is not stopping in this area.

[Rationale]: refer to D21.1 § 6.3.3.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 § 6.3.3 / §4.1.1.4.1 / §4.1.1.4.2 / §4.1.1.4.5 / §4.1.2.4.1

[END REQ]

[REQ: FP2-ASTP-SRS-037]: *ASTP computed confidence interval, stopping in an area with constraints*

[category]: NFR-PERFO.

[Requirement]: The computed ½ confidence interval (Underestimation of the estimated distance and Overestimation of the estimated distance) toward the ASTP reference position provided by ASTP shall not exceed (absolute value):

- 10m in areas with constraints if the train is stopping in this area.

[Rationale]: refer to D21.1 § 6.3.3.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 § 6.3.3 / §4.1.1.4.1 / §4.1.1.4.2 / §4.1.1.4.5 / §4.1.2.4.1

[END REQ]

[REQ: FP2-ASTP-SRS-038]: *ASTP computed estimated position accuracy*

[category]: NFR-PERFO.

[Requirement]: For at least 95% of the cases, the absolute error of the ASTP reference estimated position provided by ASTP shall not exceed:

- +- 5.0 m in areas with negligible constraints.
- +- 5.0 m in areas with constraints.

[Rationale]: Refer to D21.1 § 6.3.3. To be noticed that these values are subject to evolution especially considering the results of the demonstrations done in the scope of WP22.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §4.4 / § 6.3.3.

[END REQ]

3.1.3 Speed

[REQ: FP2-ASTP-SRS-080]: *ASTP computed confidence interval toward speed performance*

[category]: NFR-PERFO.

[Requirement]: The computed safe ½ confidence interval toward estimated speed shall not exceed 2 km/h (MASO/MASU), for speeds lower than 30 km/h, and increasing linearly up to 12 km/h for speeds between 30 km/h and 500 km/h.

[Rationale]: Refer to D21.1 § 7.1.3.
If speed <30km/h, MASO=MASU=2km/h
If speed ≥ 30km/h, MASO=MASU= (2 + (speed-30) / 47) km/h

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-002 / D21.1 § 6.2.2.

[END REQ]

[REQ: FP2-ASTP-SRS-040]: *ASTP computed estimated speed accuracy*

[category]: NFR-PERFO.

[Requirement]: For at least 95% of the cases, the absolute error of the estimated train speed provided by ASTP shall not exceed ± 1 km/h for speeds from 0 km/h to 100 km/h and ± 1% * v for speeds from 100 km/h to 500 km/h.

[Rationale]: Refer to D21.1 § 7.1.3.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-002 / D21.1 § 6.2.2.

[END REQ]

3.1.4 Acceleration

[REQ: FP2-ASTP-SRS-041]: *ASTP computed confidence interval toward acceleration performance*

[category]: NFR-PERFO.

[Requirement]: ASTP shall provide the train estimated acceleration with a computed ½ confidence interval better than 0.2 m/s^2.

[Rationale]: Refer to D21.1 § 7.1.4 and § 6.2.3. Acceleration performance is required for train protection (computation of the safe braking curve).

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-003.

[END REQ]

[REQ: FP2-ASTP-SRS-043]: *ASTP computed estimated acceleration accuracy*

[category]: NFR-PERFO.

[Requirement]: For at least 95% of the cases, the absolute error of the estimated train acceleration provided by ASTP shall not exceed 0.05 m/s^2.

[Rationale]: To be noticed that these values are subject to evolution especially considering the results of the demonstrations done in the scope of WP22.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-003.

[END REQ]

3.1.5 3D position

[REQ: FP2-ASTP-SRS-044]: *ASTP computed estimated 3D position accuracy*

[category]: NFR-PERFO.

[Requirement]:]: For at least 95% of the cases, the absolute error of the estimated 3D ASTP reference position shall not exceed 2.5m on the x y and z axis of the carriage reference frame.

