X2Rail-5

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1 Executive Summary

In line with what is indicated in the X2Rail-5 Grant Agreement for the Work Package WP5, this Gap Analysis was conducted for the Fail Safe Train Positioning system.

The document highlights the gaps but does not report the solutions to fill them, these will be analysed and possibly resolved in other tasks within the X2Rail-5 WP5, X2Rail-5 WP6 and X2Rail-5 WP7 projects.

The starting state for this Gap Analysis is what has already been achieved during the development of the X2Rail-2 WP3 project in which two solutions were created (also identified with STREAM 1 and STREAM 2). Therefore, all documents produced during the X2Rail-2 WP3 project, and the specifications contained in the current TSI were considered as a starting point for the analysis carried out. Documents produced in other projects are also part of the state of the art, provided they are public and report objectively verifiable conclusions.

The salient points that identify the two streams that arise in the X2R2-WP3 project are:

- Stream 1: Virtual Balise concepts are developed and continue to be explored through a collaboration between wayside and on-board systems to evaluate the error committed by the GNSS system in addition to the use of other sensors including the use of digital maps;
- Stream 2: the objective is to have a Stand Alone system in which all the sensors are on board the train but with interaction with the ground system for the management of digital maps, the GNSS systems belong to the set of usable sensors.

What emerged during the carrying out of the activities is that as a research project, the evolution of the gaps is extremely dynamic. The Gap Analysis performed freezes the maturity state at an early stage of X2Rail-5. The aim of the further work of X2Rail-5 is to reduce the gap to the target.

The result of the Gap Analysis shows that both Streams did not produce a complete set of documentation ready to be fully inserted into the TSI.

In order to converge on a common proposal suitable for TSI CCS, a comparative analysis will be carried out in the subsequent phases of flows.

The results obtained in this activity made it possible to evaluate the degree of maturity of the entire project.

In detail, the following results were achieved:

the documentation produced by users (EUG), which has reached a good level of maturity, but which requires some further refinements to be considered definitive.

Another aspect that emerges is that in addition to the use of GNSS, other sensors will certainly have to be used, maintaining the principle of introducing the least number of changes to the current specifications.

It was assessed that for X2R2 Stream 1 there are contributions from other projects that contribute to giving a more consolidated aspect in terms of results obtained while as the recently started X2R2 Stream 2 does not have the contribution of the results obtained in other projects.

However, in both Streams there is no documentation or proof that what has been created is ready to be fully included in the interoperability specifications.

Since this is a qualitative Gap Analysis, expressly requested by the JU, in order to provide indications on how much work was necessary to complete the documentation to be included in the TSI CCS in order to satisfy the needs of both streams 1 and 2, chapter 7 was created which tried to give a "measure" of how much work was needed to achieve the goal. In the end, the result of the Gap Analysis shows that what has been achieved in the two streams is not yet ready to be

completely included in the TSI and some activities are necessary as happens in all research projects.

The activities carried out within the task that led to the drafting of this document were conducted in plenary sessions in which the various topics were discussed and shared.

A brief description of the document.

The chapter 2 reports the table of the contents.

The chapter 3 the Abbreviation and acronyms.

The chapter 4 the background that requested the execution of these activities.

This chapter 5 clarify the objectives and reports the salient document description and the method adopted.

2 Table of Contents

2.2 Tables

3 Abbreviations and acronyms

Abbreviation / Acronyms	Description
CBA	Cost Benefit Analysis
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
EUG	EEIG ERTMS USERS GROUP
FSTP	Fail Safe Train Positioning
GA	Grant Agreement
GI	Gap Indicator
SRS	System Requirements Specification
TSI	Technical Specification of Interoperability
WP3	Work Package n 3 of the project X2Rail-2
WP5	Work Package n 5 of the project X2Rail-5
WP6	Work Package n 6 of the project X2Rail-5
WP7	Work Package n 7 of the project X2Rail-5
X2R2	Project X2Rail-2
X2R5	Project X2Rail-5

4 Background

This document has been prepared to provide the progress of the Fail Safe Trail Positioning system project. The Gap Analysis helps to set the objectives to be achieved and to evaluate the distance to cover to reach them.

Gap analysis is a process of comparing the current state with the desired state for an organization. The starting point of the analysis is clearly defined in chapter 5.

When gap refers to how far you are behind your target point; Gap analysis takes you to that point.

It is an ambitious task to perform a Gap Analysis in the context of a research project composed of different stakeholders as in Shift2Rail.

However, this plurality of participants helps to take into consideration all the needs of the various actors involved.

Of course, as a research project, all the participants are aware that some objectives may change along the way. For this reason, it will be desirable to update this Gap Analysis with the results obtained from the realization of the demonstrators foreseen in WP6 and WP7.

All the activities carried out are in line with what is reported in the Grant Agreement indicated below:

“The objective of TD2.4 is to introduce improved fail-safe train positioning function for ERTMS/ETCS through the application of GNSS and other new technologies (e.g., inertial measurement units) as well as other on-board existing sensors (e.g., axle-mounted odometric sensors). It is foreseen that this improved positioning function will bring additional benefits for end users (e.g., cost reduction, increase of robustness), as well as flexibility for line engineering, maintenance and track management. This Fail-Safe Train Positioning will be specified, developed and verified to guarantee the backward compatibility with existing ERTMS systems and the key ERTMS interoperability requirements. Based on the outputs of X2Rail-2 and other previous projects, demonstrators will be tested in laboratories and on site.

5 Objective / Aim

The purpose of this document is to provide an image of the progress of the activities carried out for the two streams defined in X2Rail-2.

This document will also be used to demonstrate the ability to work and compare among all the participants of X2Rail-5 WP5 task 5.3.

The starting point of the analysis is mainly what has been achieved in X2Rail 2 together with further references from other projects. Chapters 11 reports in detail the evidence that led to the analysis.

Being able to produce a shared GAP analysis document will be a sign of collaboration and willingness to proceed with the work within the project.

The first recipients of this document are the X2Rail-5 Steering Committee and the SHIFT2Rail JU.

In the Task 5.3 within X2Rail-5 WP5 we have set objectives with associated priorities to be undertaken for the realization of a Gap Analysis. The first important objective is to define, from a documentary point of view, whether the requirements with which the future FSTP solution must comply are clear. This translates into the creation of **chapter 6** with the identification of the Targets to be met.

A scale of values was defined to qualitatively assess the distance to fill the gap under examination (GAP indicator value). Using the contents of chapter 6 as a reference, in **chapter 7** the gap analysis is performed independently for each stream.

Chapter 7 should provide an indication of the distance to the full insertion of the specification into the TSI. This becomes the starting point for identifying potential strategies for inserting documentation into TSIs. The structure of chapter 7 is kept for the convenience of tracking the requirements and associated gaps.

Chapter 0 is expected to provide for the analysis of the gaps of the demonstrator(s) that are going to be created within the Work packages WP6 and WP7. This chapter will be updated during the project taking as input what was obtained in the mentioned WPs. Obviously, the activities identified in chapter 8 are also indispensable to insert FSTP within the TSI.

The structures of chapter 7 and chapter 8 have been deliberately kept the same to facilitate the traceability of requirements.

In the Evidence References (**chapter 11**), all the reference documents are reported that will provide evidence to how far the target is already reached. There is a set of evidence for each stream.

It is not the purpose of the document to indicate when the different documents examined will be candidates for inclusion in the TSI.

Chapter 9 reports the conclusion reached during the activities of the WP5 task 5.2.3.

6 The Target

The objective of this section is to identify all aspects of the “Fail Safe Train Positioning” (FSTP) system which are required for an inclusion in the TSI in order to achieve the expected functionality, performance in an interoperable manner. The sum of these aspects is called the **Target**.

By evaluating the currently existing information on possible solutions for the FSTP system against this target, the gap to be closed to reach full TSI readiness is identified.

Note: The objective of this section is only to identify the elements of the target, against which proposals are to be evaluated, and the way how this evaluation shall be performed.

The evaluation of the gap is part of section 7 and section 0.

6.1 Defining the Target

From the experience of specifying the European Train Control System ETCS, a list of all elements shall be produced which are needed to achieve:

- technical interoperability between on-board and trackside elements
- safe operation
- stable performance
- certification

This applies to any functionality to be included in the TSI, but needs to be specifically tailored to specific functions, and possibly also proposals.

As Target are also taken into consideration:

- Migration Strategy
- Cost Benefit Analysis

Each of these elements is called a **Target Element** and will be evaluated individually.

6.2 Evaluation of how each Target Element meets the Target

For each target element, a description of its content is provided in section 6.3, followed by a table which lists all aspects of that element, which have to be evaluated.

The description shall clarify what is expected from each target element, while the table provides a template, in which the extend, to which the target is covered by the available specification shall be inserted, as well as references to the respective evidence.

To evaluate the target achievement, a numerical indicator referred to as **Gap Indicator** (GI) shall be used. This value has no intention to define the work percentage nor the aim to be a value to be used for comparison, it is only defined to identify the missing steps.

Four levels are defined for the GI:

GI Gap Indicator	Description
3	Target identified and fully met
2	Target identified and partially met
1	Target identified but not filled in
0	Target not addressed at all

Table 1: “Gap Indicator” description

Table 1 shows a general approach on how to use the Gap Indicator. The meaning associated with each value will be promptly reported for each specific paragraph.

Finally, it is necessary to define the evidence required to meet each GI level. An evidence to be considered needs to be available to the evaluation team, either by being a publicly available document, or by being made available through a non-disclosure agreement.

Note: If evidence is not public and cannot be shared as such, an agreement has to be reached among the work package members whether it can still be considered, and under which conditions.

Note: Any technology or functionality, which needs to be part of a TSI compliant system, cannot contain IP rights of individual entities, unless free and unrestricted usage by any third party for the purpose of providing TSI compliant systems or services has been granted by the holder of the IP rights.

The assessment of the gap will have to be made with respect to the current specifications present in the TSI in force.

6.3 Target Elements

The lines associated with each target will be defined in the following paragraphs, these will have the following structure see Table 2:

Target Element	GI value [0-3]	Evidence Reference
Specific Target (reference chapter 6.3.x.y)	GI Value	

Table 2: Example of Target table

Where we have:

- **Target Element**: element that must be implemented, this can be a specification of the requirements or a list of operational rules to be applied, etc.
- **GI**: value that indicates the GAP between the system under examination with respect to the target to be reached. Each "target element" paragraph indicates the meaning of each value.
- **Evidence Reference**: Documents and / or test reports that prove the level of achievement of the target.

6.3.1 User Requirements for FSTP

6.3.1.1 FSTP High Level User Requirements Description (FSTP FRS)

This contains the high-level requirements produced at European level by users. Users are organizations that represent at least many countries of the European community. (e.g., EUG or equivalent)

No national requirements are accepted in the whole document.

