ERTMS/ETCS - ERTMS/ATO

Online Monitoring System

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1 Modification History

Issue number date	Section number	Modification / Description	Editor
0.0.1 20-12-2021	All	First issue of the document.	AC
0.0.2 31-05-2022	All	First review of the document.	AC
0.0.3 16-09-2022	All	The document content has been changed according to the EUG comments referring to the last version (0.0.2) as contained in "SUBSET-149 On Line Monitoring System Draft 04y Comments PR+DB.pdf".	AC
0.0.3 bis 16-09-2022	All	The document content has been changed according to the SNCF comments referring to the last version (0.0.2)	AC
0.0.4 19-09-2022	All	ATO – OMS on-board interface has been added. "ATO data definition is defined in Appendix 1. The text is taken from sections 6.1 to 6.3 of SUBSET-140, issue 0.0.9, 15-12-2021prepared by the ATO GoA2 workgroup. This document was originally planned to be included in the TSI 2022 but EECT decided to remove the document as the ATO should send the diagnostic information to the OMS instead of the ORD (On-board Recording Device)."	AC
0.0.5 30-09-2022	All	Document update following remarks by OMS team. Editorial changes. References and Abbreviation sections have been updated. Added clarification on access rights on data assigned to operators from IM, RU and components suppliers. Added GNSS time field in OMS packets header structure. Added SOURCE_SS field in messages header to identify source of messages (e.g. ERTMS/ETCS, ATO).	AC

Issue number date	Section number	Modification / Description	Editor
0.0.6 01/12/2022	§5.2 and §1.2 modified, §5.3 added. Term “packet” renamed in chap. 3 and 5	The OMS packet has been renamed as "Data Collection" to avoid confusion since the term packet is used in other subsets with different meaning. Variables NID_STD_VS_CUSTOM and SOURCE_SS have been removed since in the JSON format structure different message types have been defined. Added section 5.3 JSON Data Collections format. Added reference to SUBSET-147	AC
0.0.7 29-05-2023	All	Document update following remarks by ERA, CER, EUG, UIC, FWG. References and Abbreviation sections have been updated. Logical architecture section has been moved after functional requirements. Chapter 7 APPENDIX 1 – ATO data has been removed and replaced by reference to SUBSET-140. Better clarified the perimeter of the current version to manage data from ERTMS/ETCS and ATO on-boards, future evolutions will be managed by System Pillar team. For radio communication, in addition to public networks, proprietary wi-fi and GSM-R PS have been considered. Clarified data ownership aspects.	AC
0.0.8 15-09-2023	All	Modifications following remarks received from EUG, OCORA and UNISIG Super Group. Aligned with SUBSET-140v0.0.1 for ERTMS/ATO data. Modified term wayside to trackside. GNSS format has been defined. Reference to SUBSET-143 added.	AC
1.0.0 15-12-2023	All	Aligned with SUBSET-140v1.1.0 (new document title). General format and editorial review. Added reference to ATO glosssary. Reduced to 30 minutes the time limit for OMS trackside servers to share data.	AC

Issue number date	Section number	Modification / Description	Editor
		Formal release of version 1.0.0	
1.1.0 06-05-2024	All	Modifications following remarks received from CER and UNISIG Super Group: In section 3.1 clarified usage of buffer and local memory for Data Collections. In section 3.2 clarified management of OMS version. Modified definition of all GNSS data format referred to ETRS89. Modified format of SUBSET-027 and SUBSET-140 to “string”. In section 3.4 clarified criteria to identify data to be sent to IMs. Editorial modifications across the document.	AC
1.2.0 15-07-2024	All	Modifications following remarks received from CER and quality check by UNISIG Super Group. Definitions of GNSS position and time according to WGS84 and ISO 8601 were introduced. Examples of format for SUBSET-027 and SUBSET-140 were added. EtcsTrnPostn JSON structure was reviewed to take into account new definition in SUBSET-027.	AC

2 Table of Contents

3 Introduction

3.1 Scope

3.1.1.1 This document specifies the Online Monitoring System which is intended to collect monitoring information on the train and to transfer it to a trackside server, allowing to detect basic train borne malfunctions. Error messages from on-board equipment will also support trackside maintenance operations by IM e.g. by identifying defective balises.

3.1.1.2 Monitoring data will be tagged with geographical reference in order to associate each event with the absolute location where it has happened. Such reference is not to be intended as a fail-safe localization system.

3.1.1.3 The overall Online Monitoring System is not a safety related function.

3.1.1.4 Note: the current version of this document identifies monitoring data generated by ERTMS/ETCS and ERTMS/ATO on-boards. Future evolutions can include additional data as well as information generated by other devices.

3.2 References

Ref. N°	Title	Reference	Author
[Ref 1]	ERTMS/ETCS System Requirements Specification	SUBSET-026	ERA, UNISIG, EEIG ERTMS Users Group
[Ref 2]	ERTMS/ETCS FIS Juridical Recording	SUBSET-027	ERA, UNISIG, EEIG ERTMS Users Group
[Ref 3]	DIAGNOSTIC DATA TRANSMISSION FROM RAILWAY VEHICLES	UIC 559 release 1.1.2010	UIC
[Ref 4]	Industrial communication networks – Network and system security - Part 3-3: System security requirements and security levels	CEI EN IEC 62443-3-3:2020	IEC
[Ref 5]	ERTMS/ATO - ATO-OB / Recording-Monitoring devices FFFIS Application Layer	SUBSET-140	UNISIG
[Ref 6]	ERTMS/ETCS Glossary of Terms and Abbreviations	SUBSET-023	ERA, UNISIG, EEIG ERTMS Users Group
[Ref 7]	ERTMS Data Applications FFFIS part: CCS Consist Network Communication Layers	SUBSET-147	UNISIG
[Ref 8]	Electronic railway equipment - Train communication network (TCN) - Part 2-6: On-board to ground communication	IEC 61375-2-6:2018	IEC
[Ref 9]	ERTMS/ATO Interface Specification Communication Layers for On-board Communication	SUBSET-143	ERA, UNISIG, EEIG ERTMS Users Group
[Ref 10]	ERTMS/ATO Glossary EEIG	13E154	EEIG ERTMS Users Group

3.3 Abbreviations

ATO	Automatic Train Operation
CCS	Control Command and Signalling
GNSS	Global Navigation Satellite System
HTTPS	Hypertext Transfer Protocol Secure
IM	Infrastructure Manager
IS	Isolation
JSON	JavaScript Object Notation
NP	No Power
OB	On-board
OMS	Online Monitoring System
RU	Railway Undertaking
SF	System Failure
SIL	Safety Integrity Level
WGS84	World Geodetic System 1984

Refer also to [Ref 6] and to [Ref 10] for full list of abbreviations.

