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DELIVERABLE D3.5

USE CASES AND SCENARIOS FOR COST-EFFECTIVE FAIL-SAFE ON-BOARD TRAIN INTEGRITY & TRAIN LENGTH DEMOS ON G1 REGIONAL LINES.

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Executive Summary

The scope of this document, which reports the activities carried out in the FutuRe WP3 task 3.5 project, concerns the specification of the systems for determining train integrity and train length for applications with ETCS signalling systems.

On the regional lines affected by this activity, complete interoperability between main lines and regional lines is required. A train can circulate without interruptions between the different types of lines.

in this context there is a close collaboration with what R2DATO achieved in WP19 and WP20.

The operational and functional requirements reported in the document were identified within the working group, together with some significant use cases.

This set represents the right compromise to specialize, when needed, the train integrity and train length solution for applications on regional lines.

It should be remembered that when the regional train runs on the main lines the train integrity and train length functions must comply with the applicable rules.

To reduce costs, it is conceivable to integrate these functions within other existing systems as much as possible.

Depending on the type of train, these functions can be integrated into the EVC or within the TCMS.

Train integrity and train length become important when there are no longer ground systems that detect the presence of vehicles along the line. This event, which can cause serious safety consequences, can be caused by a train breaking up, therefore it is necessary to ensure that these events cannot occur.

The signalling system adopted is ETCS, not only for reasons of interoperability but also of performance and reliability. This system allows not only complete uniformity with the systems adopted on the main lines, but when used at level 3 (Hybrid or Moving block) the partial or complete removal of the Train Detection systems installed along the line.

Furthermore, the length of the train serves to determine for the following train where the point to be protected is located and which can never be reached. For these reasons, train integrity and train length systems cannot be left to manual operations or human evaluations which are subject to error.

The implementation of the demonstrator will be performed in WP8 taking what is present in this document as reference.

The reference regional trains are trains that often have a fixed composition, but it happens that these come together depending on the services they have to perform.

Therefore, in this context the concepts of joining and splitting between trains are exalted. Therefore, solutions for verifying the integrity of the train and determining its length must be designed to accommodate this type of scenario.

A preliminary comparison with what has been achieved in the System Pillar has been made, but subsequent interactions will certainly allow the solutions being carried out to be increasingly aligned.

it is important to underline that what is reported in the document does not have the aim of imposing changes on the connected ETCS system. Potential interfaces and solutions are

suggested that can or may not be taken care of without changing the essential behaviour of the system. These solutions, such as the diagnostic part, could help to understand whether the system is working or not, speeding up the process for making decisions regarding it.

Furthermore, this document does not intend to define the functioning of the ETCS system, when mentioned it is a possible proposal which, if not implemented, does not impact the functioning of the OTI-I and OTI-L systems.

What has been achieved complies with the expectations reported in the Grant Agreement and in line with the associated timescales.

List of abbreviations, acronyms and definitions

Abbreviation / Acronym	Definition
ATO	Automatic Train Operation
CONFIRMED	Train Integrity is confirmed by the OTI-I
DMI	Driver Machine Interface
EoM	End of Mission
ERJU	Europe's Rail Joint Undertaking
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
EVC	European Vital Computer
FFFIS	Form-Fit Functional Interface Specification
GA	Grant Agreement
HL3	Hybrid Level 3
OBU	On-Board Unit
OCN	Open Computer Network
ORS	Operational Requirement Specification
OTI-I	On-Board Train Integrity Function
OTI-L	On-Board Train Length Function
R2DATO	Rail to Digital automated up to Autonomous Train Operation
SI	Système International (International System of Units)
SoM	Start of Mission
TCMS	Train Control & Management System
Train x sleeping mode	The train x is mainly deactivated. Only a few components are powered. OTI-I and OTI-L are switch off.
TSI	Technical Specifications for Interoperability
UC	Use Case
UNKNOWN	Train Integrity isn't valuable, Is in Unknown state
WPn	Work Package number "n" of FutuRe project
X2Rail-n	X to Rail project "n" of IP2 Shift2Rail

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1 DOCUMENT SCOPE

The goal of FP6 WP3 task 3.5 is to provide a valid base for developing the demonstrators for train integrity train length over ETCS On Board system.

This document has the sole purpose of defining the operation of the OTI-I and OTI-L systems and does not take into consideration how the information produced will be used by the on-board ETCS system. It reports the result of the activities performed for reaching this goal.

1.1 DOCUMENT STRUCTURE

The following table reports the document structure.

Chap	Title	Description
1	Document Scope	Describes the structure of the document and its limitations
2	Development Methodology	Reports the path and all the steps taken for reaching the deliverable
3	Operational Requirements and Scenarios	Contains the Operational Requirements for Train Integrity and Train length functions
4	Train Integrity and Train length Use Cases	Presents a list of the Use Cases developed during the project.
5	OTI-I and OTI-L Functional Architecture	Reports the OTI-I and OTI-L functional architectures
6	OTI-I and OTI-L Functional Interface	Contains the functional interface include a proposal
7	Functional and Non Functional Requirements	Reports all the functional e non functional requirements applicable to OTI-I and OTI-L
8	High level Demonstrator Set up	Contains a first version of the demonstrator environment and its interface
9	Conclusions	Contains the conclusion for this document version
10	References	Contains all the references used in the document
11	Annexes	Contain all the use cases listed in the chapter 4 and the Requirements Traceability Matrix

Table 1: Document structure

1.2 LIMITATIONS

What is stated in this document may only be applicable to OTI-I and OTI-L systems. Everything reported for ETCS systems is for illustrative purposes only and does not represent requirements applicable to the ETCS on-board system.

The proposed interface provides some features which, if not implemented, will have to be replaced by operating modes.

2 DEVELOPMENT METHODOLOGY

In this section, the methodology on how this deliverable was developed is showed. The methodology section is divided into four sections:

i) Deliverable Objectives;

ii) Process Overview;

iii) Existing and Relevant Documents;

iv) Methodology for Deliverable Development.

2.1 DELIVERABLE OBJECTIVES

This deliverable is created on the basis of the guidelines as described in the Grant Agreement [GA]:

Based on the specifications, guidelines, and any other deliverables existing and/or coming from WP2, Destination 2 and the System Pillar's Architecture and Shift2Rail projects (e.g., X2Rail-2 and X2Rail-4), this task sets the scene to demonstrate the practical use of train integrity & train length features for regional lines. Thus, the following work will be done: • Definition of demonstrator's setup, relevant use cases and scenarios applicable and suitable for the different proposed locations that need to be tested are identified. Involved FMs will analyse the inputs to propose the best approach and the work plan to perform tests. • Integration of proposed use cases from partners, finding gaps and overlaps to provide a consolidated and comprehensive list of unique use cases/scenarios, which allow to perform task 8.6 more efficiently

On basis of the description that was provided in the [GA], the following can be concluded that are propaedeutic for the creation of the D5.4:

1. Relevant input from partner projects (X2Rail-2, X2Rail-4, R2DATO and SP) needs to be collected, analysed and if relevant, included in the deliverable. Input from these partner projects will be considered until month 9, September 2023, of the project.
2. Task 3.5 will create an overview of the operational functions that are necessary for the train integrity train length functions.
3. Task 3.5 will develop use cases for "Train Integrity and Train Length functions" for regional applications. This will be done in cooperation with the SP if input is received before month 9.

2.2 PROCESS OVERVIEW

The Figure 1 shows the process followed to obtain Deliverable D3.5.

As can be seen from the process shown in the Figure 1, the main steps that participated in the achievement of the final document are indicated.