These requirements are part of the ETCS system and its evolutions.

For convenience, in accordance with the assumptions indicated, the requirements are divided into categories in the following paragraphs.

6.3.1.1.1 FSTP Functional Requirements

This paragraph contains all the requirements that describe the functional behaviour of the generic FSTP system expected by users (e.g., EUG or equivalent).

6.3.1.1.2 FSTP Performance Requirements

All performance requirements that are applicable to the generic FSTP, are reported.

6.3.1.1.3 FSTP RAM Requirements

In accordance with the assumptions made previously, all RAM requirements that are applicable to the generic FSTP are reported.

6.3.1.1.4 FSTP Safety Requirements

This paragraph lists all the safety requirements that EUG, or equivalent European organizations, have explicitly issued to the FSTP system.

6.3.1.1.5 FSTP Operational Requirements

This paragraph reports the requirements issued mainly by EUG, or by equivalent organizations at European level, which affect the operational aspects in which the FSTP system is inserted, and which could affect the implementation of the FSTP.

6.3.1.1.6 FSTP Environmental Requirements

All the environmental requirements created by users at European level are reported which can clarify the conditions of use of the FSTP system. In this context, care must be taken that these are requirements accepted by all member states or by a large majority of them.

6.3.1.1.7 FSTP Interoperability Requirements

Starting from the concept that by definition the FSTP system must be interoperable and as written in the GA also backward compatible within the ETCS system, specific users' requirements affecting interoperability between systems will be included.

6.3.1.1.8 FSTP Economic Benefits Requirements

All the qualitative and quantitative requirements expressed by users (e.g., EUG or equivalent organization at European level), coming from a Cost Benefit Analysis or equivalent approach, are reported.

6.3.1.2 Gap Indicator Table template

For every category of High Level User Requirements for FSTP, the GI values are:

- GI = 3 if the specific category requirements exist and are complete
- GI = 2 if the specific category requirements exist but not closed
- GI = 1 if the specific category requirements are partially done
- GI = 0 if the specific category requirements do not exist

Exist/identified or **closed/complete** means that the document/requirement is ready to be delivered to the ERA and it is ready to be insert into the TSI.

Exist/identified but **not closed** means that the acceptance process is in progress and the document is complete and most of the requirements are formalised and closed and some of them are not fully defined.

The specific category requirements are **partially done** means that some requirements are missing.

This notation is applied to the whole paragraph 6.3.

Target Element	GI value [0-3]	Evidence Reference

Functional Requirements		
Performance Requirements		
RAM Requirements		
Safety Requirements		
Operational Requirements		
Environmental Requirements		
Interoperability Requirements		
Economic Benefits Requirements		

Table 3: FSTP- Gap indicator table template for User Requirements

6.3.2 FSTP Requirements (FSTP SRS)

6.3.2.1 FSTP Description

The FSTP description is the set of requirements to be fulfilled by the functional block. These are functional and non-functional requirements.

6.3.2.1.1 FSTP-SRS: User Requirements

This paragraph has the task of verifying whether the SRS specifications of the FSTP exist and whether they follow the requirements of paragraph 6.3.1.

The GI values:

- GI = 3 if FSTP-SRS User Requirements document exists and complete
- GI = 2 if FSTP-SRS User Requirements document exists but not closed
- GI = 1 if FSTP- SRS User Requirements document partially done
- GI = 0 if FSTP- SRS User Requirements document does not exist

6.3.2.1.2 FSTP-SRS: Functions Description

Within the FSTP-SRS functional requirements, there shall be defined a section where the core functions are described. The detail of the function's description shall allow the clear definition of interoperable functions as well as the dependencies among the functions. These requirements also report the interfaces between the functions.

The GI values:

- GI = 3 if FSTP-SRS Functions Description exists and complete
- GI = 2 if FSTP-SRS Functions Description exists but not closed
- GI = 1 if FSTP-SRS Functions Description partially done
- GI = 0 if FSTP-SRS Functions Description does not exist

6.3.2.1.3 FSTP-SRS: Performance target

Within the FSTP-SRS functional requirements, there shall be defined what are the performance requirements for the function.

The GI values:

- GI = 3 if FSTP-SRS: Performance target exist and are complete
- GI = 2 if FSTP-SRS: Performance target exist but not closed
- GI = 1 if FSTP-SRS: Performance target are partially done

- GI = 0 if FSTP-SRS: Performance target description does not exist

6.3.2.1.4 FSTP-SRS: Operational Conditions

Within the FSTP-SRS functional requirements, the operational conditions under which the proposed solution shall work, shall be specified.

The GI values:

- GI = 3 if FSTP-SRS: Operational Conditions specification exists, and it is complete
- GI = 2 if FSTP-SRS: Operational Conditions specification exists but not closed
- GI = 1 if FSTP-SRS: Operational Conditions specification is partially done
- GI = 0 if FSTP-SRS: Operational Conditions specification does not exist

6.3.2.1.5 FSTP-SRS: Safety Requirements

This paragraph reports all the safety requirements in the same manner of the subset 91 and 88 and all is safety related, The THR allocation at system constituents.

The GI values:

- GI = 3 if FSTP-SRS: Safety Requirements are all identified and are complete
- GI = 2 if FSTP-SRS: Safety Requirements are all identified but not closed
- GI = 1 if FSTP-SRS: Safety Requirements are partially done
- GI = 0 if FSTP-SRS: Safety Requirements list does not exist

6.3.2.1.6 FSTP-SRS: Cyber Security Requirements

Within the FSTP-SRS Non-functional requirements, the cyber security requirements shall be defined. Special attention shall be paid to the signal in space interface of GNSS and its usage. This can be done also for all the radio communication, for the possible environment condition that can be changing internally/externally by an intentional attacker.

The GI values:

- GI = 3 if FSTP-SRS: Cyber Security Requirements are well identified and are complete
- GI = 2 if FSTP-SRS: Cyber Security Requirements are all identified but not closed
- GI = 1 if FSTP-SRS: Cyber Security Requirements are partially done
- GI = 0 if FSTP-SRS: Cyber Security Requirements list does not exist

6.3.2.1.7 FSTP-SRS: Engineering Rules

Within the FSTP-SRS Non-functional requirements, the appropriate engineering rules to apply the proposed solution shall be defined.

The GI values:

- GI = 3 if FSTP-SRS: Engineering Rules are well identified and are complete
- GI = 2 if FSTP-SRS: Engineering Rules are all identified but not closed
- GI = 1 if FSTP-SRS: Engineering Rules are partially done
- GI = 0 if FSTP-SRS: Engineering Rules description does not exist

6.3.2.1.8 FSTP-SRS: Environmental Requirements

There shall be a clear definition of the considerations about the environmental conditions that are necessary to guarantee for the minimal operational localisation performance. The document to prove this target is met shall focus on:

1) Qualification procedure that the railway line/vehicle can be operated while using enhanced train localisation system.
2) Conditions and limitations to be taken into account in the process of engineering the line/installation on the vehicle.
3) Monitoring process to guarantee that the specified limitations and assumptions regarding environmental conditions are still valid during the operational lifetime of the system.

The GI values:

- GI = 3 if FSTP-SRS: Environmental Requirements are well identified and are complete
- GI = 2 if FSTP-SRS: Environmental Requirements are all identified but not closed
- GI = 1 if FSTP-SRS: Environmental Requirements are partially done
- GI = 0 if FSTP-SRS: Environmental Requirements list does not exist

6.3.2.2 Gap Indicator Table template

Target Element	GI value [0,3]	Evidence Reference
FSTP-SRS: User Requirements (see 6.3.2.1.1)		
FSTP-SRS: Functions Description (see 6.3.2.1.2)		
FSTP-SRS: Performance target (see 6.3.2.1.3)		
FSTP-SRS: Operational Conditions (see 6.3.2.1.4)		
FSTP-SRS: Safety Requirements (see 6.3.2.1.5)		
FSTP-SRS: Cyber Security Requirements (see 6.3.2.1.6)		
FSTP-SRS: Engineering Rules (see 6.3.2.1.7)		
FSTP-SRS: Environmental Requirements (see 6.3.2.1.8)		

Table 4: FSTP- gap indicator table template for SRS

6.3.3 FSTP Functional Architecture Specification (FSTP-ARCH)

6.3.3.1 Description

The FSTP functional architecture specification shall first identify the interfaces that interact with the function and then for each of the presented interfaces the expected information shall be described. Therefore, the target elements to be measured are first whether the interfaces are identified and second, for each identified interface, whether the appropriate specification is defined. Notice that at this level, the document shall only refer to functional interfaces.

6.3.3.1.1 FSTP-ARCH: System architecture definition with interfaces identification

Within the FSTP-ARCH it is expected to find an illustration which identifies all interfaces, by which the subsystem interacts with the environment. This defines the system boundaries.

At this level it is important to remark from the defined interfaces which interfaces are part of the existing ETCS architecture and which ones aren't. If this level of detail is not defined the GI level should reflect it.

The GI values:

- GI = 3 if FSTP-ARCH: System architecture definition is complete, and all interfaces are well indicated and closed
- GI = 2 if FSTP-ARCH: System architecture definition is complete but not closed
- GI = 1 if FSTP-ARCH: System architecture definition is partially done
- GI = 0 if FSTP-ARCH: System architecture definition does not exist

6.3.3.1.2 FSTP-ARCH: Functional Interface Specification

Within the FSTP-ARCH, for each interface defined in 6.3.3.1.1, the functional information definition shall be described. The level of the expected information is equivalent to FIS (Functional Interface Specification) if interoperability is not required but the level of FFFIS is required for the cases interoperability is not guaranteed.

The GI values:

- GI = 3 if FSTP-ARCH: Functional Interface Specification is complete and closed
- GI = 2 if FSTP-ARCH: Functional Interface Specification is complete but not closed
- GI = 1 if FSTP-ARCH: Functional Interface Specification is partially done
- GI = 0 if FSTP-ARCH: Functional Interface Specification does not exist

6.3.3.2 Gap Indicator Table template

Target Element	GI value [0,3]	Evidence Reference
FSTP-ARCH: System architecture definition with interfaces identification (see 6.3.3.1.1)		
FSTP-ARCH: Functional Interface Specification 1 (see 6.3.3.1.2)		
FSTP-ARCH: Functional Interface Specification 2 (see 6.3.3.1.2)		
FSTP-ARCH: Functional Interface Specification 3 (see 6.3.3.1.2)		
FSTP-ARCH: Functional Interface Specification …		
FSTP-ARCH: Functional Interface Specification N (see 6.3.3.1.2)		

Table 5: Gap indicator table template for Architecture

6.3.4 Impact on Existing Subsets

6.3.4.1 Description

Whether the proposed solution for the FSTP is mature or not, for all existing Subsets in the current TSI it shall be defined whether an impact is expected or not. Since the metric used here is to define the Gap level, the objective of this target element is to define on one hand whether any change is expected or not to the existing subset and whether any description detailing this expected modification is already defined or not.