4 General

4.1.1.1 Detection of trackside and on-board CCS system failures, whether imminent or already reality, supports reliable train operation. Issues might arise when failure reporting is delayed, let alone if failures remain undetected. Regular infrastructure and rolling stock maintenance activities are often of a cyclical character, implying that potential failures can remain hidden for quite some time, e.g. until the next inspection.

4.1.1.2 This document has the aim to provide a harmonised European rail network monitoring system sharing data generated by ERTMS/ETCS and ERTMS/ATO on-boards throughout the European rail network.

5 Functional Requirements

5.1 OMS On-board

5.1.1.1 OMS on-board shall receive from ERTMS/ETCS on-board the same messages sent to the JRU [Ref 2] in the format specified in §5.3.3.

5.1.1.2 OMS on-board shall receive from ERTMS/ATO messages defined in [Ref 5] in the format specified in §5.3.5.

5.1.1.3 OMS on-board shall generate Data Collections to be sent to OMS trackside, starting from received messages from ERTMS/ETCS on-board and ERTMS/ATO on-board, adding Data Collection header as specified in §5.3.2.

5.1.1.4 The OMS on-board data shall be sent to the OMS trackside immediately after messages are received from ERTMS/ETCS on-board or ERTMS/ATO.

5.1.1.5 Note: OMS will manage data on near Real Time basis. The term "Real Time" in this context means that data shall be available in accordance with the need of the relevant analysis to be performed by the trackside operator. It is to be considered that the availability of the radio network will affect the transfer of the data.

5.1.1.6 If more than one OMS on-board is installed on a vehicle, or if different vehicles with installed OMS are joined to one common train, all of them will send data to trackside. Note: Unnecessary information can be filtered by the trackside during the analysis, based on the ETCS mode.

5.1.1.7 In case of radio network unavailability, the OMS shall be able to buffer, over a defined period, all the messages until the radio connection becomes available.

5.1.1.8 OMS on-board buffer shall have the capability to store Data Collections generated in a working period of at least 24 hours, in case of temporary network unavailability. Oldest Data Collections will be deleted if the limit of the buffer is reached.

5.1.1.9 After a temporary network unavailability, when the connection becomes available, the OMS on-board shall send all the information in the buffer as fast as possible in order to clear the buffer. The system shall empty the buffer by the 'first-in first-out' principle (oldest data are sent first) when the connection is restored.

5.1.1.10 Note: In case of malfunction in the OMS on-board communication interface, the system should be put back in service as soon as possible, in order to retrieve all the information without loss. In fact, despite OMS on-board buffer and local memory, older data will be overwritten if the communication is not available for a long time. OMS trackside can send alerts to relevant RU in case a scheduled train is not sending data.

5.1.1.11 In addition to the buffer, Data Collections shall be retained in a local memory for a period of 20 days by OMS on-board. In case of necessity a local download of such data can be performed. This feature is intended to manage failure in the radio communication device. Data Collections shall be stored in the local memory even if they have been transmitted. Oldest Data Collections will be deleted if the limit of the memory is reached.

5.1.1.12 Note: If the radio link is available, the delivery of Data Collections to the OMS trackside will continue automatically. Otherwise, the delivery time depends on normal technical limitations of the radio transmission.

5.1.1.13 Note: OMS on-board manages GNSS information to tag Data Collections sent to trackside. The time between when fresh GNSS info is received and when it can be added to a Data Collection by OMS on-board is a latency to be considered. The GNSS information will be received from Train Time and Location Service [Ref 7].

5.1.1.14 The latency between having a Data Collection prepared from ERTMS/ETCS and the GNSS tag added by OMS shall be less than 3 seconds.

5.1.1.15 Such latency shall be a pre-defined amount of time, if the information does not come within it, the GNSS shall be considered as unavailable.

5.1.1.16 Note: Example for latency estimate:

Time to receive updated info from GNSS system +

Interface propagation time +

OMS on-board cycle time.

5.1.1.17 The estimated amount of such latency is a fixed configuration value depending on the architecture and on the freshness of GNSS data. It shall be specified in OMS Data Collection header.

5.1.1.18 A specific value in the message shall identify the condition of unavailability of GNSS information (refer to §5.2.2.12).

5.2 OMS Information Logic Structure

5.2.1.1 This section describes the logical structure of Data Collections to be sent by OMS on-board to trackside the intent is to describe the content. In §5.3 the JSON format to be used to build Data Collections is introduced.