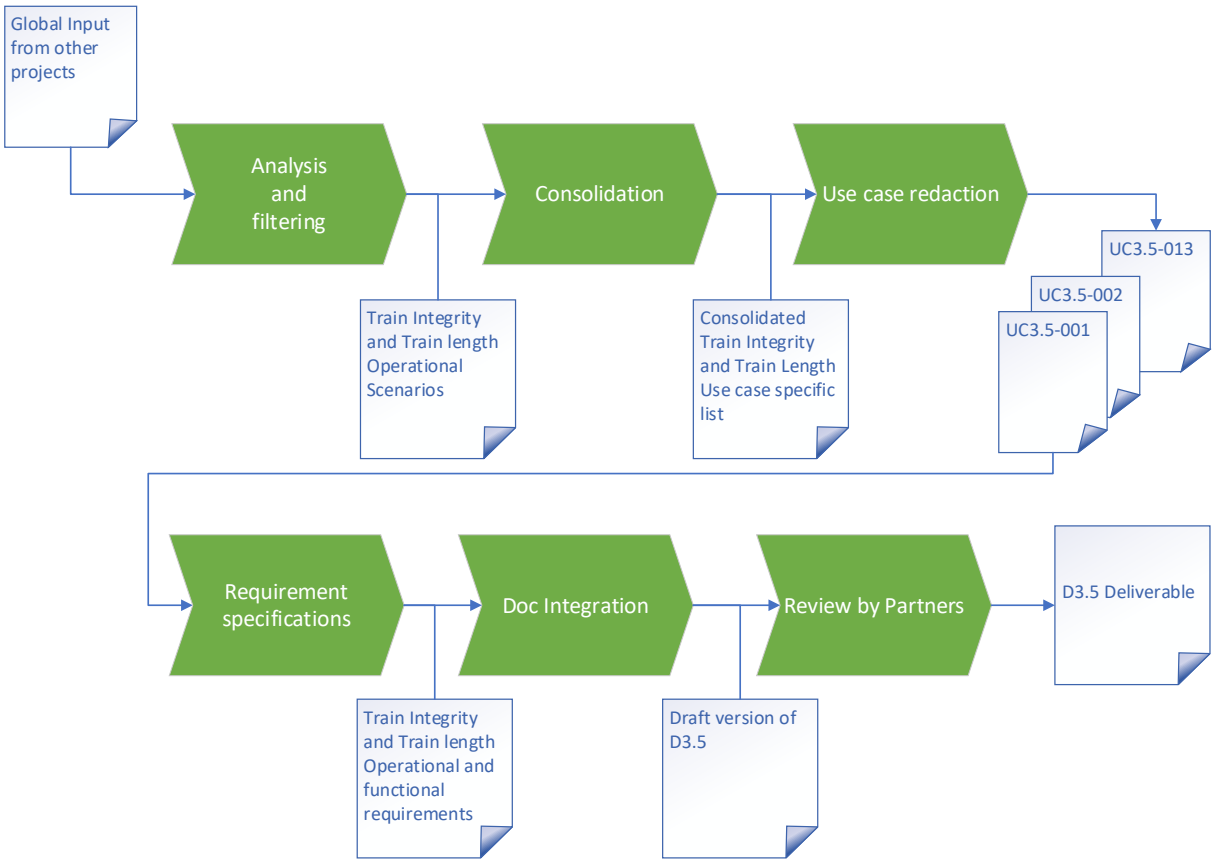

Figure 1: Process Overview

The following steps illustrate this process:

- First development stage – responsibility of partner writing the chapters;
- Review – responsibility of partner reviewing the chapters;
- Second development stage – responsibility of partner writing the chapters;
- Formal review – responsibility of partner reviewing the document;
- Third development stage – responsibility of partner writing the document;
- Finalized (stored in Cooperation Tool the Deliverable document D3.5) – responsibility of partner writing the document;
- Final Check by FutuRe SteeCo;
- Delivery of the document D3.5.

2.3 EXISTING AND RELEVANT DOCUMENTS

As input to the Work Package 3 process, the state of the art was considered and deliverables from past projects were identified and actively requested at the Work Package level. For this process, inputs were collected from several relevant projects:

[1] X2Rail-2 - Deliverable D4.1 Train Integrity Concept and Functional Requirements Specifications v. 2.3

[2] X2Rail-2 - Deliverable D4.2 Functional architecture & Interfaces specifications & Candidate technologies selection v. 3.0

[3] X2Rail-2 - Deliverable D4.3 Test scenarios & test cases specifications v. 2.0

[4] X2Rail-4 - D7.3 Standardisation Proposal v. 1.2

[5] X2Rail-4 - Deliverable D7.2 OTI Technology Migration v. 2.0

The R2DATO D19.1 and D20.1 are relevant document provided by R2DATO WP19 and WP20.

These documents are used as reference for the activities in task 3.5.

2.4 METHODOLOGY FOR DELIVERABLE DEVELOPMENT

The deliverable D3.5 is one of the deliverables for line G1 of FutuRe WP3, it is the output of the task 3.5. This task relied on deliverables from the Shift2Rail programs of X2Rail-2 and X2Rail-4. In parallel, inputs were also sourced through R2DATO WP19 and SP. These became the fundamental inputs to start the process of input collection.

The work carried out in Task 3.5 involved the study of the results obtained in previous projects.

Once these activity development points have been identified, the first step was to define the operational aspects in which Train Integrity and Train Length shall operate.

Once the chapters were drafted, the workgroup followed a structured approach from the point of drafting the chapters to finalizing of the deliverable with the required consensus and approval. The following steps illustrate this process:

A1. First development stage – responsibility of partner writing the chapters;

A2. Review – responsibility of partner reviewing the chapters;

A3. Second development stage – responsibility of partner writing the chapters;

A4. Formal review – responsibility of partner reviewing the document;

A5. Third development stage – responsibility of partner writing the document;

A6. Finalized (stored in Cooperation Tool the Deliverable document D3.5) – responsibility of partner writing the document;

As can be seen in the process described, it provided with a good collaboration among the partners for writing and reviewing the chapters before agreeing on the finalized document.

3 OPERATIONAL REQUIREMENTS AND SCENARIOS

The general scenario, in which both the determination of the integrity of the train and the calculation of the length of the train operate, involves the actors:

- Train (with OTI-I and OTI-L functions)
- ETCS OBU
- Train Driver
- TMS

The type of involvement will be specified each time.

a) Both train integrity (OTI-I) and train length (OTI-L) functions shall be automatically reset/re-evaluated when the cab is activated. Example: during train joining or splitting procedure, a reset of the cab shall automatically trigger the reset of both systems OTI-I and OTI-L.

b) The train integrity (OTI-I) monitoring function shall be triggered by the confirmation of train length. Disabling of the cab shall trigger the deactivation of the train integrity monitoring function.

c) All interactions between train Driver and OTI-L/OTI-I of the train should be integrated into the ETCS driver interface (DMI). This hasn't any impact on the OTI-I and OTI-L activities.

d) Due to the change of train composition a reset of the OTI-I and OTI-L shall be possible by the driver, triggering a re-evaluation of train integrity and train length.

e) Necessary interactions of train driver with OTI-L shall be kept to a minimum.

f) Initialization of OTI-I and OTI-L shall not to be started additionally by the driver.

3.1 TRAIN INTEGRITY ORS

This section reports the operational requirements that are applicable to OTI-I. At system level, the train integrity function affects other functional blocks for which the requirements associated with them are not reported.

Op Req1. Train Integrity information must be transmitted from OTI-I to ETCS OBU periodically.

Note: The Train Integrity Value (CONFIRMED; CONFIRMED DR, LOST; UNKNOWN) could be made visible to the train driver, this should be implemented on the DMI but isn't scope of this document describe it.

Note: for Any change in Train Integrity Value should be visible to the train driver, for example by blinking on the DMI where OTI information is displayed. Examples:

- CONFIRMED --> LOST
- UNKNOWN --> LOST
- CONFIRMED --> UNKNOWN,
- UNKNOWN --> CONFIRMED

Note: Inform the driver about what is happening, could be important, at least be informed about the changes in Train Integrity. It was hypothesized that it could be useful for variations involving loss of integrity to be highlighted by an audible warning. A loss of train integrity (Value change

CONFIRMED --> LOST or UNKNOWN->LOST) should lead to a warning sound or other measure in order to warn the train driver.