6.3.4.1.1 Analysis of Impact on existing Subset

This target element defines whether there has been any analysis performed in terms of possible impact on the referenced subset.

The GI values:

- GI = 3 if the analysis of impact on existing Subset is done

- GI = 2 if the analysis of impact on existing Subset is done on 75%
- GI = 1 if the analysis of impact on existing Subset is done less than 50%
- GI = 0 if the analysis of impact on existing Subset is not done

6.3.4.1.2 Description of the Impact on existing Subset

This target element defines whether there exist a document specifying the modifications required to the referenced Subset.

The GI values:

- GI = 3 if the impact on existing Subset is null
- GI = 2 if the impact on existing Subset is low
- GI = 1 if the impact on existing Subset is medium
- GI = 0 if the impact on existing Subset is high

6.3.4.2 Gap Indicator Table template

Target Element	GI value [0,3]	Evidence Reference
Analysis of Impact on existing Subset XX (see 6.3.4.1.1)		
Description of the Impact on existing Subset XX (see 6.3.4.1.2)		
Analysis of Impact on existing Subset YY (see 6.3.4.1.1)		
Description of the Impact on existing Subset YY (see 6.3.4.1.2)		

Table 6: Gap Indicator table for Impact on existing Subsets

6.3.5 New Subset Specification

6.3.5.1 Description

Whenever the FSTP specification is clear, there shall be identified the number of new subsets required to guarantee interoperability. This target element first needs identify the number of subsets and secondly for each subset whether it is described or not. Notice that the objective is to measure how much work is still pending to reach to the final goal.

6.3.5.1.1 New Subsets Identification

This target element defines whether it is known the number and the target description of each potential new subset required for an interoperable FSTP specification. Notice that the target is not only to have an interface or functional description but the corresponding test specification too, if necessary.

The GI values:

- GI = 3 if the analysis for the editing of a new subset has been performed and closed.
- GI = 2 if the analysis for the editing of a new subset has been performed but not close.
- GI = 1 if the analysis for the editing of a new subset has been performed around of 50%.
- GI = 0 if the analysis for the editing of a new subset is not done

6.3.5.1.2 New Subset Definition

This target element defines whether identified new subsets in 6.3.5.1.1 have their own description already defined.

The GI values are:

- GI = 3 If the effort for the realization of the new subset is less than 12 months
- GI = 2 If the effort for the realization of the new subset is less than 18 months
- GI = 1 If the effort for the realization of the new subset is less than 24 months
- GI = 0 If the effort for the realization of the new subset is more than 36 months

6.3.5.2 Gap Indicator Table template

Target Element	GI value [0,3]	Evidence Reference
New Subsets Identification (see 6.3.5.1.1)		
New Subset Definition (see 6.3.5.1.2)		
New Subsets Identification (see 6.3.5.1.1)		
New Subset Definition (see 6.3.5.1.2		

Table 7: Gap Indicator Table template for New Subsets

6.3.6 Certification Procedure

6.3.6.1 Description

This target element focuses on the need to specify how the FSTP equipment and services are integrated within the railway domain. There shall be defined a clear procedure on that.

6.3.6.1.1 Integration Procedure for Certification

Definition of the procedure to introduce GNSS equipment into the railway domain.

- GI = 3 if the procedure is defined and approved by Railway and GNSS world
- GI = 2 if the procedure is defined and it is in progress the approval process
- GI = 1 if the procedure is in progress
- GI = 0 if the procedure does not exist

6.3.6.2 Gap Indicator Table template

Target Element	GI value [0,3]	Evidence Reference
Integration Procedure for Certification (see 6.3.6.1.1)		

Table 8: Gap Indicator Table template for Certification Procedure

6.3.7 Migration Strategy

6.3.7.1 Description

A migration strategy to introduce the new functionality must be produced, covering aspects such as:

- backword compatibility description
- ground systems upgrade plan description
- fleet upgrade plan description

6.3.7.1.1 Definition of Migration Strategy

If there exists a description of the migration strategy or not.

- GI = 3 if Migration Strategy exists and complete
- GI = 2 if Migration strategy done but not closed (only two on three point showed above)
- GI = 1 if Migration Strategy partially done (only one of three points showed above)
- GI = 0 if Migration Strategy does not exist

6.3.7.2 Gap Indicator Table template

Target Element	GI value [0,3]	Evidence Reference
Definition of Migration Strategy (see 6.3.7.1.1)		

Table 9: Gap Indicator Table template for Migration Strategy

6.3.8 Cost Benefit Analysis (CBA)

6.3.8.1 Description

The CBA shall offer an assessment of the potential advantage/ disadvantages of using the FSTP system on the lines/applications under consideration.

6.3.8.1.1 CBA document

This target element defines whether there exists an CBA analysis for the proposed solution or not.

The GI values:

- GI = 3 if CBA exist and closed
- GI = 2 if CBA done but not closed
- GI = 1 if CBA partially done
- GI = 0 if CBA does not exist

6.3.8.1.2 CBA evaluation

It is a valid CBA if it expresses the potential advantages or disadvantages of adopting FSTP

The GI values:

- GI = 3 if CBA describe all the advantages or disadvantages of adopting FSTP
- GI = 2 if CBA describe partially (75%) the advantages or disadvantages of adopting FSTP
- GI = 1 if CBA describe partially (50%) the advantages or disadvantages of adopting FSTP
- GI = 0 if CBA if CBA describe partially (25%) the advantages or disadvantages of adopting FSTP

6.3.8.2 Gap Indicator Table template

Target Element	GI value [0,3]	Evidence Reference
CBA document (see 6.3.8.1.1)		
CBA Evaluation (see 6.3.8.1.2)		

Table 10: Gap Indicator Table template for CBA

7 The Gap Analysis of existing project with respect to the Target definition

7.1 Introduction

A first analysis is conducted on the state of the user specifications. Obviously, for these specifications to become operational, these must also be part of the official TSI.

The gap indication (GI value) that is reported relates to the work that must be carried out in order for all the requirements take into account in the analysis to become an effective part of the new interoperability specifications.

The paragraph 7.2 analyses the documents produced by users to identify the maturity of the targets. These then, once consolidated and accepted by all stakeholders, will be part of the new TSIs.

The paragraphs 7.3 and 7.4 contain the gap analysis of the specification documents is carried out for each X2R2 WP3 streams using the contents of paragraph 6.3 as a reference.

Despite the definition, accepted by each member of the group, of the evaluation of the GI described for each item, and the fact that this would have been a qualitative analysis, no agreement was found within the working group on the values to be attributed to the GI values.

For this reason, downstream of the internal review, of the various values expressed by some representatives in the working group, an agreement was found to report the arithmetic mean. This average, rounding the decimal value, is the one shown in the tables in paragraphs 7.3 and 7.4.

7.2 Gap Analysis of User Requirements

Target Element	GI value [0-3]	Evidence Reference
Functional Requirements	1	11.1.1
Performance Requirements	1	11.1.2
RAM Requirements	1	11.1.3
Safety Requirements	1	11.1.4
Operational Requirements	1	11.1.5
Environmental Requirements	1	11.1.6
Interoperability Requirements	1	11.1.7
Economic Benefits Requirements	1	11.1.8

Table 11: Result of the Gap Analysis of Users Requirements

Since the specifications produced by the users are not completely stable, consequently within the working group we have agreed to assign GI = 1 also for FSTP-SRS User Requirements for the two Streams.

7.3 Gap Analysis of X2R2 WP3 Stream 1

7.3.1 FSTP Requirements (FSTP SRS)

Target Element	GI value [0,3]	Evidence Reference

FSTP-SRS: User Requirements (see 6.3.2.1.1)	1	11.2.1
FSTP-SRS: Functions Description (see 6.3.2.1.2)	1,6	11.2.2
FSTP-SRS: Performance target (see 6.3.2.1.3)	1,6	11.2.3
FSTP-SRS: Operational Conditions (see 6.3.2.1.4)	2	11.2.4
FSTP-SRS: Safety Requirements (see 6.3.2.1.5)	1,6	11.2.5
FSTP-SRS: Cyber Security Requirements (see 6.3.2.1.6)	0,6	11.2.6
FSTP-SRS: Engineering Rules (see 6.3.2.1.7)	0,6	11.2.7
FSTP-SRS: Environmental Requirements (see 6.3.2.1.8)	1,7	11.2.8

Table 12: FSTP- Stream 1 Gap Analysis for SRS

7.3.2 FSTP Functional Architecture Specification (FSTP-ARCH)

Target Element	GI value [0,3]	Evidence Reference
FSTP-ARCH: System architecture definition with interfaces identification (see 6.3.3.1.1)	1,7	11.2.9
FSTP-ARCH: Functional Interface Specification 1 (see 6.3.3.1.2)	1,7	11.2.10
FSTP-ARCH: Functional Interface Specification 2 (see 6.3.3.1.2)	1,8	11.2.11
FSTP-ARCH: Functional Interface Specification 3 (see 6.3.3.1.2)	1,8	11.2.12
FSTP-ARCH: Functional Interface Specification 4 (see 6.3.3.1.2)	1,8	11.2.13
FSTP-ARCH: Functional Interface Specification 5 (see 6.3.3.1.2)	1,4	11.2.14
FSTP-ARCH: Functional Interface Specification 6 (see 6.3.3.1.2)	1,4	11.2.15
FSTP-ARCH: Functional Interface Specification 7 (see 6.3.3.1.2)	1,8	11.2.16
FSTP-ARCH: Functional Interface Specification 8 (see 6.3.3.1.2)	1,8	11.2.17
FSTP-ARCH: Functional Interface Specification 9 (see 6.3.3.1.2)	1,8	11.2.18

Table 13: FSTP-Stream 1 Gap Analysis for Architecture

7.3.3 Impact on Existing Subsets

In the document [18] in the chapter §5.4 of the expected impacts on ERMTS Subsets are listed. In the table there are the only documents that are involved in the modification.