5.2.1.2 OMS on-board shall send Data Collections to OMS trackside with the following structure:

FIELDS	Remarks	
NID_ENGINE	On-board ERTMS/ETCS identity	**Data Collection header**
NID_UIC	UIC unique vehicle number (if available)	
NID_OPERATIONAL	Train Running Number	
OMS_VERSION	OMS version	
GNSS_POSITION	GNSS coordinates and time indication associated to the Data Collection	
GNSS_LATENCY	Latency associated to GNSS information (Fixed value). Special value to identify GNSS unavailability.	
SS027_VERSION	Version of [Ref 2]. This is needed to be able to decode the data at the trackside consumer.	
SS140_VERSION	Version of [Ref 5]. This is needed to be able to decode the data at the trackside consumer.	
Messages	Messages received from ERTMS/ETCS and ERTMS/ATO on-boards and custom messages.	**Monitoring data**

5.2.1.3

5.2.2 Data Collections header Fields Description

5.2.2.1 NID_ENGINE

Description	This field contains the on-board ERTMS/ETCS identity.		
Content	**Variable**	**Length**	**Comment**
	NID_ENGINE	24	Defined in Chapter 7 of [Ref 1]

5.2.2.2 NID_UIC

Description	This field contains the vehicle identification number		
Content	**Variable**	**Length**	**Comment**
	TYPE_CODE	7	Vehicle Type code according to UIC [Ref 3]
	COUNTRY_CODE	7	Country code according to UIC [Ref 3]
	CLASS_NUMBER	14	National class number
	SERIAL_NUMBER	10	National serial number within the class
	CHECK_NUMBER	4	Check number [Ref 3]

5.2.2.3 TYPE_CODE

Name	TYPE_CODE		
Description	It is used to define the type of vehicle according to [Ref 3]		
Length of variable	**Minimum Value**	**Maximum Value**	**Resolution/formula**
7 bits	00	99	1 integer
Special/Reserved Values	100 … 126 127		not used … not used unknown

5.2.2.4 COUNTRY_CODE

Name	COUNTRY_CODE		
Description	It is used to define the country where the vehicle is registered according to [Ref 3]		
Length of variable	**Minimum Value**	**Maximum Value**	**Resolution/formula**
7 bits	00	99	1 integer
Special/Reserved Values	100 … 126 127		not used … not used unknown

5.2.2.5 CLASS_NUMBER

Name	CLASS_NUMBER		
Description	National vehicle class number		
Length of variable	**Minimum Value**	**Maximum Value**	**Resolution/formula**
14 bits	0000	9999	1 integer
Special/Reserved Values	10000 … 16382 16383		not used … not used unknown

5.2.2.6 SERIAL_NUMBER

Name	SERIAL_NUMBER		
Description	National serial number within the class		
Length of variable	**Minimum Value**	**Maximum Value**	**Resolution/formula**
10 bits	000	999	1 integer
Special/Reserved Values	1000 … 1022 1023		not used … not used unknown

5.2.2.7 CHECK_NUMBER

Name	CHECK_NUMBER		
Description	Check number according to [Ref 3]		
Length of variable	**Minimum Value**	**Maximum Value**	**Resolution/formula**
4 bits	0	9	1 integer
Special/Reserved Values	10 … 14 15		not used … not used unknown

5.2.2.8 NID_OPERATIONAL

Description	This field contains the Train Running Number		
Content	**Variable**	**Length**	**Comment**
	NID_OPERATIONAL	32	Defined in Chapter 7 of [Ref 1]

5.2.2.9 OMS_VERSION

Name	OMS_VERSION		
Description	This field contains the OMS Version		
Length of variable	**Minimum Value**	**Maximum Value**	**Resolution/formula**
8 bits	0	255	1 integer

5.2.2.10 OMS_Version value shall be specified by this subset. For OMS designed according to the current version, it shall be set to “0”. It will be incremented when a new version of this subset is created.

5.2.2.11 GNSS position and time

Name	GNSS_POSITION_LAT		
Description	Latitude in micro degrees associated to the Data Collection.		
Data Type	**Length**	**Resolution**	**Representation**
INT32 (signed)	32 bits / 4 Byte	0.000001°	Integer value is corresponding to the latitude in micro degrees in the WGS84 reference system Range: -90.000000° to +90.000000° +/- signifies North/South

Name	GNSS_POSITION_LONG		
Description	Longitude in micro degrees associated to the Data Collection		
Data Type	**Length**	**Resolution**	**Representation**
INT32 (signed)	32 bits / 4 Byte	0.000001°	Integer value is corresponding to the longitude in micro degrees in the WGS84 reference system Range: -180.000000° to +180.000000° +/- signifies East/West

Name	GNSS_TIME		
Description	Date and Time in seconds (UTC) associated to the Data Collection		
Data Type	**Length**	**Resolution**	**Representation**
String	20 char	1 s	Date and time in ISO 8601 time format converted into string, example: 2023-02-15T19:28:43Z

5.2.2.12 GNSS latency

Name	GNSS_LATENCY		
Description	This field contains the estimate of the latency associated to GNSS data.		
Length of variable	**Minimum Value**	**Maximum Value**	**Resolution/formula**
8 bits	0	200	100ms
Special/Reserved Values	201 … 254 255		not used … not used GNSS Info Not available

5.2.2.13 SS027_VERSION

Name	SS027_VERSION		
Description	This field indicates the version of the SUBSET-027 data contained in the Data Collection.		
Length of variable	**Format**		
String	xx.xx.xx		

5.2.2.14 SS140_VERSION

Name	SS140_VERSION		
Description	This field indicates the version of the SUBSET-140 data contained in the Data Collection.		
Length of variable	**Format**		
String	xx.xx.xx		

5.2.3 Monitoring data field description

5.2.3.1 Two types of messages contained in Data Collections are identified:

- Standard OMS messages as defined in [Ref 2] and [Ref 5]. They shall be managed in the generic analysis according to a standard tool by OMS operators.
- Custom messages. They contain specific data to be used by specialists for their internal improvements processes. The intended recipients are equipment manufacturers, RUs, keepers or other entities that may require additional data.

5.2.3.2 Standard OMS Messages. The following table defines the content of standard messages. Fields are defined in [Ref 2].

FIELDS	Remarks
NID_MESSAGE	Message identification number
TIME_STAMP	Current date and time (UTC)
T_TRAIN	Train borne Clock
TRAIN_POSITION	Current train position
V_TRAIN	Current train speed
SYSTEM_VERSION	Currently operated system version
LEVEL	Current level
MODE	Current mode
Complementary variables	Data associated to the message. Its length depends on the message content.

5.2.3.3 Custom OMS messages shall have the contents and the format as defined by equipment manufacturer or by the requestor. They shall have the following structure:

FIELDS	Remarks
Complementary variables	Data associated to the message. Its length depends on the message content.