Op Req2. The OTI-I has to provide, within a configurable timeout, after the train start up the train integrity status.

Op Req3. The OTI-I shall be able to provide the output with a Safety Integrity Level at least equal to 2.

3.2 TRAIN LENGTH ORS

This section reports the operational requirements that are applicable to OTI-L. At system level, the train length function affects other functional blocks for which the requirements associated with them are not reported.

Op Req4. The OTI-L reports the "real" train length calculated by the system.

Op Req5. Train Length information must be transmitted from OTI-L to ETCS OBU.

Note: For helping the driver activities, Train Length Value (CONFIRMED; UNKNOWN) should be visible to the train driver at any time during operation. Today this is possible with standstill train only.

Op Req6. The OTI-L shall be able to provide the output with a Safety Integrity Level equal to 4.

Op Req7. Train length unit shall be metric (SI) metres.

Op Req8. The OTI-L shall provide the train length value that include the max possible inaccuracy of the measurement done.

Op Req9. The Max inaccuracy in train length shall be 20 meters. (this value will be confirmed after the test campaign)

Note: In case the train length reported by OTI-L is SIL 4 no further action from the train driver shall be required. In all the other cases, the interaction between the driver and the train length value it is out of the scope of OTI-L.

Note: In case train driver input is used for train length validation, only integer values should be entered and taken into consideration.

Note: Any interaction regarding train length (e.g. entering train length manually by the driver) should be limited when the train is at standstill. In case train length data is to be entered by the train driver and the entered value differs from the automatically calculated train length value, this information should be indicated to the driver. What is written that are barriers for the hazardous event. MMI-3 (if the train length is inserted by the driver) or TI-10 (in case the input comes from external source) considered in Annex A of subset -091

4 TRAIN INTEGRITY AND TRAIN LENGTH USE CASES

This chapter contains the use cases which aim to identify the behaviour of the OTI-I and OTI-L functions in the contexts in which they are applied.

This paragraph contains the table with the Use Cases created. The use cases are present in Annex 1. Use Cases.

UC ID	Use Case title	Main Goal
UC_01_301	train length initialization and activation	Provide Train Length to the ETCS On Board
UC_01_302	train length forcing by the driver	Provide Train Length to the ETCS On Board insert by the driver
UC_01_303	Train Coupling	Coupling two trains and obtain a new one
UC_01_304	Train Splitting	Splitting a Train C in two trains Train A and Train B
UC_01_305	SoM inside a L3 area with Train Length introduced by the driver	Perform the ETCS SoM with Train length provided by driver
UC_01_306	SoM inside a L3 area with Train Length safely stored/configured onboard	Perform the ETCS SoM with Train length already present on board
UC_01_307	Dynamic entry in a L3 area without train integrity confirmed and without Confirmed Train Length	Perform the ETCS entry in L3 area
UC_01_308	Dynamic entry in a L3 area without train integrity confirmed and with Confirmed Train Length	Perform the ETCS entry in L3 area
UC_01_309	Dynamic entry in a L3 area with train integrity confirmed and without Confirmed Train Length	Perform the ETCS entry in L3 area
UC_01_310	Dynamic entry in a L3 area with train integrity confirmed and with Confirmed Train Length.	Perform the ETCS entry in L3 area
UC_01_311	Loss of train integrity inside a station.	Check the Train Integrity in Station
UC_01_312	Loss of train integrity in line.	Check the Train Integrity in the L3 area
UC_01_313	Broken of OTI-I in line.	Check the Train Integrity in the L3 area
UC_01_314	Broken of OTI-L in line.	Check the Train Integrity in the L3 area

Table 2: list of Use Cases

5 OTI-I AND OTI-L FUNCTIONAL ARCHITECTURE

For regional trains it is assumed that the configuration has a cabin at the head of the train and a cabin at the back of the train. Regional trains usually have a fixed composition. But the envisaged solution also includes a variable composition. The Figure 2 is compatible with both possibilities.

Figure 2: Generic Regional Train composition.

The logical connections between the two ends of the regional train are shown in the Figure 3.

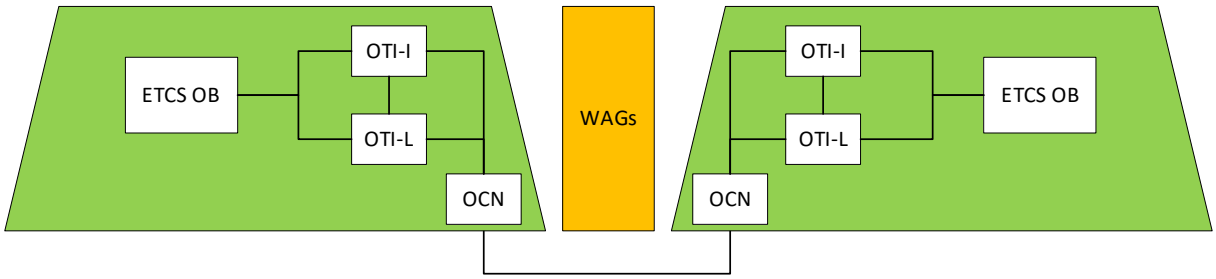

Figure 3: Functional connection between the Cabins.

the main functional modules contained in the figure are the following:

- ETCS OB: Represent the ETCS on board Unit
- OTI-I: it is the functional module responsible for the Train Integrity detection.
- OTI-L: it is the functional module responsible for the Train Length determination.
- OCN: it is the functional module responsible for the communication between the two cabins. The communication link can be wireless or wired. OCN Onboard Communication Network.

The two function OTI-I and OTI-L must communicate with the ETCS OB to transfer the Train integrity Status and the Train Length.

The OTI-I in a must be connect with the correspondent in the other cabin for checking the continuity.

Similarly, for OTI-L the connection with the other entity must be determined.

When two regional trains join, the connection between the two trains is made in the same way. This may be radio or cable.

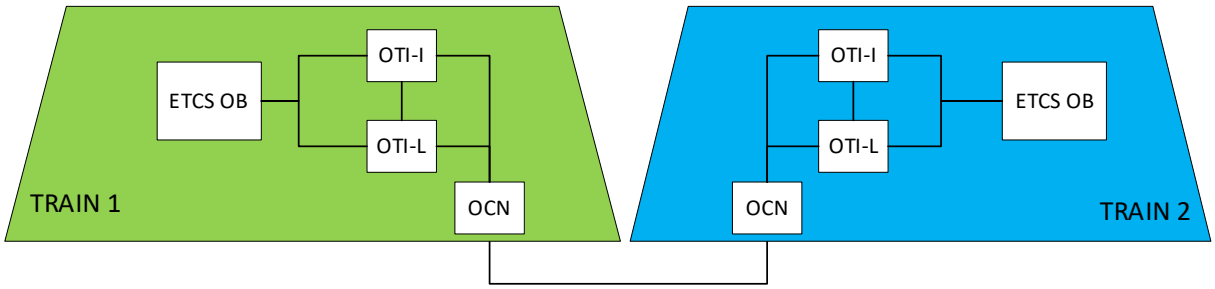

Figure 4: typical architecture for two regional train joined.

6 OTI-I AND OTI-L FUNCTIONAL INTERFACE

This chapter describes the functional interfaces between the OTI-I and OTI-L with the ETCS On Board. In this section are described the proposal for increase the information exchange between the modules.