[Rationale]: Refer to D21.1 § 7.1.5. Some perception systems require a two sigma accuracy < 5m. To be noticed that these values are subject to evolution especially considering the results of the demonstrations done in the scope of WP22.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-004/ D21.1 § 4.4

[END REQ]

3.1.6 3D velocity

[REQ: FP2-ASTP-SRS-045]: *ASTP computed estimated 3D velocity accuracy*

[category]: NFR-PERFO.

[Requirement]: For at least 95% of the cases, the absolute error of the estimated 3D train velocity shall not exceed 2 km/h on each axis of the carriage reference frame.

[Rationale]: Refer to D21.1 § 7.1.6. To be noticed that these values are subject to evolution especially considering the results of the demonstrations done in the scope of WP22.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-005.

[END REQ]

3.1.7 3D acceleration

[REQ: FP2-ASTP-SRS-046]: *ASTP computed estimated 3D acceleration accuracy*

[category]: NFR-PERFO.

[Requirement]: For at least 95% of the cases, the absolute error of the estimated 3D train acceleration shall not exceed 0.05 m/s^2 on each axis of the carriage reference frame.

[Rationale]: Refer to D21.1 §7.1.7.
To be noticed that these values are subject to evolution especially considering the results of the demonstrations done in the scope of WP22.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-006.

[END REQ]

3.1.8 Attitude (rotational angles)

[REQ: FP2-ASTP-SRS-048]: *ASTP computed estimated 3D attitude accuracy*

[category]: NFR-PERFO.

[Requirement]: For at least 95% of the cases, the absolute error of the estimated 3D attitude (rotational angles) shall not exceed 0.1° for yaw, and 0.5° for pitch and roll angles.

[Rationale]: Refer to D21.1 § 7.1.8. To be noticed that these values are subject to evolution especially considering the results of the demonstrations done in the scope of WP22.

[V&V method]: Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: ASTP_SF-007.

[END REQ]

3.1.9 Estimated distance travelled since power-on

[REQ: FP2-ASTP-SRS-049]: *ASTP computed estimated distance since power-on accuracy*

[category]: NFR-PERFO.

[Requirement]: The safe maximum distance (Estimated distance max) and the safe minimum distance (Estimated distance min) under and over estimation compared to the estimated distance travelled (Estimated distance travelled) shall be lower than 2% of the travelled distance.

[Rationale]: Refer to D21.1 § 7.1.9.

[V&V method]: Lab test.

[Safety assumptions]: Related to safety.

[traceability]: ASTP_SF-008 / §5.2.5.2.6

[END REQ]

3.2 RAMSS REQUIREMENTS

3.2.1 Reliability

[REQ: FP2-ASTP-SRS-069]: *ASTP reliability*

[category]: NFR-RAMSS.

[Requirement]: The ASTP hardware shall comply with the overall CCS on-board reliability as defined in [EEIG 92S126 [25] chapter 2]:

Minor failure: $\lambda < 1.25 * 10^{-4}$/h.
Reduced service failure: $\lambda < 3.3 * 10^{-6}$/h.
Immobility failure: $\lambda < 3.7 * 10^{-7}$/h.

[Rationale]: The mission profile for these values is defined in document [EEIG 92S126 [25] chapter 2].

These values are defined at the overall CCS on-board system level and should be derived in accordance with a future overall CCS architecture:

- A minor failure of the ASTP hardware could lead to a warning information requiring service intervention within a failure specific period to prevent reduced performance.

- A failure of the ASTP hardware could lead to a reduced service with the consequence of a reduced performance.

- A failure of the ASTP hardware could lead to immobility, for instance in case of a transition into the system failure (SF) mode.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §5.2.2.1.1

[END REQ]

3.2.2 Availability

[REQ: FP2-ASTP-SRS-050]: *ASTP availability toward confidence intervals*

[Requirement]: If the performance of the ASTP (e.g., confidence intervals are outside of MAPCI (position), MASCI (speed) or MAACI (acceleration)) induces more than 1mn of train delay during one hour of train operation, the delay of time is accounted in the overall unavailability of the ASTP.