5.3 JSON Data Collection Format

5.3.1 Data Collection structure

5.3.1.1 Each Data Collection sent to trackside shall be built in JSON format according to the following structure:

```
"properties"    : {
     "Header"              : {"ref"             : "CollectionHeader"},
                                                 // Header of the Data Collection
     "EtcsMessage"         : {"elements"        : {"ref": "EtcsMsg"}, "nullable": true},
                                                 // ERTMS/ETCS message
     "AtoMessage"          : {"elements"        : {"ref": "AtoMsg"}, "nullable": true},
                                                 // ERTMS/ETCS ATO message
     "CustomMessage"       : {"elements"        : {"ref": "CstmMsg"}, "nullable": true}
                                                 // Custommessage
                  }
```

5.3.2 Data Collection Header

5.3.2.1 The header of the Data Collection sent to trackside is built according to the following structure:

```
"definitions" : {
     "UniqueVehicleNumber" : {
                              "TypeCode"         : {"type": "int8"},
                              // Vehicle Type code according to UIC
                              "CountryCode"      : {"type": "int8"},
                              // Country code according to UIC
                              "ClassNumber"      : {"type": "int16"},
                              // National Class number
                              "SerialNumber"     : {"type": "int16"},
                              // National serial number within the class
                              "CheckNumber"      : {"type": "int8"}
                              // Check number according to UIC
                            },
     "SatelliteInfo"       : {
                              "GnssPositionLat"  : {"type": "int32"},
                               //Latitude of GNSS position in micro degrees (0.000001°)
                                                        in the WGS84 reference system
                              "GnssPositionLong" : {"type": "int32"},
                              //Longitude of GNSS position in micro degrees (0.000001°)
                                                        in the WGS84 reference system
                              "GnssTime"         : {"type": "string"}
                               //UTC time in ISO 8601 converted to string associated to
                                                                  the GNSS position
                            },
```

```
        "CollectionHeader"    : {"NidEngine"       : {"type": "int24"},
                                 // On-board ETCS identity NID_ENGINE according to SUBSET-026
                                 "NidUic"          : {"ref": "UniqueVehicleNumber"},
                                 // UIC unique vehicle number according to reference
                                 "NidOperational"  : {"type": "int32"},
                                 // Train running number NID_OPERATIONAL according to SUBSET-026
                                 "OmsVersion"      : {"type": "int8"},
                                 // OMS Version
                                 "GnssPosition"    : {"ref": "SatelliteInfo", "nullable": true},
                                 // GNSS Position and time according to reference
                                 "GnssLatency"     : {"type": "int8", "nullable": true},
                                 // Latency of GNSS position information
                                 "Ss027Version"    : {"type": "string", "nullable": true},
                                 // Version of SUBSET-027 data, used to decode the content
                                 "Ss140Version"    : {"type": "string", "nullable": true}
                                 // Version of SUBSET-140 data, used to decode the content
                               },
                    },
```

5.3.2.2 This Data Collection header shall only be present once at the beginning of each Data Collection sent to trackside.

5.3.3 ERTMS/ETCS message

5.3.3.1 A set of ERTMS/ETCS messages shall be sent to trackside within a Data Collection. The ERTMS/ETCS message itself shall be built according to the following structure:

```
"definitions" : {
        "EtcsMsg"             : {"Header"          : {"ref": "EtcsMsgHeader"},
                                 // Header of SUBSET-027 ETCS message
                                 "EtcsDataBase64"  : {"type": "string", "nullable": true}
                                 // Content of SUBSET-027 ETCS message encoded to Base64
                               },
                    },
```

5.3.4 ERTMS/ETCS message header

5.3.4.1 The header of the ERTMS/ETCS messages sent to trackside within a Data Collection shall be built according to the following structure (the structure is the one related to version SUBSET-027 Ver. 4.0.0 in case of former versions, the structure shall be project specific) :

```
"definitions" : {
        "EtcsTrnPostn"     : {"NID_SOLR"           : {"type": "int32"},
                              // Last relevant balise group NID_SOLR according to SUBSET-026
                              "D_SOLR"             : {"type": "int32"},
                              // Distance D_SOLR according to SUBSET-026 in 10 cm scale
                              "Q_DIRSOLR"          : {"type": "int8"},
```

```
                        // Train orientation Q_DIRSOLR according to SUBSET-026
                        "Q_DSOL"              : {"type": "int8"},
                        // Qualifier for front end Q_DSOLR according to SUBSET-026
                        "L_DOUBTOVER_SOLR"    : {"type": "int32"},
                        // Over-reading L_DOUBTOVER according to SUBSET-026 in 10 cm scale
                        "L_DOUBTUNDER_SOLR"   : {"type": "int32"}
                        // Under-reading L_DOUBTUNDER as in SUBSET-026 in 10 cm scale
                        "NidLrbg"             : {"type": "int32", "nullable": true },
                        // Last relevant balise group NID_LRBG according to SUBSET-026
                        "DLrbg"               : {"type": "int32", "nullable": true },
                        // Distance D_LRBG according to SUBSET-026 in 10 cm scale
                        "QDirLrbg"            : {"type": "int8", "nullable": true },
                        // Train orientation Q_DIRLRBG according to SUBSET-026
                        "QDLrbg"              : {"type": "int8", "nullable": true },
                        // Qualifier for front end Q_DLRBG according to SUBSET-026
                        "LDoubtover"          : {"type": "int32", "nullable": true },
                        // Over-reading L_DOUBTOVER according to SUBSET-026 in 10 cm scale
                        "LDoubtunder"         : {"type": "int32, "nullable": true "}
                        // Under-reading L_DOUBTUNDER as in SUBSET-026 in 10 cm scale

    },
    "EtcsMsgHeader"    : {"NidMessage"          : {"type": "int8"},
                        // Message identifier NID_MESSAGE according to SUBSET-027
                        " Year "              : {"type": "int8"},
                        // Year as defined in SUBSET-027
                        " Month "             : {"type": "int8"},
                        // Month as defined in SUBSET-027
                        " Day "               : {"type": "int8"},
                        // Day as defined in SUBSET-027
                        " Hour "              : {"type": "int8"},
                        // Hour as defined in SUBSET-027
                        " Minutes "           : {"type": "int8"},
                        // Minutes as defined in SUBSET-027
                        " Seconds "           : {"type": "int8"},
                        // Seconds as defined in SUBSET-027

                        "TTrain"              : {"type": "int32", "nullable": true},
                        // Trainborne clock T_TRAIN according to SUBSET-026
                        "TrainPosition"       : {"ref": "EtcsTrnPostn"},
                        // TRAIN_POSITION according to SUBSET-027
                        "VTrain"              : {"type": "int16"},
                        // Train speed V_TRAIN according to SUBSET-027
                        "SystemVersion"       : {"type": "int32"},
                        // Currently operated SYSTEM_VERSION according to SUBSET-027
                        "Level"               : {"type": "int8"},
```

```
                    // Currently operated LEVEL according to SUBSET-027
                    "Mode"                : {"type": "int8"}
                    // Currently operated MODE according to SUBSET-027
                },
            }
```