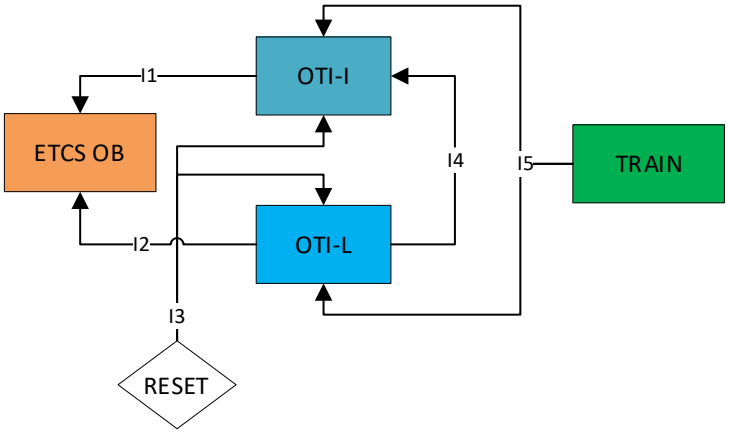

Figure 5: OTI-I and OTI-L functional interfaces

In Figure 5 are reported the following interfaces:

- **Interface I1**: it is the functional interface that reports periodically from OTI-I to ETCS On Board the train integrity status-
- **Interface I2**: it is the functional interface that reports to the ETCS On Board the train length calculates by OTI-L periodically.
- **Interface I3**: It is the functional interface that provides to the OTI-I and OTI-L a reset when necessary.
- **Interface I4**: it is the functional interface that reports the train length from OTI-L to OTI-I.
- **Interface I5**: it is the functional interface that reports the status of the cabin desk.

6.1 INTERFACE I1

This interface has to transfer from OTI-I to ETCS On Board the train integrity status elaborates internally to the OTI-I. The assumption is to adopt the serial interface already specified in the TSI.

The following table reports the meaning of the information exchange from OTI-I to ETCS for the **Train Integrity** information to transfer the information from OTI-I to ETCS On Board.

T_TRI_S1_N/TR_OBU_TrainIntegrity_S1	T_TRI_S1_I/TR_OBU_TrainIntegrity_S1_Not	T_TRI_S2_N/TR_OBU_TrainIntegrity_S2	T_TRI_S2_I/TR_OBU_TrainIntegrity_S2_Not	Meaning
0	0	0	0	Invalid
0	0	0	1	Invalid
0	0	1	0	Invalid
0	0	1	1	Invalid
0	1	0	0	Invalid
0	1	0	1	Train Integrity Lost
0	1	1	0	Train integrity status unknown
0	1	1	1	Invalid
1	0	0	0	Invalid
1	0	0	1	Invalid
1	0	1	0	Train integrity confirmed
1	0	1	1	Invalid
1	1	0	0	Invalid
1	1	0	1	Invalid
1	1	1	0	Invalid
1	1	1	1	OTI-I out of order

Table 3: Coding for Train Integrity

In the table the proposal is to add the field for providing the status out of order identify by the OTI-I system. This field when transfer means the OTI-I is out of order but is able to transfer the information. All the other values are invalid. Potentially, other information can be used in the serial interface.

6.2 INTERFACE I2

Through this interface the ETCS On Board system receives the calculated train length from OTI-L. This is the length between the two ends of the train.

In the TSI for the **Train Length** is specified an UNSIGNED16 variable where only the less 12 significant bits are used. This value expresses the length in meters. The remaining bit must be set to 0.

0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X

The maximum length allowed is 4095 meters.

The proposal is to use the two most significant bits for providing diagnostic information.

D	D	0	0	X	X	X	X	X	X	X	X	X	X	X	X

The possible information are:

1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**OTI-L out of order**
0	0	0	0	X	X	X	X	X	X	X	X	X	X	X	X	**OTI-L works correctly**

This way the on-board system would be informed that the OTI-L system is out of service and can make decisions accordingly.

6.3 INTERFACE I3

The OTI-I and OTI-L functional modules activate their operations when the desk is activated in order to have a clear idea of which cabin is activated and to identify which will be the queue of the train. There are cases in which the composition of the train can change without the driving desk being closed.

In this case to ensure that the OTI-I and OTI-L systems can guarantee that the ends of the train are correctly identified they need a reset. This must be produced by an external entity. The I3 interface highlights this need.

6.4 INTERFACE I4

This interface allows the OTI-I functional module to know the status of the train length calculation and its value.

The train integrity confirmed can only be sent when the train length produced by OTI-L is confirmed valid.

The OTI-L functional module periodically provides this information to the OTI-I functional module. The operating information of the OTI-L module is also sent in this interface.

6.5 INTERFACE I5

Via the I5 interface the functional modules are informed which cabin has been activated. When the cabin is activated, the recognition of the modules that contribute to determining the state of the integrity of the train, and those involved in calculating the length of the train, starts.

7 FUNCTIONAL AND NON FUNCTIONAL REQUIREMENTS

This section starts from the X2Rail Requirements [6], adding new requirements coming from the analyses carried out during the working group's activities and including the Train Length as a validated value to be transmitted to ETCS OBU. Furthermore, requirements resulting from TSI CCS 2023 v4.0 [17] regarding train length and integrity are added.

In the requirement when is not explicit mentioned the Generic OTI is applicable at both OTI-I or OTI-L.

The communication network is managed by the functional module OCN.

7.1 GENERAL FUNCTIONAL REQUIREMENTS

The OTI system consists of the train's OTI Unit (OTI-Master and OTI-Slave) and associated components. The OTI implements the functions train length determination (OTI-L) and train integrity monitoring (OTI-I).

Fun. Req 1. OTI monitoring functional module shall be composed of the following functional modules: i) OTI Master; ii) On-board Communication Network; iii) OTI Slave .

Fun. Req 2. OTI monitoring functional module shall have a unique identifier OTI_ID.

Fun. Req 3. OTI unique identifier OTI_ID shall be the MAC address of OTI communication interface.

Fun. Req 4. OTI monitoring functional module shall include its unique identifier inside each transmitted message.

Fun. Req 5. At power-on, the OTI monitoring functional module shall manage a master-ship assignment procedure to assume Master or Slave role.

Fun. Req 6. After master-ship assignment procedure, the OTI monitoring functional module shall manage an inauguration phase composed of: (i) identification procedure and (ii) association procedure. Note that Identification procedure is aimed at identifying all OTI modules connected to the OCN.

Fun. Req 7. After identification procedure, the OTI monitoring functional module shall manage association procedure to pair OTI Master in front cabin and OTI Slave at train tail.

Fun. Req 8. Association procedure shall ensure that only one TAIL OTI Slave is present.

Fun. Req 9. After association procedure, the OTI monitoring functional module in monitoring state shall manage the communication between paired OTI Master and OTI Slave.

Fun. Req 10. OTI Master Functional Module shall receive train tail status from OTI Slave Functional Module.

Fun. Req 11. OTI Master Functional Module shall check train tail status to verify train integrity. Note that train integrity criteria are reported at section 7.1.1.5

Fun. Req 12. OTI-I Master Functional Module shall provide train integrity information to ETCS module periodically. Periodicity is a configurable parameter.

Fun. Req 13. OTI-L Master Functional Module shall provide train length information to ETCS module periodically. Periodicity is a configurable parameter.

Fun. Req 14. (OPTIONAL) OTI Master Functional Module shall acquire waggon/cargo diagnostic messages from OTI Slave modules.

Fun. Req 15. (OPTIONAL) OTI Master Functional Module shall determine train composition based on acquired waggon/cargo diagnostic messages from OTI Slave modules.

Fun. Req 16. (OPTIONAL) OTI Master Functional Module shall receive train composition from Wayside Maintenance Centre Note that optional requirement related to train composition determination refers to two different cases: (i) OTI Slave provides composition data or (ii) Wayside Maintenance Centre provides train composition to OTI Master.

Fun. Req 17. (OPTIONAL) OTI Master Functional Module shall provide waggon/cargo diagnostic data to a Wayside Maintenance Centre.