[Rationale]: the impact of ASTP performance availability on train operation is complex to specify or to model since deeply related on the type of line (low traffic / low performance vs high traffic /high performance) and on the Movement Authority mechanism and update (if the EoA is systematically a long way ahead of the train or if the distance between the EoA and the danger point is significant). From the results of the demonstrations and from the agreed common architecture, this requirement can be refined by considering a compromise between high-level needs and common design choices. The objective is to formulate the ASTP performance availability requirements as a time ratio that 1/2 CIs overrun MAPCI/MASCI/MAACI or on a probability density of CIs overrunning values.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §8.2.1.1.3

[END REQ]

[REQ: FP2-ASTP-SRS-051]: *ASTP overall availability*

[category]: NFR-RAMSS.

[Requirement]: The ASTP shall have an overall availability of 99.998% during operation.

[Rationale]: Refer to D21.1 §8.2.1.1.5.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §8.2.1.1.5.

[END REQ]

3.2.3 Maintainability

[REQ: FP2-ASTP-SRS-052]: *ASTP as a generic application*

[category]: NFR-RAMSS.

[Requirement]: The ASTP shall be designed as a generic application (CF EN50126 [18])

[Rationale]: As a generic application, ASTP will ease its integration in the future onboard CCS and will ease technologic updates.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §5.2.2.1.3 / §5.2.3.1.1

[END REQ]

[REQ: FP2-ASTP-SRS-070]: *ASTP preventive maintenance*

[category]: NFR-RAMSS.

[Requirement]: Preventive maintenance and periodic workshop sensor calibration period of the overall ASTP shall exceed 2 years.

[Rationale]: If possible, preventive maintenance or periodic sensor calibration period shall be avoided.

Also, if several sensors are used, the preventive maintenance plan shall factorise their preventive maintenance or calibration.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §5.2.3.1.7

[END REQ]

[REQ: FP2-ASTP-SRS-071]: *ASTP periodic workshop calibration*

[category]: NFR-RAMSS.

[Requirement]: If a periodic workshop sensor calibration is needed, the procedure shall not exceed two hours for the whole ASTP sensors and shall be done without the use of complex calibration benches.

[Rationale]: If possible periodic sensor calibration performed in workshops shall be avoided.

[V&V method]: Verification / test

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §5.2.3.1.7

[END REQ]

[REQ: FP2-ASTP-SRS-015]: *ASTP calibration and specific trackside equipment*

[category]: NFR-RAMSS.

[Requirement]: Calibration procedure(s) operated during the train operation shall avoid the use of specific trackside equipment.

[Rationale]: For example, calibration of localisation equipment can be done with specific precise balises on track as done in some CBTC systems. This type of solutions shall be avoided unless it became a standardised technique.

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 § 4.1.1.4.3

[END REQ]

[REQ: FP2-ASTP-SRS-016]: *Replacement of an ASTP component*

[category]: NFR-RAMSS.

[Requirement]: Following the installation and configuration of a new set of on-board equipment (line replaceable unit of the ASTP), ASTP shall reach full operational capability at switch-on in less than 20 minutes with no driver or operational staff intervention.

[Rationale]: Maintenance operations shall be optimised with minimal human supervision.

[V&V method]: Verification / Lab test.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §5.2.3.1.7 / §8.3.1.1.2

[END REQ]

[REQ: FP2-ASTP-SRS-053]: *ASTP software updates*

[category]: NFR-RAMSS.

[Requirement]: The ASTP shall be designed to ease software updates (including security patches) by avoiding complex workshop procedures requiring bench testing.

[Rationale]: The ability to update the ASTP software is essential.
To minimize maintenance cost, the default update deployment mechanism shall be remote (e.g., over-the-air) with no physical presence of any maintenance personnel on site (e.g., on the train).

[V&V method]: Verification.

[Safety assumptions]: Not related to safety.

[traceability]: D21.1 §8.3.

[END REQ]

3.2.4 Safety

[REQ: FP2-ASTP-SRS-054] ***Safety demonstration***

[category]: NFR-RAMSS.

[Requirement]: The safety of the ASTP shall be ensured and demonstrated according to the Common Safety Methods [ERA_CSM] and the [EN 50126 [18]] standard.

[Rationale]: ASTP is a safety related constituent, Common Safety Methods and the EN 50126 standard shall apply.