Target Element	GI value [0,3]	Evidence Reference
Analysis of Impact on existing Subset 026 (see 6.3.4.1.1)	1,6	11.2.19
Description of the Impact on existing Subset 026 (see 6.3.4.1.2)	1,5	11.2.20
Analysis of Impact on existing Subset 037 (see 6.3.4.1.1)	1	11.2.21
Description of the Impact on existing Subset 037 (see 6.3.4.1.2)	2	11.2.22

Analysis of Impact on existing Subset 041 (see 6.3.4.1.1)	1,5	11.2.23
Description of the Impact on existing Subset 041 (see 6.3.4.1.2)	1,5	11.2.24
Analysis of Impact on existing Subset 023 (see 6.3.4.1.1)	1,6	11.2.25
Description of the Impact on existing Subset 023 (see 6.3.4.1.2)	1,6	11.2.26
Analysis of Impact on existing Subset 040 (see 6.3.4.1.1)	1,8	11.2.27
Description of the Impact on existing Subset 040 (see 6.3.4.1.2)	1,8	11.2.28
Analysis of Impact on existing Subset 088 (see 6.3.4.1.1)	1,5	11.2.29
Description of the Impact on existing Subset 088 (see 6.3.4.1.2)	1,5	11.2.30
Analysis of Impact on existing Subset 091 (see 6.3.4.1.1)	1,3	11.2.31
Description of the Impact on existing Subset 091 (see 6.3.4.1.2)	1,3	11.2.32

Table 14: FSTP-Stream 1 Gap Analysis for Impact on existing Subsets

7.3.4 New Subset Specification

Target Element	GI value [0,3]	Evidence Reference
New Subsets Identification (see 6.3.5.1.1)	0	11.2.33
New Subset Definition (see 6.3.5.1.2	0	11.2.34
New Subsets Identification (see 6.3.5.1.1)	0	11.2.35
New Subset Definition (see 6.3.5.1.2	0	11.2.36

Table 15: FSTP-Stream 1 Gap Analysis for New Subsets

7.3.5 Certification Procedure

Target Element	GI value [0,3]	Evidence Reference
Integration Procedure for Certification (see 6.3.6.1.1)	1,8	11.2.37

Table 16: FSTP-Stream 1 Gap Analysis for Certification Procedure

7.3.6 Migration Strategy

Target Element	GI value [0,3]	Evidence Reference
Definition of Migration Strategy (see 6.3.7.1.1)	0	11.2.38

Table 17: FSTP-Stream 1 Gap Analysis for Migration Strategy

7.3.7 Cost Benefit Analysis (CBA)

Target Element	GI value [0,3]	Evidence Reference
CBA document (see 6.3.8.1.1)	2	11.2.39
CBA Evaluation (see 6.3.8.1.2)	1,8	11.2.40

Table 18: FSTP-Stream 1 Gap Analysis CBA

7.4 Gap Analysis of X2R2 WP3 Stream 2

7.4.1 FSTP Requirements (FSTP SRS)

Target Element	GI value [0,3]	Evidence Reference
FSTP-SRS: User Requirements (see 6.3.2.1.1)	1	11.3.1
FSTP-SRS: Functions Description (see 6.3.2.1.2)	1,5	11.3.2
FSTP-SRS: Performance target (see 6.3.2.1.3)	1,7	11.3.3
FSTP-SRS: Operational Conditions (see 6.3.2.1.4)	1,5	11.3.4
FSTP-SRS: Safety Requirements (see 6.3.2.1.5)	1,3	11.3.5
FSTP-SRS: Cyber Security Requirements (see 6.3.2.1.6)	0	11.3.6
FSTP-SRS: Engineering Rules (see 6.3.2.1.7)	0	11.3.7
FSTP-SRS: Environmental Requirements (see 6.3.2.1.8)	1,2	11.3.8

Table 19: FSTP- Stream 2 Gap Analysis for SRS

7.4.2 FSTP Functional Architecture Specification (FSTP-ARCH)

Target Element	GI value [0,3]	Evidence Reference
FSTP-ARCH: System architecture definition with interfaces identification (see 6.3.3.1.1)	1	11.3.9
FSTP-ARCH: Functional Interface Specification 1 (see 6.3.3.1.2)	0	11.3.10
FSTP-ARCH: Functional Interface Specification 2 (see 6.3.3.1.2)	0	11.3.11
FSTP-ARCH: Functional Interface Specification 3 (see 6.3.3.1.2)	0	11.3.12
FSTP-ARCH: Functional Interface Specification N (see 6.3.3.1.2)	0	11.3.13

Table 20: FSTP-Stream 2 Gap Analysis for Architecture

7.4.3 Impact on Existing Subsets

Target Element	GI value [0,3]	Evidence Reference
Analysis of Impact on existing Subset XX (see 6.3.4.1.1)	0	11.3.14
Description of the Impact on existing Subset XX (see 6.3.4.1.2)	0	11.3.15
Analysis of Impact on existing Subset YY (see 6.3.4.1.1)	0	11.3.16
Description of the Impact on existing Subset YY (see 6.3.4.1.2)	0	11.3.17

Table 21: FSTP-Stream 2 Gap Analysis for Impact on existing Subsets

7.4.4 New Subset Specification

Target Element	GI value [0,3]	Evidence Reference

New Subsets Identification (see 6.3.5.1.1)	0	11.3.18
New Subset Definition (see 6.3.5.1.2	0	11.3.19
New Subsets Identification (see 6.3.5.1.1)	0	11.3.20
New Subset Definition (see 6.3.5.1.2)	0	11.3.21

Table 22: FSTP-Stream 2 Gap Analysis for New Subsets

7.4.5 Certification Procedure

Target Element	GI value [0,3]	Evidence Reference
Integration Procedure for Certification (see 6.3.6.1.1)	0	11.3.22

Table 23: FSTP-Stream 2 Gap Analysis for Certification Procedure

7.4.6 Migration Strategy

Target Element	GI value [0,3]	Evidence Reference
Definition of Migration Strategy (see 6.3.7.1.1)	0	11.3.23

Table 24: FSTP-Stream 2 Gap Analysis for Migration Strategy

7.4.7 Cost Benefit Analysis (CBA)

Target Element	GI value [0,3]	Evidence Reference
CBA document (see 6.3.8.1.1)	0	11.3.24
CBA Evaluation (see 6.3.8.1.2)	0	11.3.25

Table 25: FSTP Stream 2 CBA

8 Demonstrated Completeness

8.1 Description

This chapter reports the evidence that an FSTP demonstrator has achieved the targets indicated in paragraph 6.3.

Any demonstration that has happened in the past may not have the current specification and therefore the metric to show the differences between the demonstrated performance and the current specification shall be defined too.

8.2 Target Elements for the Demonstrator only

In this case, the GAP is evaluated both in terms of documentation and in terms of performance. If the GAP is in terms of documentation and is already covered by what is indicated in chapter 7 then there will only be a pointer to the corresponding paragraph.

8.2.1 High Level User Requirements for FSTP

8.2.1.1 FSTP Functional Requirements

The Test Specification for checking the compliance with the USER FSTP Functional Requirements must be present and the test report provides evidence of the achievement of the objective.

8.2.1.2 FSTP Performance Requirements

The Test Specification for checking the compliance with the USER FSTP Performance Requirements must be present and the test report provides evidence of the achievement of the objective.

8.2.1.3 FSTP Availability Requirements

The Test Specification for checking the compliance with the USER FSTP Availability Requirements must be present and the test report provides evidence of the achievement of the objective.

8.2.1.4 FSTP Safety Requirements

The Test Specification for checking the compliance with the USER FSTP Safety Requirements must be present and the test report provides evidence of the achievement of the objective.

8.2.1.5 FSTP Operational Requirements

The Test Specification for checking the compliance with the USER FSTP Operational Requirements must be present and the test report provides evidence of the achievement of the objective.

8.2.1.6 FSTP Environmental Requirements

The Test Specification for checking the compliance with the USER FSTP Environmental Requirements must be present and the test report provides evidence of the achievement of the objective.

8.2.1.7 FSTP Interoperability Requirements

The Test Specification for checking the compliance with the USER FSTP Interoperability Requirements must be present and the test report provides evidence of the achievement of the objective.

8.2.1.8 FSTP Economic Benefits Requirements

All the qualitative and quantitative requirements expressed by users (e.g., EUG or equivalent organization at European level), coming from a Cost Benefit Analysis or equivalent approach, are reported.

8.2.1.9 Gap Indicator Table template

For every category of High Level User Requirements for FSTP the GI values:

- GI = 3 if all the requirements are fulfilled
- GI = 2 if at least the 75% requirements are fulfilled
- GI = 1 if at least the 50% requirements are fulfilled
- GI = 0 if at least the 25% requirements are fulfilled

In the case that no Test Specification is present the sentence **No Evaluable** will be reported.

Target Element	GI value [0-3]	Evidence Reference
Functional Requirements (See 8.2.1.9)		
Performance Requirements (See 8.2.1.9)		
Availability Requirements (See 8.2.1.9)		
Safety Requirements (See 8.2.1.9)		
Operational Requirements (See 8.2.1.9)		
Environmental Requirements (See 8.2.1.9)		
Interoperability Requirements (See 8.2.1.9)		
Economic Benefits Requirements (See 8.2.1.9)		

Table 26: FSTP- Gap indicator table template for User Requirements

8.2.2 FSTP Requirements (FSTP SRS)

This paragraph check if the FSTP Requirement present on paragraph (7.3 or 7.4) are fulfilled through the result of the test report linked to its Test Specification.

For every category of FSTP Requirements the GI values:

- GI = 3 if all the requirements are fulfilled
- GI = 2 if at least the 75% requirements are fulfilled
- GI = 1 if at least the 50% requirements are fulfilled
- GI = 0 if at least the 25% requirements are fulfilled

In the case that no Test Specification is present the sentence **No Evaluable** will be reported.