Fun. Req 18. (OPTIONAL) OTI Master Functional Module shall provide waggon/cargo diagnostic data to train Driver. Note that optional requirement related to providing cargo/waggon alarms to train Driver is aimed at reducing train Driver reaction time in case of emergencies.

Fun. Req 19. (OPTIONAL) OTI Master Functional Module shall record waggon/cargo diagnostic data received from OTI Slave modules.

Fun. Req 20. At least one OTI Unit shall be associated with each consist.

Fun. Req 21. Each OTI Unit shall, as a minimum, provide the integrity status and length of the associated consist to the OTI Master.

Fun. Req 22. One or multiple OTI Unit shall be able to be combined to form an OTI Composition for a consist or train.

Fun. Req 23. An OTI Composition shall, as a minimum, provide the integrity status and length of its associated OTI Unit to other OTI Compositions.

Fun. Req 24. The interface between the OTI system to the ETCS OBU shall be realized according to the TSI CCS 2023 (version 4.0) and especially with regard to the train interface specified Subset-034 [1] Train Interface FIS and Subset-119 [1] Train Interface FFFIS). At these information's will be added the train length and optionally diagnostic ones.

Fun. Req 25. The OTI system shall detect intended/not intended changes to the train configuration (Coupling/Splitting) and train length. The result shall be a no data confirmation.

Note: The detection of Coupling/Splitting events shall be implemented with SIL4. (Subset-034 [1] 2.5.3.2.2 Note: If the train integrity information fails it can be mitigated by detecting a change of the train length.)

Fun. Req 26. OTI Master Functional Module shall communicate with ETCS to acquire active cabin information and the train length stored on board.

Fun. Req 27. OTI Master Functional Module shall provide to ETCS On Board the train integrity information with the following three values: • Train integrity CONFIRMED • Train integrity LOST • Train integrity status UNKNOWN.

Fun. Req 28. (OPTIONAL) OTI Master shall communicate with OTI Slaves for waggon/cargo diagnosis.

Fun. Req 29. (OPTIONAL) OTI Master shall communicate with Wayside Maintenance Centre.

Fun. Req 30. (OPTIONAL) OTI Master shall provide to train Driver waggon/cargo alarms. 7.1.1.7 Safety Requirement

7.1.1 Start of Mission – Power-On by Driver

Fun. Req 31. The train devices shall be powered-on by the Driver.

Fun. Req 32. When powered-on, the OTI system shall go into the status of INAUGURATION.

Fun. Req 33. When powered-on, the default OTI state shall be SLAVE unit.

Fun. Req 34. Train Length Determination function and Train Integrity Monitoring function shall be activated when the train is powered-on by the Driver.

7.1.2 Start of Mission – OTI Initialization

Fun. Req 35. Train Length Determination function and Train Integrity Monitoring function shall be started in case of cab activation.

Fun. Req 36. Train Length Determination function and Train Integrity Monitoring function shall be reset in case of cab deactivation or cab changing.

Fun. Req 37. OTI shall identify the head and tail unit or coupler of the train (uncoupled end of the front and rear vehicle of a train composition).

Fun. Req 38. OTI shall be able to identify the leading consist of the train at the very front end, as the Head-Unit.

Fun. Req 39. OTI shall be able to identify the (uncoupled) head coupler at the leading consist of the train at the very front end, as the Head-Coupler.

Fun. Req 40. OTI shall monitor the HEAD status of the Head Unit and head coupler status.

Fun. Req 41. OTI shall be able to identify the last consist at the very rear end of the train as Tail-Unit.

Note: If only one consist is present, then no Tail-Unit exists.

Fun. Req 42. OTI shall be able to identify the (uncoupled) tail coupler at the last consist of the train at the very rear end, as the Tail-Coupler.

Note: If only one consist is present, then the Tail-Coupler is the rear coupler depending on cab location and driving direction.

Fun. Req 43. OTI shall monitor the TAIL status of the Tail Unit and tail coupler status.

Fun. Req 44. Identification of intermediate consists (Trunk-Unit):

Fun. Req 45. OTI shall be able to identify all remaining consists in the train as Trunks units (NON-TAIL)

Note: If only one Head-Unit and one Tail-Unit are present, then no Trunks exists.

Fun. Req 46. OTI shall monitor the TRUNK status of the Trunk Units and their coupler status.

Fun. Req 47. After receiving active cab status from ETCS, the corresponding OTI Unit or OTI composition associated to the cab shall be MASTER unit.

Note: The Master is defined at least by the active cab. Depending on the technical solution, Head status and/or coupler status may be used additionally.

Fun. Req 48. OTI Master, after going into MASTER, shall determine all OTI slaves units in the train.

Fun. Req 49. OTI Master, after going into MASTER, shall determine the OTI slaves TAIL status for all OTI slaves units in the train.

Fun. Req 50. Disabling of the cab shall trigger the MASTER unit state to switch to SLAVE unit state.

Fun. Req 51. In each OTI system, composed of OTI Unit or OTI Compositions, only a single OTI unit in MASTER state shall exist.

The train composition can change, for instance some additional wagon are added to the train in the station. The following requirement is linked to this scenario. Unintentional train integrity LOST isn't a train composition change.

Fun. Req 52. Due to any change of train composition, a reset of the OTI shall be triggered and possibly initiate a SoM procedure by the driver or TCMS, triggering a re-evaluation of train integrity and train length.

Fun. Req 53. Due to the change of the train length as part of train data, a reset of the train length shall be triggered and possibly initiate a SoM procedure by the driver or TCMS, triggering a re-evaluation of train integrity and train length.

7.2 TRAIN LENGTH REQUIREMENTS

7.2.1 Start of Mission – OTI-L Operations

Fun. Req 54. The Train Length (nominal) shall be calculated as the overall distance along the rail from the real head train front and the real tail train end including the couplers.

Fun. Req 55. The Train Length value shall be sent to ETCS-OBU as input provided from external source.

Note: As a proposal for future scenarios, to the Train Length sent to ETCS-OBU, an additional information about the SIL level of the external information may be added to allow conclusion about the quality of data.

Note: The Train Length provided by external source shall be at least SIL2. The Train Length should be provided by external source with SIL4, if possible. If the Train Length is not provided by external source with at least SIL4, the ETCS OBU shall be able to validate the train length value or using additional information to mitigate a wrong train length from external source.

Note: Confirmed train length sent in position report by the ETCS OBU shall be SIL4. This requires a SIL4 train length information to be used for the calculation of the confirmed train length. However this SIL4 train length does not translate into a mandatory SIL4 train length requirement for the OTI; if OTI-L provides the train length already with SIL4 it is sufficient, if OTI-L provides the train length with less than SIL4, then a validation or additional source of information of train length has to be done by ETCS OBU, so that the ETCS OBU could determine a SIL4 train length value using the independent source.

Fun. Req 56. The Train Length shall be calculated internally by OTI-L when it is an information necessary to evaluate Train Integrity (e.g. for wireless communication

network or as mitigation and validation of the train integrity or to detect Coupling/Splitting events.)

Fun. Req 57. In case of voluntary change of composition (Coupling/Splitting events), the necessary information (new composition) shall be detected and provided to OTI-L for the new determination of the Train Length.

7.3 TRAIN INTEGRITY REQUIREMENTS

7.3.1 Start of Mission – OTI-I Operations

Fun. Req 58. The train integrity monitoring function operation shall be triggered by the determination and confirmation of train length and train composition.

Fun. Req 59. A confirmation of train integrity (train integrity status confirmed) shall only be possible to provide after the determination and confirmation of train length, otherwise, train integrity status is unknown.

Fun. Req 60. All interactions between train driver/TMS and OTI-L/OTI-I of the train shall be integrated into the ETCS driver interface (DMI), if any interaction is required.

Fun. Req 61. Any necessary interactions of train driver with OTI-I shall be kept to a minimum.

Fun. Req 62. Initialization of OTI-I and determination of train integrity status shall not require to be started additionally by the driver.