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §5.2.1.1.8

[END REQ]

[REQ: FP2-ASTP-SRS-056] ***True position and confidence interval***

[category]: NFR-RAMSS.

[Requirement]: The ASTP reference point true position shall be included in ASTP computed confidence interval within the most constraining THR.

[Rationale]: One of the feared events identified being ASTP reference point real position not included in the confidence interval which can lead to catastrophic events (collision or catch-up for example).
Users of localisation dataset may have different needs toward safety requirements. The most constraining user shall be considered as the reference.
Since users may translate the ASTP reference point to another reference, each user needs to take into account the possible degradation on the data (for example: elasticity of the coupling).

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §5.2.1.1.8

[END REQ]

[REQ: FP2-ASTP-SRS-067] ***True speed and confidence interval***

[category]: NFR-RAMSS.

[Requirement]: The ASTP true speed shall be included in ASTP computed confidence interval within the most constraining THR.

[Rationale]: One of the feared events identified being the ASTP real speed exceed the max safe speed provided by ASTP which can lead to catastrophic events (derailment for example).
Users of speed dataset may have different needs toward safety requirements. The most constraining user shall be considered as the reference.
Since users may translate the ASTP reference point to another reference, each user needs to consider the possible degradation on the data (for example: elasticity of the coupling).

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §5.2.1.1.8

[END REQ]

[REQ: FP2-ASTP-SRS-068] ***True acceleration and confidence interval***

[category]: NFR-RAMSS.

[Requirement]: The ASTP true acceleration shall be included in ASTP computed confidence interval within the most constraining THR.

[Rationale]: One of the feared events identified being the ASTP acceleration not included in the confidence interval which can lead to erroneous braking curves and then catastrophic events (collision or catch-up for example).
Users of acceleration dataset may have different needs toward safety requirements. The most constraining user shall be considered as the reference.
Since users may translate the ASTP reference point to another reference, each user needs to consider the possible degradation on the data (for example: elasticity of the coupling).

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §5.2.1.1.8

[END REQ]

[REQ: FP2-ASTP-SRS-068] ***Track edge ID safety attribute***

[category]: NFR-RAMSS.

[Requirement]: The track edge ID generated by the ASTP shall be included in the real train route within the most constraining THR.

[Rationale]: The track edge ID related to the real ASTP position my diverge form the one generated using the estimated ASTP position which is not problematic if the track edge ID is included in the real train route. The safety related event is related to the provision of a track edge ID not included on the train real route, for example after crossing a switch.

[V&V method]: Verification / Testing.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §5.2.1.1.8

[END REQ]

[REQ: FP2-ASTP-SRS-058] ***Safe calibration of ASTP***

[category]: NFR-RAMSS.

[Requirement]: If needed, calibration procedure(s) shall comply with the safety requirements.

[Rationale]: Calibration may impact safety. For example, if ASTP uses several sensors as GNSS, IMU and balise reader, using one sensor to calibrate another one may be acceptable for non-safe information but induce a common mode that may not be acceptable for safety related data. Safety requirements are defined in § 3.2.4

[V&V method]: Verification.

[Safety assumptions]: Related to safety.

[traceability]: D21.1 §5.2.1.1.8

[END REQ]

3.2.5 Security

[REQ: FP2-ASTP-SRS-059]: *ASTP security constraints*

[category]: NFR-RAMSS.

[Requirement]: ASTP shall fulfil requirements and recommendations for cybersecurity as specified in :

- CLC/TS 50701 [15]
- SP-PRAMSS 30_Secure Component Specification [26]
- SP-PRAMSS 40_Secure Communication Specification [27]
- SP-PRAMSS 50_Shared Security Services Specification[28]
- SP-PRAMSS 60_Security_Program_Requirements [29]

[Rationale]: Cybersecurity threats shall be considered, and mitigation measures shall be provided. Since ASTP users are numerous and have different levels of criticality (ATP to infotainment), special attention must be paid to secure and non-secure digital interfaces. ASTP should be accessible according to users and roles.

The purpose is to demonstrate that the system is up to date from a cybersecurity perspective and that it meets and maintains the target level of security for the entire system life cycle.