5.3.4.2 This ERTMS/ETCS message header shall only be present once at the beginning of each ERTMS/ETCS message contained in a Data Collection.

5.3.5 ERTMS/ATO message

5.3.5.1 A set of ERTMS/ATO messages can be sent to trackside within a Data Collection. The ERTMS/ATO message itself shall be built according to the following structure:

```
"definitions" : {
     "AtoMsg"              : {"Header"          : {"ref": "AtoMsgHeader"},
                              // Header of ATO message
                              "AtoDataBase64"    : {"type": "string", "nullable": true}
                              // Content of ATO message encoded to Base64
                             }
                    }
```

5.3.6 ERTMS/ATO message header

5.3.6.1 The header of the ERTMS/ATO messages sent to trackside within a Data Collection shall be built according to the following structure:

```
"definitions" : {
     "AtoMsgHeader"        : {"NidC"            : {"type": "int16"},
                              // Country identity number NID_C according to SUBSET-026
                              "NidSP"            : {"type": "int32"},
                              // Segment profile identity NID_SP according to SUBSET-126
                              "DSendingPosition": {"type": "int32"},
                              // Estimated front end position D_Sending_Position in cm
                              "VEst"             : {"type": "int32"}
                              // Estimated train speed V_EST according to SUBSET-130
                    }
```

5.3.6.2 This ERTMS/ATO message header shall only be present once at the beginning of each ERTMS/ATO message contained in a Data Collection.

5.3.7 Custom message

5.3.7.1 A set of custom proprietary messages can be sent to trackside within a Data Collection. The custom proprietary message itself shall be built according to the following structure:

```
"definitions" : {
     "CstmMsg"             : {"CustomId"        : {"type": "int8"},
                              // Identifier of the custom message indicating the supplier ID
                              "CstmDataBase64"   : {"type": "string", "nullable": true}
                              // Content of custom message encoded to Base64
                             }
                   }
```

5.4 OMS Trackside

5.4.1.1 The OMS trackside shall receive and store received data and provide an interface for accessing it.

5.4.1.2 The OMS trackside may be used by different operators, each of them may have different needs in terms of analysis.

5.4.1.3 OMS Data Collections shall be received by data owners (RUs or Train keepers).

5.4.1.4 Data owners will forward subsets of such data to IMs and other operators according to their needs and right, based on specific agreement with data owners.

5.4.1.5 Note: data to be sent to IMs will be identified by means of geographical criteria to be specified in specific agreements with RUs.

5.4.1.6 Note: data owners should agree to share these subsets of data. In case they don't, this will be a limitation on the OMS service.

5.4.1.7 Note: any laws and regulations related to data protection are not considered in this document, in any case data owners (RUs or train keepers) shall apply them to put in practice technical requirements specified in this document.

5.4.1.8 Note: RUs operators will have access to data generated by their trains. IMs operators may receive data generated by trains running on their infrastructure under specific agreement with RU. Operators from equipment suppliers may receive data generated by trains equipped with their products under specific agreement with RU. Other operators can be agreed for specific monitoring purposes under specific agreement with RU. The specific agreement between RUs and other operators will identify the subset of data to be forwarded.

5.4.1.9 The OMS trackside server shall provide an interface to receive Data Collections.

5.4.1.10 OMS trackside receiving server shall share data with entitled OMS trackside operators within 30 minutes after having received the data.

5.4.1.11 OMS trackside shall be considered the GNSS Latency in the analysis of the data in terms of confidence interval on the localisation. Such interval shall be computed from the estimated latency and the current train speed.

6 OMS Architecture

6.1 Logical Architecture

6.1.1.1 From a logical standpoint, the OMS consists of:

- A train borne part (OMS on-board) which receives and collects data from ERTMS/ETCS and ERTMS/ATO on-boards).
- A trackside part (OMS trackside) which receives monitoring information from trains in operation. It stores such information and provides an interface to operators according to their needs and access rights.
- A radio transmission infrastructure to permit data delivery from OMS on-board to OMS trackside.