8.2.2.1 FSTP-SRS: User Requirements

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.2.2 FSTP-SRS: Functions Description

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.2.3 FSTP-SRS: Performance target

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.2.4 FSTP-SRS: Operational Conditions

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.2.5 FSTP-SRS: Safety Requirements

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.2.6 FSTP-SRS: Cyber Security Requirements

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.2.7 FSTP-SRS: Engineering Rules

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.2.8 FSTP-SRS: Environmental Requirements

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.3 FSTP Functional Architecture Specification (FSTP-ARCH)

8.2.3.1 FSTP-ARCH: System architecture with interfaces identification

All the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.3.2 FSTP-ARCH: Functional Interface Specification

For every interface, all the requirements present in the corresponding paragraph of chapter 7 are verified

8.2.4 Impact on Existing Subsets

Not Applicable

8.2.5 New Subset Specification

Not Applicable

8.2.6 Certification Procedure

Not Applicable

8.2.7 Migration Strategy

Not Applicable

8.2.8 Cost Benefit Analysis (CBA)

Not Applicable

8.3 Demonstrated Implementation of X2R2 WP3 Stream 1

8.3.1 User Requirements for FSTP

Target Element	GI value [0-3]	Evidence Reference
Functional Requirements (See 8.2.1.9)		
Performance Requirements (See 8.2.1.9)		
Availability Requirements (See 8.2.1.9)		
Safety Requirements (See 8.2.1.9)		
Operational Requirements (See 8.2.1.9)		
Environmental Requirements (See 8.2.1.9)		
Interoperability Requirements (See 8.2.1.9)		
Economic Benefits Requirements (See 8.2.1.9)		

Table 27: FSTP- Stream 1 Demonstration of User Requirements implementation

8.3.2 FSTP Requirements (FSTP SRS)

Target Element	GI value [0,3]	Evidence Reference
FSTP-SRS: User Requirements (see 8.2.2)	1	11.2.1
FSTP-SRS: Functions Description (see 8.2.2)	3	[41], [42], [43], [46], [47], 11.2.2
FSTP-SRS: Performance target (see 8.2.2)	2	[41], [46], [47], 11.2.3
FSTP-SRS: Operational Conditions (see 8.2.2)	2	11.2.4
FSTP-SRS: Safety Requirements (see 8.2.2)	3	[41], 11.2.5
FSTP-SRS: Cyber Security Requirements (see 8.2.2)	0,6	11.2.6
FSTP-SRS: Engineering Rules (see 8.2.2)	1	[41], 11.2.7
FSTP-SRS: Environmental Requirements (see 8.2.2)	1,7	11.2.8

Table 28: FSTP- Stream 1 Demonstration of SRS implementation

8.3.3 FSTP Functional Architecture Specification (FSTP-ARCH)

Target Element	GI value [0,3]	Evidence Reference
FSTP-ARCH: System architecture definition with interfaces identification (see 6.3.3.1.1)	3	[41], [42], [43], [45], 11.2.9
FSTP-ARCH: Functional Interface Specification 1 (see 6.3.3.1.2)	2.5	[41], [42], [44], [45], 11.2.10
FSTP-ARCH: Functional Interface Specification 2 (see 6.3.3.1.2)	2,5	[48], [49], 11.2.11
FSTP-ARCH: Functional Interface Specification 3 (see 6.3.3.1.2)	2.5	[43], 11.2.12
FSTP-ARCH: Functional Interface Specification 4 (see 6.3.3.1.2)	2.5	[50], [51], 11.2.13
FSTP-ARCH: Functional Interface Specification 5 (see 6.3.3.1.2)	2	[45], 11.2.14
FSTP-ARCH: Functional Interface Specification 6 (see 6.3.3.1.2)	2	[42], 11.2.15
FSTP-ARCH: Functional Interface Specification 7 (see 6.3.3.1.2)	1,8	11.2.16
FSTP-ARCH: Functional Interface Specification 8 (see 6.3.3.1.2)	2,5	[42], 11.2.17
FSTP-ARCH: Functional Interface Specification 9 (see 6.3.3.1.2)	2,5	[42], 11.2.18

Table 29: FSTP-Stream 1 Demonstration of Architecture implementation

Notes:

- FSTP-ARCH: System architecture definition with interfaces identification (see 6.3.3.1.1): it is fully described in [41], [42], [43] and [45].
- FSTP-ARCH: Functional Interface Specification 1, namely "GNSS Augmentation Information and Position Report Verification FFFIS: GNSS Augmentation Info Dissemination & Position Report Verification Vs Estimate Safe Train Pos(t) » : the interface between the GNSS Augmentation information and on-board was further specified through the last updates of related ICD, see [41], [42], [44] and [45].
- FSTP-ARCH: Functional Interface Specification 2, namely "GNSS Signal in Space FFFIS: GNSS SiS Vs GNSS Augmentation Info Dissemination & Position Report Verification. Interface identified and specified" is further specified in [48] and [49].
- .FSTP-ARCH: Functional Interface Specification 3, namely " EGNOS Signal in Space FFFIS: EGNOS SiS Vs GNSS Augmentation Info Dissemination & Position Report Verification " is further specified in [43].
- FSTP-ARCH: Functional Interface Specification 4, namely " GNSS Signal in Space FFFIS: GNSS Satellites Vs Handle GNSS SiS (Multi Frequency)" is further specified in [50] and [51].
- FSTP-ARCH: Functional Interface Specification 5, namely " Static Track Data Information FFFIS: Static Track Data Vs [Estimate Safe Train Pos(t), Detect Virtual Balise]. " was specified through the inclusions of concepts as digital map data and the related functions to manage it, see [45].
- FSTP-ARCH: Functional Interface Specification 6, namely " Dynamic Route Info FFFIS: Dynamic Route Info Vs Estimate Safe Train Pos(t)" is further specified in [42].
- FSTP-ARCH: Functional Interface Specification 7 namely " RAWDATA_Info Interface FIS: Determine (Dual Constellation) Pseudo Ranges Vs Estimate Safe Train Pos(t)." is not further specified
- FSTP-ARCH: Functional Interface Specification 8 namely "ODOM_Info Interface FIS: ETCS Kernel Vs Estimate Safe Train Pos(t)." is further specified in [42].
- FSTP-ARCH: Functional Interface Specification 9 namely " BAL_Info Interface FIS: Detect Virtual Balise Vs ETCS Kernel" is further specified in [42].

8.3.4 Impact on Existing Subsets

Not Applicable

8.3.5 New Subset Specification

Not Applicable

8.3.6 Certification Procedure

Not Applicable

8.3.7 Migration Strategy

Not Applicable

8.3.8 Cost Benefit Analysis (CBA)

Not Applicable

8.4 Demonstrated Implementation of X2R2 WP3 Stream 2

8.4.1 User Requirements for FSTP

Target Element	GI value [0-3]	Evidence Reference
Functional Requirements (See 8.2.1.9)		
Performance Requirements (See 8.2.1.9)		
Availability Requirements (See 8.2.1.9)		
Safety Requirements (See 8.2.1.9)		
Operational Requirements (See 8.2.1.9)		
Environmental Requirements (See 8.2.1.9)		
Interoperability Requirements (See 8.2.1.9)		
Economic Benefits Requirements (See 8.2.1.9)		

Table 30: FSTP- Stream 2 Demonstration of User Requirements implementation

8.4.2 FSTP Requirements (FSTP SRS)

Target Element	GI value [0,3]	Evidence Reference
FSTP-SRS: User Requirements (see 8.2.2)		
FSTP-SRS: Functions Description (see 8.2.2)	2	[52], [53], [54]
FSTP-SRS: Performance target (see 8.2.2)	2	[52], [53], [54]
FSTP-SRS: Operational Conditions (see 8.2.2)	2	[52], [53], [54]
FSTP-SRS: Safety Requirements (see 8.2.2)	1.5	[52], [53], [54]
FSTP-SRS: Cyber Security Requirements (see 8.2.2)	1.0	[52], [53], [54][13]
FSTP-SRS: Engineering Rules (see 8.2.2)	0	[52], [53], [54]
FSTP-SRS: Environmental Requirements (see 8.2.2)	1.5	[52], [53], [54]

Table 31: FSTP- Stream 2 Demonstration of SRS implementation

8.4.3 FSTP Functional Architecture Specification (FSTP-ARCH)

Target Element	GI value [0,3]	Evidence Reference
FSTP-ARCH: System architecture definition with interfaces identification (see 8.2.3.1)	2	[52], [53], [54]
FSTP-ARCH: Functional Interface Specification 1 (see 8.2.3.2)	N/A	
FSTP-ARCH: Functional Interface Specification 2 (see 8.2.3.2)	N/A	
FSTP-ARCH: Functional Interface Specification 3 (see 8.2.3.2)	N/A	
FSTP-ARCH: Functional Interface Specification N (see 6.3.3.1.2)	N/A	

Table 32: FSTP-Stream 2 Demonstration of Architecture implementation

8.4.4 Impact on Existing Subsets

Not Applicable

8.4.5 New Subset Specification

Not Applicable

8.4.6 Certification Procedure

Not Applicable

8.4.7 Migration Strategy

Not Applicable

8.4.8 Cost Benefit Analysis (CBA)

Not Applicable

9 Conclusions

The activities carried out for the GAP Analysis make it possible to make the degree of maturity of the project more visible even for those who should approach the topic of Fail Safe Trail Positioning for the first time.

A first result concerns the documentation produced by users (EUG), which has reached a good degree of maturity, but which needs further refinements to be definitively proposed as a universal reference within the interoperability specifications (TSI).

The activities that are underway will produce improvements in the users' specifications that will certainly be immediately taken into consideration within the X2Rail-5 project.

Another aspect that emerges is linked to the activities carried out over time associated with the solutions proposed within the two streams.

At the beginning of X2R2-WP3 the Virtual Balise concept follows a “generic” goal: to introduce the GNSS into ETCS with minimal changes in the current specifications.

During the development of the X2R2-WP3 project, priority was given to the use of GNSS train localization function to see if it would then be possible to fill the foreseeable gap with the use of other sensors. This was also a statement in the X2R2 GA.

It must also be emphasized that in addition to the use of GNSS, other sensors must certainly be used, keeping the principle of introducing the least number of changes to the current specifications.

For X2R2 Stream 1 there are contributions from other projects, so for some arguments there are contribution coming from these other projects, obviously when applicable.

Since the project associated with the X2R2 Stream 2 started recently, for this reason it does not have the contribution of the results obtained in other projects.

In both Streams is no documentation and no proof that what has been created is ready to be completely included within the interoperability specifications.

Despite the creation of 2 different concepts, both Streams are based on some common principles: the Gap Analysis provided will enable the identification of such common needs and their relevance in terms of interoperability.

It should also be noted that during the X2R2-WP3 project no agreements were reached between the participants on the definition of the degree of description of the functional blocks. Whether to adopt a black box approach or a white box. This aspect influenced the activities of the working group by introducing some delays. Both solutions are possible in the case of the black box approach in the verification phase it may be necessary to take into account more combinations of variables. This last aspect will have to be addressed in the definition of the detailed specifications of the tests.

Mainly, as mentioned several times in this document, this is a qualitative Gap Analysis, expressly requested by the JU, in order to provide indications of how much work is needed to complete the documentation to be included in the TSI CCS in order to fulfil needs of both Stream 1 and 2.

For this reason, it was agreed not to assess whether all the requirements present in the documents used as evidence were reachable and in line with the users' requests. As showed in paragraph 7.1 during the activities of the working group an agreement has been reached on the evaluation method of the GI Values for the various items, these evaluation principles are contained in paragraph 6.3. But the fact is that during the activities it was necessary to go back to the rules to determine the GIs.

During the works, no agreement was reached on how to evaluate the Gaps and indeed each representative expressed a value that followed a different principle from another representative.

In some cases, certain assessments did not exactly follow the principle for which they were required.

To avoid the persistence of sterile discussions and entrenchments on personal positions, the working group reached an agreement to express the evaluations using a decimal notation by making an arithmetic average of the values expressed by some members.