[V&V method]: Verification / Testing.

[Safety assumptions]: not related to safety.

[traceability]: ASTP_SF-202 / D21.1 §8.4

[END REQ]

3.3 ENVIRONMENTAL REQUIREMENTS

3.3.1 General

[REQ : FP2-ASTP-SRS-060] : *ASTP environnemental contraints*

[category]: NFR-ENV.

[Requirement]: ASTP components shall comply with the relevant environmental standards (depending on the selected technology).

[Rationale]: 97s0665 [24] describes the minimum system specific environmental requirements for the operation of ERTMS track side and train mounted equipment toward the following topics:

- Ambient temperature
- Solar Radiation
- Humidity
- Wind and pressure pulses
- Altitude
- Water and precipitation
- Pollutants and contaminants
- Mechanical (shock and vibration)
- Electrical (power supplies)
- Electromagnetic Compatibility
- Ergonomics

97s0665 [24] point an exhaustive list of standards such as EN50155 [20] or ENV 50121-4 [17].

Detailed requirement and acceptance criteria toward each component of the ASTP shall be defined for each solution depending on the conception choices as sensors positioning, use of safe computer etc.

[V&V method]: Verification / Testing.

[Safety assumptions]: not related to safety.

[traceability]: D21.1 §8.5 / §4.1.1.4.9 / §4.1.1.4.10 / §4.1.1.4.11

[END REQ]

3.3.2 Fire protection

[REQ: FP2-ASTP-SRS-061] *ASTP fire protection constraints*

[category]: NFR-ENV.

[Requirement]: ASTP components shall comply with the EN 45545 [16] standard: Railway applications - Fire protection on railway vehicles. The latest edition shall apply.

[Rationale]:

[V&V method]: Verification / Testing.

[Safety assumptions]: not related to safety.

[traceability]: D21.1 §5.2.3.1.2

[END REQ]

3.3.3 REACH / RoHs

[REQ: FP2-ASTP-SRS-062] *ASTP REACH RoHS constraints*

[category]: NFR-ENV.

[Requirement]: ASTP components shall comply with the REACH and RoHS2. The latest edition shall apply.

[Rationale]:

[V&V method]: Verification.

[Safety assumptions]: not related to safety.

[traceability]: D21.1 §5.2.3.1.2

[END REQ]

4 CONCLUSIONS

The requirements defined in the present document enable the launch of a proof-of-concept campaign, including objectives in line with current knowledge, particularly in terms of performance, while providing certain assumptions concerning the safety of the localisation data.

The confrontation of this set of requirements within WP22 demonstration will provide important feedback on the feasibility of a safe localisation equipment using alternative technology from the one specified today (odo balise principle).

WP22 will then provide a gap analysis up to the definition of TSI.

Although completeness of requirements is a primary objective, the fact that the project is a research project means that assumptions were made and some results from other works package or standardisation teams are not yet produced. To be noticed that the scope of localisation is also not yet stabilised with the introduction of new concepts or functional allocation in the scope of the System Pillar (Basic ASTP, Train Time and Localisation Service etc).

Concerning the identified open issues, since most of it where related to the overall CCS-OB architecture or specification (out of WP21 scope), WP21 could only provide the members points of view and proposals without considering the open issue closed. Only the System Pillar, with a broader scope of work, is able to take the right decisions to definitely close the identified open issues.

Even if efforts have been made to resolve the open points, it must be said that many remain open as:

- Unstable user needs (for example perception or ATO).
- Undefined (and unagreed) embedded CCS architecture.
- Undefined (and unagreed) functional allocation between embedded CCS components.
- Cross-disciplinary work in progress on the definition of the Digital map (definition and handling).
- Availability and definition of supporting information provided to the localisation.
- Real need from the localisation in term supporting information.
- Technology readiness of the sensors and techniques used to achieve the performance requested within the safety objectives.

These uncertainties need to be considered in other projects as R2DATO phase 2 concerning the technology readiness and System Pillar especially concerning the overall CCS-OB architecture and functional allocation which were one on the major source of uncertainties.