Fun. Req 63. The presence and use of the OTI system shall not influence the operation, e.g. Coupling or Splitting, except for the resulting modification of the train data in the SoM procedure.

7.3.2 Mission – OTI-I Train Integrity Status Monitoring

Confirmation and continuous monitoring of train integrity:

Fun. Req 64. The OTI-I continuously confirms and monitors the completeness (integrity) of a train consisting of several (two or more) consists (vehicles or wagons) that could separate unintendedly.

Monitoring the integrity status of the train between consists or OTI Compositions:

Fun. Req 65. OTI-I shall monitor the integrity status of the entire train incl. all OTI Unit and/or OTI Compositions.

Fun. Req 66. OTI-I shall continuously verify the train integrity after Start of Mission incl. determination and validation of the train composition and train length and during train operation and provide the integrity status of the train to the ETCS OBU via the train interface (Subset-034 [1])

Monitoring the integrity status of the train within a vehicle unit (consist):

Fun. Req 67. OTI-I shall continuously determine and monitor the integrity of each vehicle unit of several (two or more) subunits (vehicles or wagons) that could separate unintendedly.

Note: This sub-function is not required if the failure of the mechanical Joining system between two wagons is considered very unlikely. (e.g. Jacobs bogies)

Fun. Req 68. If the train integrity cannot be confirmed by OTI-I (e.g., train integrity information is not available, or train integrity is lost), OTI-I shall not send a confirmed train integrity status (Q_INTEGRITY == 1). Generate output of the train integrity status (Q_INTEGRITY) to the ETCS-OBU:

- OTI-I shall provide an output to the ETCS OBU with the information, that the integrity of the train is confirmed, or
- the integrity of the train has been lost if there is any change in the train composition, or
- the integrity of the train is unknown if the integrity of the train cannot be determined.

Fun. Req 69. If there is a change in the train composition, intended or unintended, the OTI-I shall send the integrity LOST status (Subset-034 2.5.3.2.1" In case of detected train split intentional or unintentional) or a train joining, the vehicle shall provide the information "Train integrity lost"".)

Fun. Req 70. OTI-I shall reevaluate TAIL status (e.g. coupler status) at standstill to determine Joining or Splitting events.

Note: Train integrity status determination may be mitigated by train composition and/or train length determination, to achieve sufficient safety level for the detection of an intended change of train composition. (Subset-034 2.5.3.2.2 Note: If the train integrity information fails it can be mitigated by detecting a change of the train length.)

Note: If there is an intended change in the train configuration (Coupling or Splitting), the OTI-I triggers the OTI-L to determines the resulting train length,

7.4 Non-Functional Requirements

Not Fun. Req 1. All faults of the OTI system shall be detected, within 24 hours at the latest. (Subset-120 FFFIS TI – Safety-related requirements 2.1.6.3 Train Integrity 2.1.6.3.3.5 FDT for the signals = 24 h and FDT for for train coupling failures = 10s)

Note: To achieve the safety targets of the TIMS, detection of a malfunction of the OTI system by the self-test function is necessary within a dormancy or latency period of 24 hours at the maximum.

Not Fun. Req 2. The overall train integrity monitoring function shall achieve at least SIL 2. (Subset-091 9.6. EXT_SR08)

Info: The occurrence of a lack of detection of loss of train integrity (Q_INTEGRITY) shall not be more frequent than with a THR of <= 2.61*10-6/h (SIL2) (for passenger trains). (Subset-091 10.3.2.10 Max. unexpected loss of train integrity)

Note: For freight trains, the THR shall be <=6.98*10-5/h [1], assuming screw-hook coupler for freight trains. The resulting occurrence of an erroneous confirmation of the train integrity (Q_INTEGRITY), in case of a loss of train integrity, shall not be more frequent than with a THR of <= 10-9/h (SIL4). This is in accordance with the safety requirement of L_TRAININT (Subset-091 9.6. EXT_SR06)

Not Fun. Req 3. The train length reported to the ETCS On Board shall achieve at least SIL 4.

8 HIGH LEVEL DEMONSTRATOR SET UP

This section reports a first hypothesis of the configuration of the environment in which to insert any demonstrators created.

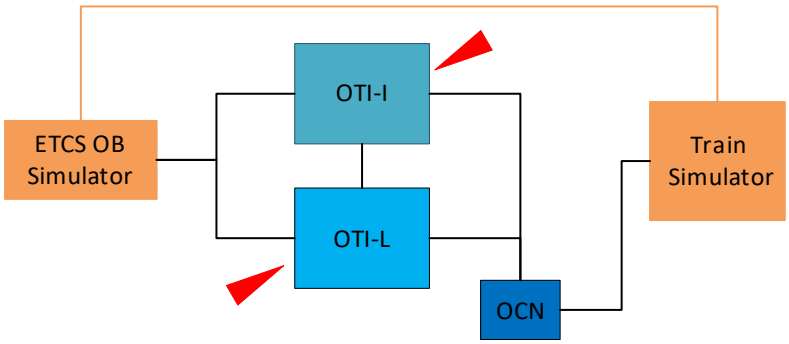

Figure 6: Demonstrator environment.

The interface to the on-board system is made with a serial interface. Similarly, the interface towards the train is created with a serial interface.

For every OTI box it is possible the fault injections.

9 CONCLUSIONS

In this phase of the project, the possible use cases and requirements coming from internal activities and activities carried out in other flagship projects were explored.

What is reported in this document is preparatory for the activities that will be designed and carried out in the continuation of the project in WP8 of FutuRe.

what is produced represents a good starting point in terms of identified requirements.

The identified use cases represent all the possible scenarios that can be present on a generic regional line.

The objectives set for this phase of the project present in the GA have been achieved.

10 REFERENCES

[6] X2Rail-2 - Deliverable D4.1 Train Integrity Concept and Functional Requirements Specifications v. 2.3

[7] X2Rail-2 - Deliverable D4.2 Functional architecture & Interfaces specifications & Candidate technologies selection v. 3.0

[8] X2Rail-2 - Deliverable D4.3 Test scenarios & test cases specifications v. 2.0

[9] X2Rail-4 - D7.3 Standardisation Proposal v. 1.2

[10] X2Rail-4 - Deliverable D7.2 OTI Technology Migration v. 2.0

[11] ERTMS/ETCS Train Interface FFFIS SUBSET-119 ISSUE: 4.0.0 DATE: 2023-07-05

[12] EN50159 Safety related communication in transmission systems

[13] IEC61375-2-3 TCN – Train Communication Network – Communication Profile 2015

[14] ERTMS/ETCS Train Interface FIS SUBSET-034 VERSION: 4.0.0 DATE: 05/07/2023

[15] ERTMS/ETCS System Requirements Specification SUBSET-026 VERSION: 4.0.0 DATE: 05/07/2023

[16] ERTMS/ETCS Interoperable performance requirements SUBSET-041 VERSION: 4.0.0 DATE: 05/07/2023

[17] ERTMS/ETCS Safety Requirements for the Technical Interoperability of ETCS in Levels 1 & 2 FIS SUBSET-091 VERSION: 4.0.0 DATE: 05/07/2023

[18] ERTMS/ETCS FFFIS TI – Safety related Requirements SUBSET-120 VERSION: 4.0.0 DATE: 05/07/2023

11.1 ANNEX 1. USE CASES

11.1.1 Train length initialization and activation

Use Case Group	01
Use Case	train length initialization and activation
UC ID	UC_01_301
Main actor	OTI-L
Other actors	Driver, ETCS OTI-I
Main goal	Provide Train Length to the ETCS On Board
Assumptions	Train is stand still
Precondition	The train is in sleeping mode OTI-I and OTI-L are switch off
Flow of events	1. The driver requires the train to power on 2. The driver requires the train to enable. 3. The train becomes enabled. 4. The OTI-L and OTI-I performs internal test. 5. The OTI-L switch to “Train Length Determination Mode” 6. The OTI-L identify the “Train Tail”. 7. The OTI-L Evaluate the train length. 8. The OTI-L send the Train length to ETCS On Board
Postcondition	The ETCS On Board know the Train length
Safety relation	It is a function safety related
Open topics / consideration	