Therefore, in the tables of paragraphs 7.3 and 7.4, unlike that indicated in chapter 6, the values indicated are decimal, keeping the meaning of the values.

The reason for the decimal representation is present to indicate any proximity to the primary integer value.

Regardless of the notation adopted, the result of the Gap Analysis shows that what has been achieved in the two Streams is not yet ready to be completely inserted in the TSI.

10 References

All the documents used as evidence of the achievement of the expected targets are present in the directory named REF in the Task 5_3 inside the WP5 of the X2Rail-5 in the Cooperation Tool.

[1] EUG Ref:18E112 V.2 Railways Localisation System - High Level Users' Requirements (*)
[2] EUG Ref:19E100 V.3 Railways Localisation System - Localisation Performance Requirements from use cases (*)
[3] EUG Ref: 20E084 V.0g Economic Justification of Accurate Onboard Localisation (CR 1368)
[4] EUG Ref: 20E085 V 0c FIS for GNSS Augmentation System, EUG/ESA
[5] EUG/ESA Ref: 20E087 V 0c Solution for Enhanced Onboard Localisation Change Request (CR1368) – GNSS Augmentation System for ERTMS/ETCS V 0c
[6] EUG/ESA Ref: 20E087 V 0c Failure Modes and Effects Analysis for GNSS Augmentation System
[7] X2R2 D3.1 System Requirement Specification of the Fail-Safe Train Positioning Functional Block V 06
[8] X2R2 D3.2 System Architecture Specification and System Functional Hazard Analysis of the Fail-Safe Train Positioning subsystem V09.
[9] X2R2 D3.3 Business Model Impact Analysis associated with the Introduction of the Fail-Safe Train Positioning subsystem V 03.
[10]X2R2 D3.5 – Internal Report Technical solutions for Fail Safe train positioning, advantages and disadvantages V 04
[11]X2R2 D3.6 Minimum Operational Performance Requirements of the multi-sensor devices required for the Fail-Safe Train Positioning subsystem Guidelines for Virtual Balise Transmission System V03.
[12]X2R2 D3.7 V&V Process Definition and Functional-Non Functional Test Specification for the Fail-Safe Train Positioning Subsystem V 00
[13]X2R2 D3.8 Stand Alone System Requirements Specification for Fail-Safe Train Positioning V 06
[14]X2R2 D3.9 System Architecture Specification and System Functional Hazard Analysis for Stand Alone Fail-Safe Train Positioning V 05
[15]X2R2 D3.10 Technical solutions for Fail Safe train positioning, advantages and disadvantages V 05
[16]X2R2 D3.12 Verification and Validation compliant Testing Environment definition for Stand Alone Fail-Safe Train Positioning V 04
[17]STARS project D4.3 Railway environment characterization V 07
[18]STARS D5.1 State of the art of EGNSS projects for the rail application V 09
[19]STARS D5.3 - EGNSS Target Performances to meet railway safety requirements V 07
[20]STARS D5.4 - EGNSS Services Evolution for railways and ETCS impacts V 07
[21]STARS D6.2 - Cost-Benefit Analysis: Case studies V 08
[22]STARS D6.3 - Impact analysis V 05
[23]ASTRAIL D1.2 - Local GNSS Effects V 1.1
[24]ASTRAIL D1.3 - The ERTMS hazards associated with GNSS faults V2.0
[25]ASTRAIL D1.4 - GNSS Algorithms Design V 1.15
[26]ASTRAIL D1.6 - Proposed GNSS Minimum Performance Requirements V 1.1
[27]ERSAT-GGC D2.1 - Enhanced Functional ERTMS Architecture Capable of using GNSS and Public Radio TLC Technologies V 01
[28]ERSAT-GGC D2.2 - Functional and Not Functional Test Specification V 03

[29]ERSAT-GGC D3.1 - Safety Analysis of ERSAT ERTMS Application over GNSS V 02
[30]ERSAT-GGC D3.2 -.GNSS Quantitative Analysis for ERSAT GGC Project V 02
[31]ERSAT-GGC D5.1 - Assessment report of the enhanced functional ERTMS architecture V 02
[32]“Report on Rail User Needs and Requirements”, GSA, 2018 V 2.0
[33]SBAS L1 Receiver Guidelines for Railway - On-Board Unit”, ESSP-TN-25931 V 01-00
[34]SBAS DFMC Receiver Guidelines for Railway On-Board Unit”, ESSP-TN-26136 V 01-00
[35]SBAS L1 Receiver Guidelines for Railway - Trackside Unit”, ESSP-TN-26038 V 01-00
[36]SBAS DFMC Receiver Guidelines for Railway Trackside Unit”, ESSP-TN-26137 V 01-00
[37]NGTC D7.4 Engineering Rules Specification V 0.3
[38]Vennarini, Alessia, Coluccia, Andrea, Gerbeth, Daniel, Crespillo, Omar Garcia, Neri, Alessandro, "Detection of GNSS Interference in Safety Critical Railway Applications using Commercial Receivers," Proceedings of the 33rd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2020), September 2020, pp. 1476-1489.
[39]L. Xing, Y. Wen, D. W. P. Thomas, J. Zhang, D. Zhang and J. Xiao, "A Joint Time-Frequency Analytical Method for Electromagnetic Interference in Railway GNSS System," 2020 International Symposium on Electromagnetic Compatibility - EMC EUROPE, 2020, pp. 1-4, doi: 10.1109/EMCEUROPE48519.2020.9245779.
[40]J. Wang, “Test and Evaluation of GNSS-based Railway Train Positioning under Jamming Conditions,” in IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2020, pp. 4–9.
[41]X2Rail-5 D5.1– VB Train Positioning Specification
[42]X2Rail-5 D5.5– Roadmap and Migration Strategy
[43]GNSS Augmentation for ERTMS/ETCS System Requirement Specification, Ref. 20E085, version 0g, June 2023
[44]GNSS Augmentation for ERTMS/ETCS Interface Control Document for GA-OB/GA-TS (Airgap), Ref 20E087, version 0g, June 2023
[45]X2Rail-5 D5.3– Contribution to the standardisation activities
[46]X2Rail-5 D6.2– VB Train Positioning Updated Test Scenarios
[47]X2Rail-5 D6.3– VB Train Positioning Demonstrators Analysis and Test Report
[48]SBAS L1 Receiver Guidelines for Railway - Trackside Unit, Ref.: ESSP-TN-26038, version 01-00, July 2020
[49]SBAS DFMC Receiver Guidelines for Railway Trackside Unit, Ref.: ESSP-TN-26137, version 01-00, July 2020
[50]SBAS L1 Receiver Guidelines for Railway - On-Board Unit, Ref.:ESSP-TN-25931, version 01-00, July 2020
[51]SBAS DFMC Receiver Guidelines for Railway On-Board Uni, Ref.: ESSP-TN-26136, version 01-00, July 2020
[52]X2R5-T7_5-D-CAF-015-03_-_D7_3 Demonstrator Analysis All, FSTP stream2 analys report
[53]X2R5-T7_5-D-CAF-027-02_-_D7_4_BroaderErrorAnalysis, FSTP stream2 analysis report extension
[54]X2R5_Demonstrator_SMO_ADS_Deliverable_D7.5_Rel0.3, Analysis report

11 Evidence References for Chapter 7

For completeness, this chapter contains the Evidence References used to demonstrate the level of achievement of the specific target that is being taken into consideration.

For simplicity there will be a chapter for each X2R2 Stream.

the structure for every target to be used is the following:

Target	This field reports the link to the target considered
Documents	There is the list of documents that demonstrate the Gap level
Description	there is a description to help understand the level of GI achieved

11.1 Evidence References for User Requirements

Target	**11.1.1 Functional Requirements Evidence References**
Documents	[1] §4, §5 and §6, [3]
Description	In [1] §4 there is a Problem description, in §5 there is the Enhancement of OB odo for ERTMS application and in §6 the Train localisation system users' requirements that are applicable. In [3] there is a Problem description

Target	**11.1.2 Performance Requirements Evidence References**
Documents	[1] §5.4 and §6.4, [2] § 2.2, §6
Description	The performances are indicated in [1] §5.4 and §6.4 The whole document [2] is about performance (accuracy) requirements for the Train Localisation System (allocation of requirement to on-board VL and trackside is not provided) in different specific operational scenarios (use cases). In [2] § 2.2 and § 6

Target	**11.1.3 RAM Requirements Evidence References**
Documents	[1] § 5.3 and § 6.3
Description	The document [1] provides high level requirements which are related to RAM and not only to availability. See § 5.3 and § 6.3

Target	**11.1.4 Safety Requirements Evidence References**
Documents	[1] §5.2 and §6.2, [2] §6
Description	The primary values are [1] § 5.2 and § 6.2 In the document [2] §6 a qualitative safety evaluation is provided for each use case

Target	**11.1.5 Operational Requirements Evidence References**
Documents	[1] §6.1, [2] §6
Description	[1] §6.1 The document [2] is about performance requirements for the Vehicle Locator. Specific scenarios (use cases) for different operation in chapter 6

Target	**11.1.6 Environmental Requirements Evidence References**
Documents	[1] §5.1 and §6.1, [2] §5
Description	

Target	**11.1.7 Interoperability Requirements Evidence References**
Documents	[1] §6.1
Description	

Target	**11.1.8 Economic Benefits Requirements Evidence References**
Documents	[1] §5.1 and §6.1, [3]
Description	[3] Economic Justification of accurate Onboard localisation

11.2 Evidence References for X2R2 Stream1

Target	**11.2.1 FSTP-SRS: User Requirements Evidence References STR1**
Documents	[8] §6.2 [8] §6.3.2, [11] §7, [19] §5, [20] §5, [26] §3, [10] §9.1.2 [8] §6.4.4 [8] §6.4.5, [29]§7, [31]§4, [30] [7] §10, [8] §6.1.3 [8] §6.3.3, [11] §7.1.1.3 and §7.1.1.4, [18] §4, [26] §3 [7] §11.5, [4] [7] § 8.1.1.9, § 8.1.1.10 [7] §8, [32]
Description	For Functional [8] §6.2 For Performances [8] §6.3.2, [11] §7, [19] §5, [20] §5, [26] §3, [10] §9.1.2

	For RAM [8] §6.4.4 For Safety [8] §6.4.5, [29]§7, [31]§4, [30] For Operational [7] §10, [8] §6.1.3 For Environmental. In [8] there are the requirements, with reference to CENELEC–EN 50155 and 50125. In [11] §7.1.1.3 the interference environment described in Appendix C of Do229 is presented. GNSS antennas placed on roof of trains operate in a different environment, due to electromagnetic disturbances by train elements and rail infrastructure. Main disturbance sources are considered in 7.1.1.4, with resultant formalization of a set of requirements related to EMI in the railway environment, according to CENELEC-EN 50121. In the remaining documents a qualitative description and insights of the issues are given For Interoperability. As the introduction of the Virtual Balise Concept shall guarantee interoperability, in [7] the functional interfaces among the VBR block and the other elements has been analysed outlining also their types (i.e. FFFIS, FIS). The [4] EUG/ESA specification addresses only interoperability relevant requirements enabling the use of GNSS augmentation. For Economic benefit [7] § 8.1.1.9, § 8.1.1.10 For FSTP-SRS: User Requirements [7] §8, [32]

Target	**11.2.2 FSTP-SRS: Functions Description Evidence References STR1**
Documents	[7] §11, [8] §6
Description	In [7] the functions are defined and are linked to the requirements. In [8] they are specified and linked to the requirements

Target	**11.2.3 FSTP-SRS: Performance target Evidence References STR1**
Documents	[8] §6.3.2, [10] §9.1.2, [11] §7, [19] §5, [20] §5, [18] §3, [26] §3
Description	[11] collects minimum operational performance requirements formalized for the components of the VBTS dedicated to the task of processing the balises information based on the acquisition of GNSS and SBAS SiS signals and the odometry information, as well as on the potential use of kinematic sensors.