REFERENCES

[1] D21.1 Operational Requirements and System Capabilities of ASTP System

[2] SUSBSET-023 ERTMS/ETCS Glossary of Terms and Abbreviations

[3] SUBSET-026 Baseline 3 R2 ERTMS/ETCS System Requirements Specification

[4] SUBSET-034

[5] SUBSET-035 Baseline 3 R2 ERTMS/ETCS Specific Transmission Module FFFIS

[6] SUBSET-041 Baseline 3 R2 ERTMS/ETCS Performance Requirements for Interoperability

[7] SUBSET-125 Issue 0.0.18 ATO over ETCS System Requirements Specification

[8] SUBSET-126 Issue 0.0.16 ATO over ETCS ATO-OB / ATO-TS FFFIS Application Layer

[9] SUBSET-130 Issue 0.0.11 ATO over ETCS ATO-OB / ETCS-OB FFFIS Application Layer

[10] SUBSET-147

[11] SUBSET 091 Baseline 3 R2 ERTMS/ETCS Safety Requirements for the Technical Interoperability of ETCS in Levels 1 & 2

[12] D27.1 Set of requirements on the Digital Register in FP2-R2DATO

[13] X2Rail-5 Road map and migration strategy D5.5

[14] RCA Digital Map System Definition RCA.Doc.59

[15] CLC/TS 50701 Railway Applications – Cybersecurity

[16] EN 45545

[17] ENV 50121-4

[18] EN 50126 Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability

[19] EN 50159

[20] EN 50155

[21] ERTMS Users Group/UIC - ERTMS/ETCS RAMS Requirements Specification - Chapter 2 – RAM - 96S126

[22] LOC-OB System Definition & Operational Context LWG.Doc.022

[23] OCORA-TWS01-101

[24] ERTMS Users Group/UIC - ERTMS/ETCS Environmental Requirements - 97S066

[25] ERTMS Users Group/UIC – ERTMS/ETCS RAMS Requirements Specification – 96S126

[26] SP-PRAMSS 30_Secure Component Specification

[27] SP-PRAMSS 40_Secure Communication Specification

[28] SP-PRAMSS 50_Shared Security Services Specification

[29] SP-PRAMSS 60_Security_Program_Requirements

REQUIREMENTS TRACEABILITY MATRIX

D21.2 Requirement	Corresponding system function	Corresponding chapters in D21.1
REQ: FP2-ASTP-SRS-001		§4.1.1.4.11 §4.1.2.4.1 §8.1.1.1.2
REQ: FP2-ASTP-SRS-002	ASTP_SF-001	
REQ: FP2-ASTP-SRS-003	ASTP_SF-002	
REQ: FP2-ASTP-SRS-004	ASTP_SF-003	
REQ: FP2-ASTP-SRS-005	ASTP_SF-004	
REQ: FP2-ASTP-SRS-006	ASTP_SF-004	§2.1.1.1.4
REQ: FP2-ASTP-SRS-007	ASTP_SF-005	
REQ: FP2-ASTP-SRS-008	ASTP_SF-006	
REQ: FP2-ASTP-SRS-009	ASTP_SF-007	
REQ: FP2-ASTP-SRS-010	ASTP_SF-008	
REQ: FP2-ASTP-SRS-011	ASTP_SF-201	
REQ: FP2-ASTP-SRS-013		§8.2
REQ: FP2-ASTP-SRS-014	ASTP_SF-203	§4.1.1.4.8 §8.3.1.1.4 §4.1.1.2
REQ: FP2-ASTP-SRS-015		§4.1.1.4.3
REQ: FP2-ASTP-SRS-016		§5.2.3.1.7 §8.3.1.1.2
REQ: FP2-ASTP-SRS-017		§7.2.1.1.4
REQ: FP2-ASTP-SRS-018		§5.2.1.1.2 §7.2.1.1.1 §7.2.1.1.2 §7.2.1.1.4
REQ: FP2-ASTP-SRS-019		§5.2.1.1.2 §5.2.1.1.3 §7.2.1.1.2 §7.2.1.1.4
REQ: FP2-ASTP-SRS-020		§5.2.1.1.5 §7.2.1.1.3 §9.2.1.1.2
REQ: FP2-ASTP-SRS-021	ASTP_SF-001	
REQ: FP2-ASTP-SRS-023		§5.2.4.1.3
REQ: FP2-ASTP-SRS-024	ASTP_SF-103	
REQ: FP2-ASTP-SRS-025	ASTP_SF-109	
REQ: FP2-ASTP-SRS-027	ASTP_SF-102	
REQ: FP2-ASTP-SRS-028	ASTP_SF-107	
REQ: FP2-ASTP-SRS-029	ASTP_SF-101	
REQ: FP2-ASTP-SRS-032	ASTP_SF-105	