Table 4: UC_01_301 Train Length Initialization and Activation

11.1.2 Train length forcing by the driver

Use Case Group	01
Use Case	train length forcing by the driver
UC ID	UC_01_302
Main actor	OTI-L
Other actors	Driver, ETCS OTI-I
Main goal	Provide Train Length to the ETCS On Board
Assumptions	Train is stand still
Precondition	The train is activated OTI-I and OTI-L are switch off.
Flow of events	1. The train is switch on 2. The OTI-L and OTI-I performs internal test 3. The OTI-L switch to “Train Length Determination Mode” 4. The OTI-L doesn’t report the train length 5. The “Train Integrity” (Q_INTEGRITY) is set to UNKNOWN and provided to ETCS on Board and to driver 6. The Driver enters the Train Length in SoM procedure.
Postcondition	The train Integrity isn’t confirmed
Safety relation	It is a function safety related
Open topics / consideration	

Table 5: UC_01_302 train length forcing by the driver.

11.1.3 Train Coupling

Use Case Group	01
Use Case	Train Coupling
UC ID	UC_01_303
Main actor	OTI-L
Other actors	Driver, ETCS, OTI_I
Main goal	Coupling two trains and obtain a new one
Assumptions	There are two trains, Train A and Train B both trains are stand still
Precondition	The Train A is activated OTI-L of Train A is working. OTI-I of Train A is working. OTI-L of Train B is switch off. OTI-I of Train B is switch off.
Flow of events	1. The train A is powered on and enabled, 2. For the Train A "Train Length" data is valid 3. The OTI-L of Train A is in "Train Length Determination Mode" 4. The OTI-I of Train A "Train Integrity" provides CONFIRMED 5. The Train B is in sleeping mode 6. The driver of train A moves the Train A to the Train B 7. When Train A couples with Train B, Driver open and close the Cabin desk and OTI-I and OTI-L restart the evaluation.. 8. OTI-I and OTI-L of New train C (Train A+ Train B) invalidate Train length and train integrity. 9. OTI-L of Train C calculate new Train C length 10. OTI-I of Train C evaluate train integrity 11. OTI-I of Train C Provide Train Integrity status
Postcondition	The train Integrity status is transfer to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 6: UC_01_303 train Coupling

11.1.4 Train Splitting

Use Case Group	01
Use Case	Train Splitting
UC ID	UC_01_304
Main actor	OTI-L
Other actors	Driver, ETCS, OTI_I
Main goal	Splitting a Train C in two trains Train A and Train B
Assumptions	There is a train Train C stand Still.
Precondition	The train C is activated OTI-L of Train C is working. OTI-I of Train C is working.
Flow of events	1. The train C is powered on and enabled, 2. For the Train C "Train Length" data is valid 3. The OTI-L of Train C is in "Train Length Determination Mode" is in AUTOMATIC 4. The OTI-I of Train C "Train Integrity" provides CONFIRMED 5. The Driver is in the driving cabin of the train C 6. The Train C is splitted and OTI-I reports Train Integrity lost 7. Two new trains are present Train A and Train B, The driver is in the cabin of Train A. Driver open and close the Cabin desk. 8. The OTI-I and OTI-L of Train A invalidate Train length and train integrity. 9. OTI-L of Train A calculate new Train A length 10. OTI-I of Train A evaluate train integrity 11. OTI-I of Train A Provide Train Integrity status
Postcondition	The train Integrity status is transfer to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 7: UC_01_303 train Splitting

11.1.5 SoM inside a L3 area with Train Length introduced by the driver

Use Case Group	01
Use Case	SoM inside a L3 area with Train Length introduced by the driver
UC ID	UC_01_305
Main actor	OTI-L
Other actors	Driver, ETCS, OTI_I
Main goal	Perform the ETCS SoM
Assumptions	There is the Train 1 in stand Still condition in L3 area. For this Use Case the assumption is that the OTI-L takes more time for providing the Train Length respect the Driver manual insertion.
Precondition	The Train 1 is activated OTI-I and OTI-L are switch off.
Flow of events	1. The Train 1 is powered on and enabled, 2. The Driver performs the SoM procedure on ETCS 3. OTI-L of Train 1 calculate Train 1 length. 4. OTI-I of Train 1 evaluate train integrity. 5. For the Train 1 “Train Length” data is insert by the Driver. 6. OTI-I of Train 1 Provide Train Integrity status. 7. OTI-L of Train 1 provide Train length. 8. EVC has both values.
Postcondition	The train Integrity status can be transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	The EVC shall take in charge which value adopt. The one insert by the driver or which was received by the OTI-L

Table 8: UC_01_305 SoM inside a L3 area with Train Length introduced by the driver.

11.1.6 SoM inside a L3 area with train length safely stored/configured onboard

Use Case Group	01
Use Case	SoM inside a L3 area with train length safely stored/configured onboard
UC ID	UC_01_306
Main actor	OTI-L
Other actors	Driver, ETCS, OTI_I
Main goal	Perform the ETCS SoM with Train length already present on board
Assumptions	There is the Train 1 in stand Still condition in L3 area.
Precondition	The Train 1 is activated OTI-I and OTI-L are switch off.
Flow of events	1. The Train 1 is powered on and enabled, 2. The Driver performs the SoM procedure on ETCS 3. OTI-L of Train 1 calculate Train 1 length. 4. OTI-I of Train 1 evaluates train integrity. 5. For the Train 1 “Train Length” data is available on board. 6. OTI-I of Train 1 Provide Train Integrity status. 7. OTI-L of Train 1 provide Train length. 8. EVC has both values.
Postcondition	The train Integrity status can be transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	The EVC shall take in charge which value adopt. The one stored on board or which was received by the OTI-L

Table 9: UC_01_306 SoM inside a L3 area with train length safely stored/configured onboard.

11.1.7 Dynamic entry in a L3 area without train integrity confirmed and without Confirmed Train Length

Use Case Group	01
Use Case	Dynamic entry in a L3 area without train integrity confirmed and without Confirmed Train Length
UC ID	UC_01_307
Main actor	ETCS
Other actors	Driver, OTI_I, OTI-L
Main goal	Perform the ETCS entry in L3 area
Assumptions	There is the Train 1 that approaching the L3 area. OTI-I doesn't provide train integrity confirmed. OTI-L doesn't provide Confirmed Train Length.
Precondition	The Train 1 is in FS, with Train Integrity UNKNOW OTI-I is working providing Train integrity UNKNOW OTI-L is working providing a not valid train length
Flow of events	1. The Train 1 is running il FS and train integrity is in UNKNOWN state. 2. OTI-L of Train 1 calculate Train length. 3. OTI-I of Train 1 is continuing to assess the integrity of the train. two scenarios (A & B) are possible: Scenario A: A1: If the timer associated with the unknow state expires, the state changes to LOST. A2: OTI-L doesn't calculate the Train Length A3: The OTI-I reports Train Integrity status = LOST A4: OTI-L doesn't provide the Train Length Scenario B: B1: The train integrity is reached the status change to CONFIRMED. B2: OTI-L provides the Train Length B3: The OTI-I reports Train Integrity status = CONFIRMED. B4: The OTI-L provides the Train Length value 4. EVC has to manage the information to send in the PR.
Postcondition	The train Integrity status is transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 10: UC_01_307 Dynamic entry in a L3 area without train integrity confirmed and without Confirmed Train Length.