Target	**11.2.4 FSTP-SRS: Operational Conditions Evidence References STR1**
Documents	[7] §10, [8] §6.1.3, [26] §3, [23] §2, [19] §7
Description	In Chapter 10 of [7] a set of ERTMS Operational Scenarios based on Virtual Balises are described, with the related rationales and the events to be considered at FSTP blocks level

Target	**11.2.5 FSTP-SRS: Safety Requirements Evidence References STR1**
Documents	[8] §6.4, [12] §10, [29] §7, [31] §4, [30]
Description	In [8] the hazard analysis is described, in [12] there is the safety analysis. In [30] there is a THR allocation for each subsystem

Target	**11.2.6 FSTP-SRS: Cyber Security Requirements Evidence References STR1**
Documents	[20] §4.2 and §6.2, [25] §4, [6], [38],[39], [40]
Description	[20] provides a security analysis of the communication layer of the proposed EDAS-R service with security recommendations that can be considered for improvements in the short-term evolution. [25] describes potential Algorithms for enhanced robustness against RFI In these [38],[39] and [40] there are methods that identified cyber threats and propose techniques to mitigate them.

Target	**11.2.7 FSTP-SRS: Engineering Rules Evidence References STR1**
Documents	[10] §8, [27] §5.1, [37] §4.
Description	In §4 of [37] engineering rules are analysed for the placement of virtual balises, similar to the ones for physical balises.

Target	**11.2.8 FSTP-SRS: Environmental Requirements Evidence References STR1**
Documents	[8] §6.3.3, [18] §4, [17] §5, [11] §7.1.1.3 and §7.1.1.4, [26] §3
Description	In [8] there are the requirements, with reference to CENELEC–EN 50155 and 50125. In [11] §7.1.1.3 the interference environment described in Appendix C of Do229 is presented. GNSS antennas placed on roof of trains operate in a different environment, due to electromagnetic disturbances by train elements and rail infrastructure. Main disturbance sources are considered in 7.1.1.4, with resultant formalization of a set of requirements related to EMI in the railway environment, according to CENELEC-EN 50121. In the remaining documents a qualitative description and insights of the issues are given

Target	**11.2.9 FSTP-ARCH: System architecture definition with interfaces identification Evidence References STR1**
Documents	[7] §11.5, [8] §6.1.1, §6.1.4 and §9, [4]
Description	As the introduction of the Virtual Balise Concept shall guarantee interoperability, in [7] the functional interfaces among the VBR block and the others elements has been preliminary analysed outlining also their types (i.e. FFFIS, FIS).

	The Appendix [8]§9 provides the specification for the interfaces (listed in §6.1.4) of the proposed VBTS architecture (see §6.1.1) The [4] EUG/ESA specification addresses only interoperability relevant requirements enabling the use of GNSS augmentation.

Target	**11.2.10 FSTP-ARCH: Functional Interface Specification 1 Evidence References STR1**
Documents	[8] §9.1
Description	GNSS Augmentation Information and Position Report Verification FFFIS: GNSS Augmentation Info Dissemination & Position Report Verification Vs Estimate Safe Train Pos(t). This interface is used by "Estimate Safe Train Pos" Block to enhance Train Position Computation based on Satellite Signals. Moreover it is used to exchange data between trackside and onboard constituents about results of verifications applied to Position Reports

Target	**11.2.11 FSTP-ARCH: Functional Interface Specification 2 Evidence References STR1**
Documents	[8] §9.2
Description	GNSS Signal in Space FFFIS: GNSS SiS Vs GNSS Augmentation Info Dissemination & Position Report Verification. Interface identified and specified. This interface is used by the VBTS wayside "GNSS Augmentation Info Dissemination & Position Report Verification" functional block to get GNSS navigation data (see [8] §6.2.3)

Target	**11.2.12 FSTP-ARCH: Functional Interface Specification 3 Evidence References STR1**
Documents	[8] §9.2
Description	EGNOS Signal in Space FFFIS: EGNOS SiS Vs GNSS Augmentation Info Dissemination & Position Report Verification. Interface identified and specified. This interface is used by the VBTS wayside "GNSS Augmentation Info Dissemination & Position Report Verification" functional block to get EGNOS data (see §6.2.3 of [8])

Target	**11.2.13 FSTP-ARCH: Functional Interface Specification 4 Evidence References STR1**
Documents	[8] §9.2
Description	GNSS Signal in Space FFFIS: GNSS Satellites Vs Handle GNSS SiS (Multi Frequency). Interface identified and specified.

	This interface is used by “Handle GNSS SiS” Functional Block to receive Radio Frequency Signals from Satellites. This Interface shall be “Multi Frequencies”, i.e. it shall allow Functional Block to receive RF Signals on more carriers.

Target	**11.2.14 FSTP-ARCH: Functional Interface Specification 5 Evidence References STR1**
Documents	[8] §9.3
Description	Static Track Data Information FFFIS: Static Track Data Vs [Estimate Safe Train Pos(t), Detect Virtual Balise]. Interface identified and specified. This interface is used by “Estimate Safe Train Pos” Block to compute 1D Train Position along the track. This Train Position is computed based on (a) Satellite Signals (b) GNSS Augmentation, (c) Odometry Data and (d) data coming from Kinematic Sensors, if needed. Optionally, such position can be estimated by means of Radio Localization Technology. Moreover, this interface is used by “Detect Virtual Balise” Block to evaluate if a condition of “matching” between the Estimated Safe Position of the train and the known VB Location occurred. Other sensor technologies, such as the IMU, shall potentially benefit from Static Track Data, to help estimate the safe train position.

Target	**11.2.15 FSTP-ARCH: Functional Interface Specification 6 Evidence References STR1**
Documents	[8] §9.4
Description	Dynamic Route Info FFFIS: Dynamic Route Info Vs Estimate Safe Train Pos(t). Interface identified and specified. This interface is used by “Estimate Safe Train Pos” Block to compute 1D Train Position along the track, avoiding all track ambiguities thanks to the (a) switch points status information, (b) initial train position and (c) initial train orientation (see [8] §6.2.5).

Target	**11.2.16 FSTP-ARCH: Functional Interface Specification 7 Evidence References STR1**
Documents	[8] §9.5
Description	RAWDATA_Info Interface FIS: Determine (Dual Constellation) Pseudo Ranges Vs Estimate Safe Train Pos(t). Interface identified and specified. This interface is used by “Estimate Safe Train Pos” Block to retrieve Pseudo Ranges Information from “Determine (Dual Constellation) Pseudo Ranges” block. This information is essential, in addition to Augmentation Data, to estimate Train Position.

Target	**11.2.17 FSTP-ARCH: Functional Interface Specification 8 Evidence References STR1**

Documents	[8] §9.6
Description	ODOM_Info Interface FIS: ETCS Kernel Vs Estimate Safe Train Pos(t). Interface identified and specified. This interface is used by “Estimate Safe Train Pos” Block to determine Train Position when Satellite Signal is not available (e.g. during degraded situations like travelling under an overpass).

Target	**11.2.18 FSTP-ARCH: Functional Interface Specification 9 Evidence References STR1**
Documents	[8] §9.7
Description	BAL_Info Interface FIS: Detect Virtual Balise Vs ETCS Kernel. Interface identified and specified. This interface is used by Virtual Balise Reader to send Balise Information to ETCS Kernel. It provides to ETCS Kernel the time when the data used for the estimated safe train position computation are available (TDATA, see [8] §6.2.2.6.4), the Balise Information, the estimated time and location (in the odometric reference system) of the Virtual Balise and the related uncertainty (i.e. Virtual Balise Location Confidence Interval).

Target	**11.2.19 Analysis of Impact on existing Subset 026 Evidence References STR1**
Documents	[18] §5.4, [19] §9.1, [10]§9, [11] §7.2.2, [5] §2, [7], [8]
Description	In §5.4 of [18] the expected impacts on ERMTS Subsets are listed. In [10] Chapter 9 there is the analysis of the impact on Train position confidence interval as determined in ETCS Kernel using Virtual Balise Location and the related uncertainty. In [11] and [5] the packet definitions and the data exchange from wayside to on board unit has been specified showing the impact (i.e. extension) on Subset 026.

Target	**11.2.20 Description of the Impact on existing Subset 026 Evidence References STR1**
Documents	[10] §9, [11] §7.2.2, [5] §2
Description	Dynamic accuracy of VB reading is estimated based on GNSS and other involved sources ERTMS/ETCS In [11] and [5] extension of Subset-026 v3.6.0 for EGNOS Data Transfer via ETCS including Packets Definition

Target	**11.2.21 Analysis of Impact on existing Subset 037 Evidence References STR1**
Documents	[11] §7.2.2, [20] §6.1 and §6.2.2.2
Description	Impactless analysis: in [11] and in [20] it is specified that the proposed solution concerning data exchange between the trackside and the train onboard shall be integrated into the existing ERTMS/ETCS train to wayside communications system, defined by Subset-037

Target	**11.2.22 Description of the Impact on existing Subset 037 Evidence References STR1**
Documents	[11] §7.2.2, [20] §6.1 and §6.2.2.2
Description	Analysis shows no impact on the Subset-037: modification are only at application layer (i.e. Subset-026)

Target	**11.2.23 Analysis of Impact on existing Subset 041 Evidence References STR1**
Documents	[19] §9.4, [20] §5.4, [10] §9.1.2.2
Description	In [20] §5.4the expected impacts on ERMTS Subsets are listed. In §9.1.2.2 of [10] the minimum performance required for “Accuracy of distances measured on-board” according to Subset-041 is considered for the evaluation of accuracy of distances measured by on-board.