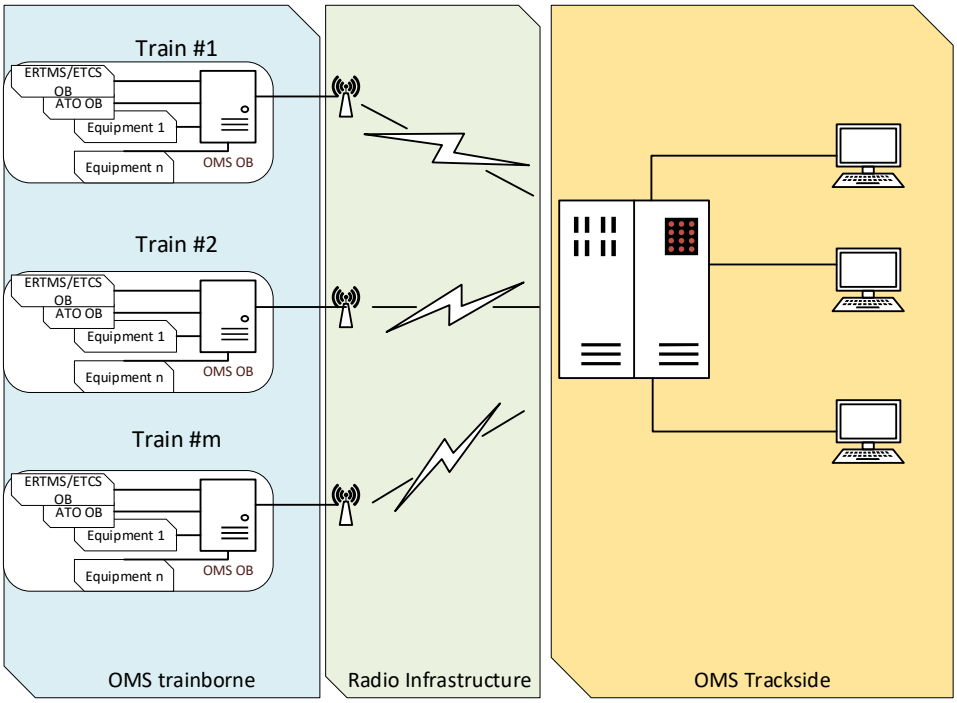

Figure 1 - OMS Architecture logical view

6.1.1.2 In Figure 1 the OMS logical architecture is depicted. Each OMS on-board collects data from OB equipment and transfers it to the OMS trackside. In the current version of this document, interfaces with ERTMS/ETCS and ERTMS/ATO on-boards are considered. The OMS trackside is shown as a central server, being a logical view. Such representation is intended to describe the concept.

6.1.1.3 Figure 2 shows the logical interface between OMS on-board and OMS trackside.

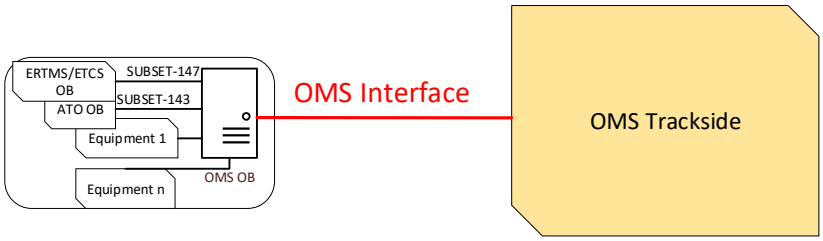

Figure 2 - Logical interface

6.2 Physical Architecture

6.2.1 OMS on-board

6.2.1.1 OMS on-board shall provide the interface towards the Radio Infrastructure.

6.2.1.2 OMS on-board consists of a logical component that can be implemented by means of a dedicated physical device or can be embedded inside an existing component.

6.2.1.3 Figure 3 shows the OMS on-board as a device installed on the vehicle.

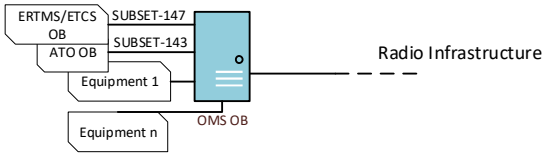

Figure 3 - OMS on-board as a physical device

6.2.1.4 Figure 4 shows the OMS on-board implemented in Equipment 1 as a logical function. External interfaces, depicted in solid line in the picture, are the same as the option in Figure 3.

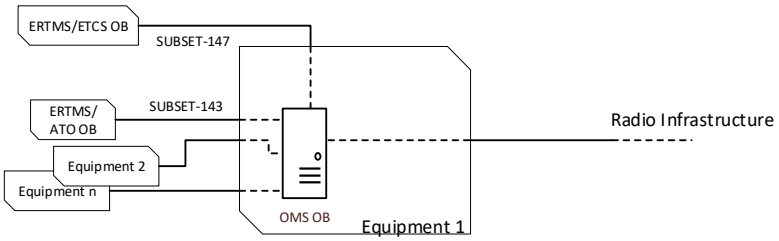

Figure 4 - OMS on-board as a logical function embedded in Equipment 1

6.2.2 Radio Infrastructure

6.2.2.1 OMS on-board shall use radio network services to transfer monitoring data to OMS trackside.

6.2.2.2 Note: possible network services are: 4G/5G networks (e.g. public networks), wi-fi, GSM-R PS or other systems to be defined at integration level.

6.2.2.3 Note: for future evolutions the transmission can be managed by means of the FRMCS as preferred solution, using OB_{APP} standardised interface.

6.2.2.4 In case a suitable radio connection device is available in the vehicle, it may be used by the OMS on-board as a preferred solution. A project specific protocol shall be defined.

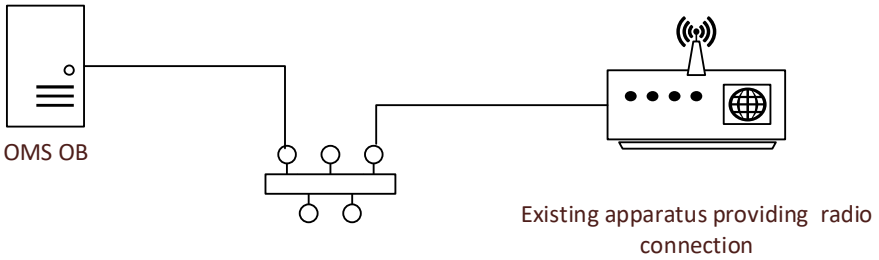

Figure 5 - OMS OB using an existing radio service device

6.2.2.5 In case the vehicle doesn't have any radio connection device available, the OMS on-board shall embed a dedicated modem to transfer data to the OMS trackside. Such modem shall work at least according to 4G standard and cover all frequencies used in Europe. In any case it shall work at least according to the current deployed standards in terms of radio communications.