11.1.8 Dynamic entry in a L3 area without train integrity confirmed and with Confirmed Train Length

Use Case Group	01
Use Case	Dynamic entry in a L3 area without train integrity confirmed and with Confirmed Train Length
UC ID	UC_01_308
Main actor	ETCS
Other actors	Driver, OTI_I, OTI-L
Main goal	Perform the ETCS entry in L3 area
Assumptions	There is the Train 1 that approaching the L3 area. OTI-I doesn't provide train integrity confirmed. OTI-L provide Train Length.
Precondition	The Train 1 is in FS, with Train Integrity UNKNOW OTI-I is working providing Train integrity UNKNOW OTI-L is working
Flow of events	1. The Train 1 is running il FS and train integrity is in UNKNOWN state. 2. OTI-L of Train 1 calculate Train length. 3. OTI-I of Train 1 is continuing to assess the integrity of the train. two scenarios (A & B) are possible: Scenario A: A1: If the timer associated with the unknow state expires, the state changes to LOST. A2: The OTI-I reports Train Integrity status = LOST Scenario B: B1: The train integrity is reached the status change to CONFIRMED. B2: The OTI-I reports Train Integrity status = CONFIRMED. 4. The OTI-L provides the Train Length value 5. EVC has to manage the information to send in the PR.
Postcondition	The train Integrity status is transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 11: UC_01_308 Dynamic entry in a L3 area without train integrity confirmed and with safe train length.

11.1.9 Dynamic entry in a L3 area with train integrity confirmed and without Confirmed Train Length

Use Case Group	01
Use Case	Dynamic entry in a L3 area with train integrity confirmed and without Confirmed Train Length
UC ID	UC_01_309
Main actor	ETCS
Other actors	Driver, OTI_I, OTI-L
Main goal	Perform the ETCS entry in L3 area
Assumptions	There is the Train 1 that approaching the L3 area. OTI-I provides train integrity confirmed. OTI-L doesn't provide Train Length.
Precondition	The Train 1 is in FS, with Train Integrity UNKNOW OTI-I is working providing Train integrity UNKNOW OTI-L is working providing a not valid train length
Flow of events	No events. The Train Integrity cannot be confirmed without having a validated train length. This is an error condition.
Postcondition	
Safety relation	It is a function safety related
Open topics / consideration	

Table 12: UC_01_309 Dynamic entry in a L3 area with train integrity confirmed and without Confirmed Train Length.

11.1.10 Dynamic entry in a L3 area with train integrity confirmed and with Confirmed Train Length.

Use Case Group	01
Use Case	Dynamic entry in a L3 area with train integrity confirmed and with Confirmed Train Length.
UC ID	UC_01_310
Main actor	ETCS
Other actors	Driver, OTI_I, OTI-L
Main goal	Perform the ETCS entry in L3 area
Assumptions	There is the Train 1 that approaching the L3 area. OTI-I provides train integrity confirmed. OTI-L provides Train Length.
Precondition	The Train 1 is in FS, with Train Integrity CONFIRMED OTI-I is working OTI-L is working
Flow of events	1. The Train 1 is running il FS and train integrity is in CONFIRMED state. 2. OTI-L of Train 1 calculate Train length. 3. OTI-I of Train 1 is continuing to assess the integrity of the train. 4. The OTI-L provides the Train Length value 5. EVC has to manage the information to send in the PR.
Postcondition	The train Integrity status is transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 13: UC_01_310 Dynamic entry in a L3 area with train integrity confirmed and with safe train length.

11.1.11 Loss of train integrity inside a station.

Use Case Group	01
Use Case	Loss of train integrity inside a station.
UC ID	UC_01_311
Main actor	OTI_I
Other actors	Driver, ETCS, OTI-L
Main goal	Check the Train Integrity in Station
Assumptions	There is the Train 1 that it is stopped at the station. OTI-I provides train integrity status. OTI-L provides Train Length.
Precondition	The Train 1 is in FS, with Train Integrity CONFIRMED OTI-I is working OTI-L is working
Flow of events	1. The Train 1 is stopped at the station. 2. OTI-L of Train 1 calculate Train length. 3. OTI-I of Train 1 is finding incoherences in the train integrity check. 4. OTI-I of Train 1 goes in the state UNKNOW 5. The OTI-I reports Train Integrity status = UNKNOW. 6. In the OTI-I if nothing changes, when the timer associated with the unknow state expires, the state changes to LOST 7. The OTI-I reports Train Integrity status = LOST. 8. EVC has to manage the information to send in the PR.
Postcondition	The train Integrity status is transferred to RBC in line with the ETCS mode
Safety relation	It is a function safety related
Open topics / consideration	

Table 14: UC_01_311 Lose of train integrity inside a station.

11.1.12 Loss of train integrity in line.

Use Case Group	01
Use Case	Loss of train integrity in line.
UC ID	UC_01_312
Main actor	ETCS
Other actors	Driver, OTI_I, OTI-L
Main goal	Check the Train Integrity in the L3 area
Assumptions	There is the Train 1 that is running on the line. OTI-I provides train integrity confirmed. OTI-L provides Train Length.
Precondition	The Train 1 is in FS, with Train Integrity CONFIRMED OTI-I is working OTI-L is working
Flow of events	1. The Train 1 is running on the line. 2. OTI-L of Train 1 calculate Train length. 3. OTI-I of Train 1 is finding incoherences in the train integrity check. 4. OTI-I of Train 1 goes in the state UNKNOW. 5. The OTI-I reports Train Integrity status = UNKNOW. 6. In the OTI-I if nothing changes, when the timer associated with the unknow state expires, the state changes to LOST. 7. The OTI-I reports Train Integrity status = LOST. 8. EVC has to manage the information to send in the PR.
Postcondition	The train Integrity status is transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 15: UC_01_312 Lose of train integrity in line.

11.1.13 Broken of OTI-I in line.

Use Case Group	01
Use Case	Broken of OTI-I in line.
UC ID	UC_01_313
Main actor	ETCS
Other actors	Driver, OTI_I, OTI-L
Main goal	Check the Train Integrity in the L3 area
Assumptions	There is the Train 1 that is running on the line. OTI-I provides train integrity confirmed. OTI-L provides Train Length.
Precondition	The Train 1 is in FS, with Train Integrity CONFIRMED OTI-I is working OTI-L is working
Flow of events	1. The Train 1 is running on the line. 2. OTI-L of Train 1 calculate Train length. 3. OTI-I of Train 1 is broken and doesn't provide any output. 4. OTI-I diagnostic interface recognise the fault. 5. EVC has to manage the information to send in the PR.
Postcondition	The train Integrity status is transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 16: UC_01_312 Broken of OTI-I in line.

11.1.14 Broken of OTI-L in line.

Use Case Group	01
Use Case	Broken of OTI-L in line.
UC ID	UC_01_314
Main actor	ETCS
Other actors	Driver, OTI_I, OTI-L
Main goal	Check the Train Integrity in the L3 area
Assumptions	There is the Train 1 that is running on the line. OTI-I provides train integrity confirmed. OTI-L provides Train Length.
Precondition	The Train 1 is in FS, with Train Integrity CONFIRMED OTI-I is working OTI-L is working
Flow of events	1. The Train 1 is running on the line. 2. OTI-I of Train 1 is evaluated the train integrity. 3. OTI-L is broken. 4. OTI-I doesn't provide any output. 5. OTI-L diagnostic interface recognise the OTI-L fault. 6. EVC has to manage the information to send in the PR.
Postcondition	The train Integrity status is transferred to RBC
Safety relation	It is a function safety related
Open topics / consideration	

Table 17: UC_01_314 Broken of OTI-L in line.

11.2 ANNEX 1. TRACEABILITY MATRIX

It is reported the traceability matrix from the requirements collected in Future-WP2-task 2.2 deliverable D2.2 and the requirements developed in the task Future-WP3-task 3.5. This matrix will be useful for the next implementation in the WP8 task 8.6 activities.

Traceability%20D3.5%20e%20D2.2.xlsx