Target	**11.2.24 Description of the Impact on existing Subset 041 Evidence References STR1**
Documents	[20] §5.4, [10] §9.1.2.2
Description	

Target	**11.2.25 Analysis of Impact on existing Subset 023 Evidence References STR1**
Documents	[20] §5.4, [7] §9 and §3
Description	In [20] §5.4the expected impacts on ERMTS Subsets are listed. The VB concept has been analysed in the context of different projects, including in [7], see §9 (§3 considers abbreviations)

Target	**11.2.26 Description of the Impact on existing Subset 023 Evidence References STR1**

Documents	[20] §5.4, [7] §9 and §3
Description	

Target	**11.2.27 Analysis of Impact on existing Subset 040 Evidence References STR1**
Documents	[20] §5.4, [19] §9.3
Description	In [20] §5.4 the expected impacts on ERMTS Subsets are listed.

Target	**11.2.28 Description of the Impact on existing Subset 040 Evidence References STR1**
Documents	[20] §5.4, [19] §9.3
Description	

Target	**11.2.29 Analysis of Impact on existing Subset 088 Evidence References STR1**
Documents	[20] §5.4, [19] §5 and §6, [12] §10, [24]
Description	In [20] §5.4 the expected impacts on ERMTS Subsets are listed. In [19] after a hazard analysis of the current ERTMS / ETCS based on Subset-088 v.3.5.0, the THRs apportionment is performed to elements of the reference architecture In [24] the ERTMS hazards associated with GNSS faults are analysed. In §10 of [12] the allocation of safety targets to the VBTS using GNSS in ERTMS consists in apportioning the THR of the ETCS Core Hazard (Exceedance of safe speed or distance limits as advised to ETCS) to the grouping of constituents described in Subset-088-part 3 and in Subset-091 and to the VBTS functions.

Target	**11.2.30 Description of the Impact on existing Subset 088 Evidence References STR1**
Documents	[20] §5.4, [19] §5 and §6, [12] §10, [24]
Description	

Target	**11.2.31 Analysis of Impact on existing Subset 091 Evidence References STR1**
Documents	[20] §5.4, [12] §10, [24]
Description	In [24] the ERTMS hazards associated with GNSS faults are analysed.

	In §10 of [12] the allocation of safety targets to the VBTS using GNSS in ERTMS consists in apportioning the THR of the ETCS Core Hazard (Exceedance of safe speed or distance limits as advised to ETCS) to the grouping of constituents described in Subset-088-part 3 and in Subset-091 and to the VBTS functions.

Target	**11.2.32 Description of the Impact on existing Subset 091 Evidence References STR1**
Documents	[20] §5.4, [12] §10, [24]
Description	

Target	**11.2.33 New Subsets Identification Evidence References STR1**
Documents	None
Description	

Target	**11.2.34 New Subset Definition Evidence References STR1**
Documents	None
Description	

Target	**11.2.35 New Subsets Identification Evidence References STR1**
Documents	None
Description	

Target	**11.2.36 New Subset Definition Evidence References STR1**
Documents	None
Description	

Target	**11.2.37 Integration Procedure for Certification Evidence References STR1**
Documents	[33], [34], [35], [36], [11], [20] §10.3, [31]
Description	Preliminary receiver requirements for the on-board unit that uses EGNOS L1 to support safe train positioning in ERTMS Preliminary requirements for the on-board unit in railway domain which uses the EGNOS L5 signal, i.e., DFMC augmentation data, to support safe train positioning in ERTMS

	Preliminary GNSS receiver requirements for the trackside unit for railway domain which is planned to use the EGNOS L1 augmentation system to support safe train positioning in ERTMS Preliminary requirements for the trackside unit in the railway domain which uses the EGNOS L5 signal, i.e., DFMC augmentation data, to support safe train positioning in ERTMS Requirements and guidelines to be used to define the minimum operational performance standards (MOPS) for a European Train Control System (ETCS) compliant fail-safe train positioning system using Global Navigation Satellite Systems (GNSS) augmented by Satellite-Based Augmentation Systems (SBAS) - which in Europe is the European Geostationary Navigation Overlay system (EGNOS) - and other sensors. [31] contains and independent assessment performed by the Notified Bodies of the VBTS Architecture defined in [27] and of the Safety Analysis and THR allocation performed in [29] and [30].

Target	**11.2.38 Definition of Migration Strategy Evidence References STR1**
Documents	None
Description	

Target	**11.2.39 CBA document Evidence References STR1**
Documents	[7] § 8.1.1.9, § 8.1.1.10, [9] (with related referenced GSA documents to be used only for D3.3 purposes), [21], [22]
Description	As far as concerned the outcomes from X2R2, WP3 produced a dedicated document namely D3.3 [9] on the topic of Cost Benefit Analysis. Such document depicts and refers the wider activity carried out by GSA which deeply analyse the CBA by considering several operative scenarios and by investigating the economic benefits over a line of 100km under the perspective of three different railways stakeholders: Infrastructure Managers, Railway undertakings and Industrial Suppliers. D3.3 [9] complements the analysis by deepening the ERTMS business model and analysing the impact of the Virtual Balise solution on it. STARS documents could be considered as the sources of the X2R2 documents and GSA ones but enclose a well-defined analysis on the operative scenarios and economic target to be applied. In particular STARS document D6.2 [21] exploit the case studies and the D6.3 [22] focus on the impact analysis on them.

Target	**11.2.40 CBA Evaluation Evidence References STR1**
Documents	[9] (with related referenced GSA documents to be used only for D3.3 purposes), [21], [22]

Description	As per the section 11.2.39, the X2R2 Document [9] (including the attachment related to the GSA deliverables) beyond the description of the scenarios and contexts for the CBA, depicts the economic analysis from the perspective of Infrastructure Managers, Railway Undertakings and Industrial Suppliers by describing the computation of costs (€ per 100km) and benefit as well as the calibration of the used model. At completion of the description also the alongside sensitivity analysis and final conclusion are present. STARS Documents [21] and [22] shares part of the scenario considered in [9] but performs a more aggregate evaluation of costs and benefits from a more general user perspective.

11.3 Evidence References for X2R2 Stream2

Target	**11.3.1 FSTP-SRS: User Requirements Evidence References STR2**
Documents	[13], X2R2 System Requirements Specification Stream 2
Description	For Performances. Document [13], In section 7.1 performance requirements for Speed and travelled distance is defined. For Operational. Operational conditions are defined in [13] §7.3

Target	**11.3.2 FSTP-SRS: Functions Description Evidence References STR2**
Documents	[13], X2R2 System Requirements Specification Stream 2
Description	The document contains a section on Mission Profile, Operational Conditions, Safety and reliability.

Target	**11.3.3 FSTP-SRS: Performance target Evidence References STR2**
Documents	[13], X2R2 System Requirements Specification Stream 2
Description	In section 7.1 performance requirements for Speed and travelled distance is defined.

Target	**11.3.4 FSTP-SRS: Operational Conditions Evidence References STR2**
Documents	[13], X2R2 System Requirements Specification Stream 2
Description	Operational conditions are defined in 7.4

Target	**11.3.5 FSTP-SRS: Safety Requirements Evidence References STR2**

Documents	[13], X2R2 System Requirements Specification Stream 2
Description	Safety aspects are defined in 8.1

Target	**11.3.6 FSTP-SRS: Cyber Security Requirements Evidence References STR2**
Documents	None
Description	

Target	**11.3.7 FSTP-SRS: Engineering Rules Evidence References STR2**
Documents	None
Description	

Target	**11.3.8 FSTP-SRS: Environmental Requirements Evidence References STR2**
Documents	[13], X2R2 System Requirements Specification Stream 2
Description	Operational conditions are defined in [13] §7.4

Target	**11.3.9 FSTP-ARCH: System architecture definition with interfaces identification Evidence References STR2**
Documents	[14], X2R2 D3.9 System Architecture Specification and System Functional Hazard Analysis for Stand Alone Fail-Safe Train Positioning V 05
Description	The document identifies the main interfaces of the system including the safety target for each of them, including a Hazard analysis and a Failure Mode and Effects Criticality Analysis (FMECA).

Target	**11.3.10 FSTP-ARCH: Functional Interface Specification 1**
Documents	None
Description	

Target	**11.3.11 FSTP-ARCH: Functional Interface Specification 2**
Documents	None
Description	

Target	**11.3.12 FSTP-ARCH: Functional Interface Specification 3**

Documents	None
Description	

Target	**11.3.13 FSTP-ARCH: Functional Interface Specification N**
Documents	None
Description	

Target	**11.3.14 Analysis of Impact on existing Subset XX**
Documents	None
Description	

Target	**11.3.15 Description of the Impact on existing Subset XX**
Documents	None
Description	

Target	**11.3.16 Analysis of Impact on existing Subset YY**
Documents	None
Description	

Target	**11.3.17 Description of the Impact on existing Subset YY**
Documents	None
Description	

Target	**11.3.18 New Subsets Identification**
Documents	None
Description	

Target	**11.3.19 New Subset Definition**
Documents	None
Description	

Target	**11.3.20 New Subsets Identification**
Documents	None
Description	

Target	**11.3.21 New Subset Definition**
Documents	None
Description	

Target	**11.3.22 Integration Procedure for Certification**
Documents	None
Description	

Target	**11.3.23 Definition of Migration Strategy**
Documents	None
Description	

Target	**11.3.24 CBA document**
Documents	None
Description	

Target	**11.3.25 CBA Evaluation**
Documents	None
Description	

12 Evidence References for Chapter 8

For completeness, this chapter contains the Evidence References used to demonstrate the level of achievement of the specific target that is being taken into consideration.

For simplicity there will be a chapter for each Demonstrators Stream.

the structure for every target to be used is the following:

Target	This field reports the link to the target considered
Documents	There is the list of documents that demonstrate the Gap level
Description	there is a description to help understand the level of GI achieved

12.1 Evidence References for Demonstrators Stream1

12.2 Evidence References for Demonstrators Stream2

13 Appendix A: Ownership of results

The following Table 33 lists the ownership of results for this deliverable.

Ownership of results			
Company	Percentage	Short Description of share/ of delivered input	Concrete Result (where applicable)
All beneficiaries contributing to WP5	-	The ownership of the WP5 results is shared between the X2Rail-5 beneficiary members of WP5. STS led the WP5 work and the WP5 members contributed to this work. Authors and Contributors of this deliverable D5.4 "Gap Analysis" are listed on page 3.	Gap Analysis

Table 33: Ownership of results

- End of the Document -