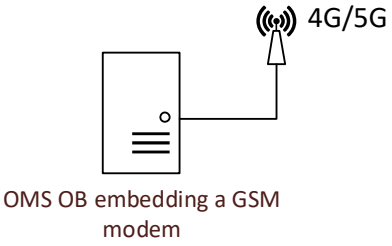

Figure 6 - OMS OB using its own 4G or 5G modem

6.2.3 OMS Trackside

6.2.3.1 Note: OMS trackside will consist of a number of local servers in different countries that shall be able to receive monitoring data from OMS on-board. Each country or operator can have one or more servers to implement OMS trackside. Receiving servers are expected to be managed by RU to which the train belongs or in any case by the keeper of the train. Each RU shall define to which server the OMS on-board has to connect, independently where the train is, regarding country/infrastructure. Each RU will have access to the data of any train in its fleet.

6.2.3.2 Trackside shall implement a scalable architecture in order to cope with a rising amount of data, e.g. as a cloud-based service.

6.2.3.3 The interface between OMS on-board and OMS trackside (refer to OMS Interface in § 6.1) shall be based on HTTPS [Ref 8].

6.2.3.4 All OMS trackside servers shall have the capability to share data among them where required.

6.2.3.5 OMS trackside server shall identify the proper set of Data Collections to be forwarded to each operator based on the specifically agreed criteria.

6.2.3.6 OMS trackside server shall send Data Collection to Data consumer operators keeping the same format and using HTTPS [Ref 8].

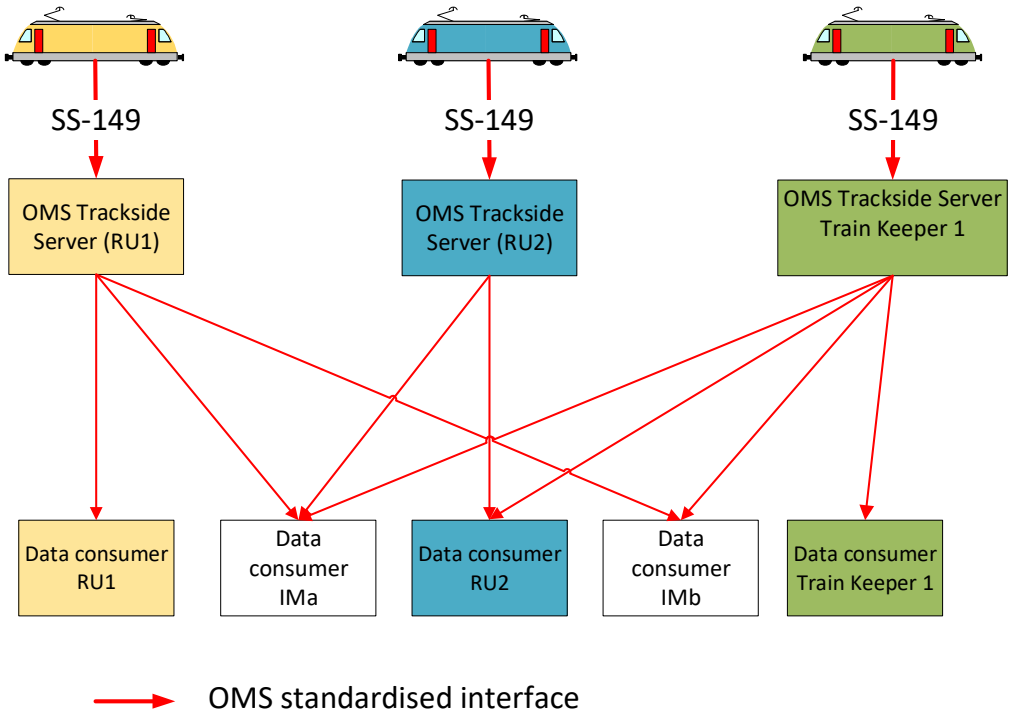

Figure 7 -Example of OMS trackside architecture

6.2.4 Example of existing architecture and its integration in OMS

6.2.4.1 Some RU may have in place a diagnostic system sending data to their server. This paragraph considers a possible integration within the OMS. Data are sent by existing trackside server client (diagnostic system server) directly to the OMS Trackside. The interface between the existing monitoring system and the OMS trackside (OMS Interface) shall convey the same Data Collections, in terms of data format and protocol, as if they were received from the OMS on-board. Basically, it shall provide the same interface.