D21.2 Requirement	Corresponding system function	Corresponding chapters in D21.1
REQ: FP2-ASTP-SRS-033	ASTP_SF-108	
REQ: FP2-ASTP-SRS-034		§4.4.1
REQ: FP2-ASTP-SRS-035		§4.4 §5.2.4
REQ: FP2-ASTP-SRS-036		§6.3.3 §4.1.1.4.1 §4.1.1.4.2 §4.1.1.4.5 §4.1.2.4.1
REQ: FP2-ASTP-SRS-037		§6.3.3 §4.1.1.4.1 §4.1.1.4.2 §4.1.1.4.5 §4.1.2.4.1
REQ: FP2-ASTP-SRS-038		§4.4 §6.3.3
REQ: FP2-ASTP-SRS-040	ASTP_SF-002	§6.2.2
REQ: FP2-ASTP-SRS-041	ASTP_SF-003	
REQ: FP2-ASTP-SRS-043	ASTP_SF-003	
REQ: FP2-ASTP-SRS-044	ASTP_SF-004	§4.4
REQ: FP2-ASTP-SRS-045	ASTP_SF-005	
REQ: FP2-ASTP-SRS-046	ASTP_SF-006	
REQ: FP2-ASTP-SRS-048	ASTP_SF-007	
REQ: FP2-ASTP-SRS-049	ASTP_SF-008	§5.2.5.2.6
REQ: FP2-ASTP-SRS-050		§8.2.1.1.3
REQ: FP2-ASTP-SRS-051		§8.2.1.1.5
REQ: FP2-ASTP-SRS-052		§5.2.2.1.3 §5.2.3.1.1
REQ: FP2-ASTP-SRS-053		§8.3
REQ: FP2-ASTP-SRS-054		§5.2.1.1.8
REQ: FP2-ASTP-SRS-056		§5.2.1.1.8
REQ: FP2-ASTP-SRS-058		§5.2.1.1.8
REQ: FP2-ASTP-SRS-059	ASTP_SF-202	§8.4
REQ: FP2-ASTP-SRS-060		§8.5 §4.1.1.4.9 §4.1.1.4.10 §4.1.1.4.11
REQ: FP2-ASTP-SRS-061		§5.2.3.1.2
REQ: FP2-ASTP-SRS-062		§5.2.3.1.2
REQ: FP2-ASTP-SRS-067		§5.2.1.1.8
REQ: FP2-ASTP-SRS-068		§5.2.1.1.8
REQ: FP2-ASTP-SRS-069		§5.2.2.1.1
REQ: FP2-ASTP-SRS-070		§5.2.3.1.7

D21.2 Requirement	Corresponding system function	Corresponding chapters in D21.1
REQ: FP2-ASTP-SRS-071		§5.2.3.1.7
REQ: FP2-ASTP-SRS-072		§7.2.1.1.1
REQ: FP2-ASTP-SRS-073		§9.3.2.1.2
REQ: FP2-ASTP-SRS-075		§4.1.2.4.5
REQ: FP2-ASTP-SRS-080	ASTP_SF-002	§6.2.2
REQ: FP2-ASTP-SRS-083		§9.3.2.1.2
REQ: FP2-ASTP-SRS-084		§11.5.1.1.2
REQ: FP2-ASTP-SRS-085	ASTP_SF-004	
REQ: FP2-ASTP-SRS-086	ASTP_SF-009	