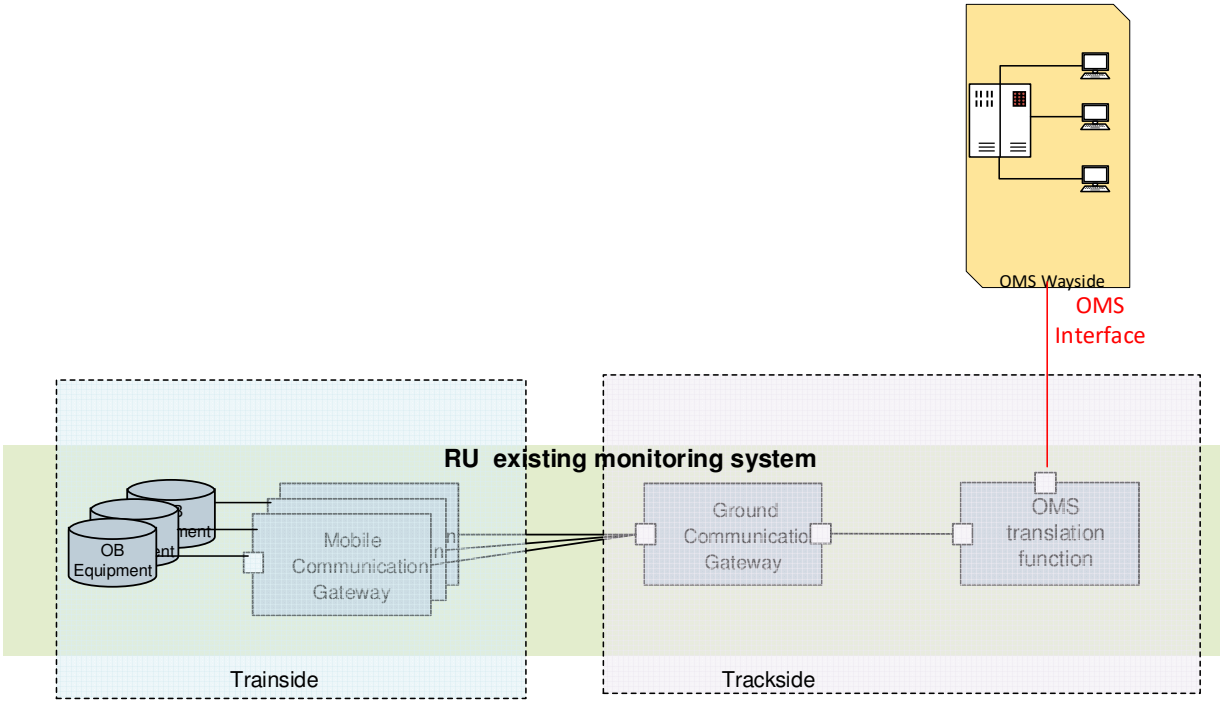

Figure 8 – Example of existing architecture

7 OMS On-board Interfaces

7.1 OMS - ERTMS/ETCS Interface

7.1.1.1 In the current version of this document, monitoring data are generated by ERTMS/ETCS and ERTMS/ATO on-boards. In case there is an update of the [Ref 2] or [Ref 5], changes of the dataset will be reflected in OMS. Other equipment and their relevant interfaces will be described in future versions of this document.

7.1.1.2 OMS on-board, when it is a physical device, shall provide an Ethernet interface compliant with [Ref 7] to receive monitoring data.

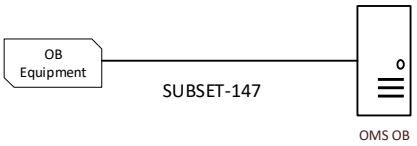

Figure 9 - OMS on-board - ERTMS/ETCS on-board interface

7.1.1.3 Note: The interface mentioned in 7.1.1.2 is applicable for OMS installed on new trains; On existing installation, in order to manage the transition phase, existing legacy busses and communication stacks can be reused to interface the OMS.

7.1.1.4 An equipment (ERTMS/ETCS and ERTMS/ATO on-boards, …) shall send its monitoring data to the OMS on-board only when it is capable to do so. E.g.: ERTMS/ETCS on-board is not required to provide data after entering in NP, SF, IS to OMS on-board.

7.2 OMS – Train Time and Location Service Interface

7.2.1.1 GNSS coordinates shall be included in OMS data in order to provide an absolute geographical reference, useful for the analysis.

7.2.1.2 OMS on-board shall receive the GNSS data from the Train Time and Location Service, if available, as preferred solution [Ref 7]. In this case the interface shall be the one defined for the Train Time and Location Service.

7.2.1.3 Note: GNSS position will allow events to be easily correlated with train position. Moreover, it could permit to follow the train path on a map.

7.2.1.4 Each OMS on-board Data Collection sent to the OMS Trackside shall contain GNSS coordinates.

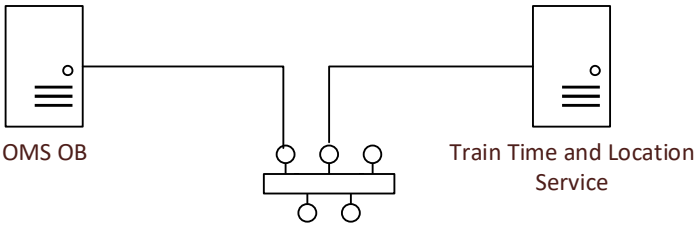

Figure 10 - OMS receiving GNSS data from Train Time and Location Service

7.2.1.5 Note: This solution is applicable for new trains where the Train Time and Location Service will be available. The following two alternatives are conceived for retrofit of existing installations.

7.2.1.6 As an alternative, in case another existing GNSS source is available in the CCS or vehicle, it may be used by the OMS on-board. A project specific protocol shall be defined at specific application level.

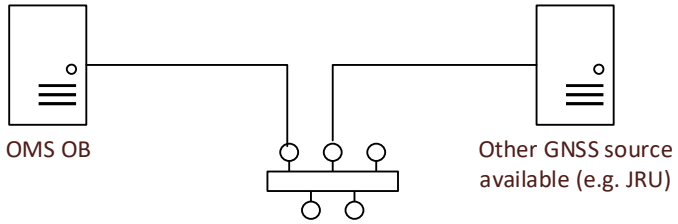

Figure 11 - OMS receiving GNSS data from existing sources on the vehicle

7.2.1.7 As an alternative: in case there is no other GNSS source available, the Train Time and Location Service can be implemented in OMS on-board using a dedicated GNSS receiver.

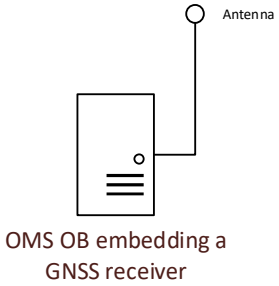

Figure 12 - OMS embedding a GNSS receiver and implementing Train Time and Location Service

7.3 OMS Trackside Interface

7.3.1.1 OMS on-board shall establish and maintain connection with a pre-defined trackside server to send monitoring data.

7.3.1.2 A set of parameters shall be configurable within the OMS on-board:

- OMS – Trackside Server address (IP address)
- Distance of the GNSS antenna to the front of the train
- GNSS Latency
- OMS On Board IP address

- NID_ENGINE
- NID_UIC

7.3.1.3 The connection is established at the start-up with a server and never changed, even in case of border crossing.

7.3.1.4 In case the connection drops, the OMS on board will establish a new one.

8 Safety and Cybersecurity Requirements

8.1.1.1 The OMS is not safety related, no SIL is required for this function.

8.1.1.2 The OMS will be verified in terms of Cybersecurity, according [Ref 4], in conjunction with the whole CCS architecture. Its security level shall be defined at integration level.