OCORA

Open CCS On-board Reference Architecture

Proof of Concept SUBSET-149

Results

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Management Summary

This preliminary report describes the findings from the proof of concept for SUBSET-149, which specifies in its current edition an online monitoring system for the ETCS system.

For the proof of concept, this year two vehicles of a Swiss Railway Undertaking were equipped with OMS (Online Monitoring System) onboard units. For the onboard and server infrastructure as well as the SW implementation of the monitoring system, a system solution from the railway-experienced company Railnova was chosen in order to reduce risks. In regular operation the vehicles run exclusively on ETCS Level 1 LS lines.

Due to problems with data availability that have not been solved yet, final statements about the feasibility of the SUBSET-149 regarding the monitoring of ETCS on- and offboard are mainly based on analyses of the specifications in the referenced documents. By the next release, this shall be worked through and enriched with experience from the vehicles' operation.

Revision history

Version	Change Description	Initial	Date of change
0.x	▪ Initial draft	TF	19.06.2023
0.1	▪ Final version for OCORA Release R4	TF	30.06.2023
1.0	▪ Updated version for OCORA Release R5	TF	17.11.2023

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References

Reader's note: please be aware that the numbers in square brackets, e.g. [1], as per the list of referenced documents below, is used throughout this document to indicate the references to external documents. Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). OCORA always reference to the latest available official version of the SUBSET, unless indicated differently.

[1] OCORA-BWS01-010 – Release Notes

[2] OCORA-BWS01-020 – Glossary

[3] OCORA-BWS01-030 – Question and Answers

[4] OCORA-BWS01-040 – Feedback Form

[5] OCORA-BWS03-010 – Introduction to OCORA

[6] OCORA-BWS03-020 – Guiding Principles

[7] OCORA-BWS04-010 – Problem Statements

[8] OCORA-TWS15-050 – PoC SS-149 Concept description

[9] MVB ETCS Verkabelung_Rotstift.pdf - Red pencil drawing of the Railster and interposer integration in the MVB ring bus

[10] SUBSET-149: Online Monitoring System, Version 0.0.8

[11] SUBSET-027: FIS Juridical Recording, Version 3.1.0

[12] Generisches Lastenheft Online Monitoring auf ETCS Fahrzeugen, Version 1.3.3

1 Introduction

1.1 Purpose of the document

The purpose of this document is to describe the preliminary results of the proof of concept of SUBSET-149 [10]. The development of [10] is in the responsibility of UNISIG as part of UNIFE in the working group for the implementation of CR 1362. OCORA project participants were also involved in the development as part of the RU resources on SBB side. This proof of concept was initiated to gain knowledge about implementation possibilities.

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA concepts for on-board CCS. The reader is invited to provide feedback to the OCORA collaboration and can, therefore, engage in shaping OCORA. Feedback to this document and to any other OCORA documentation can be given by using the feedback form [4].

If you are a Railway Undertaking, you may find useful information to compile tenders for OCORA compliant CCS building blocks, complete on-board CCS system, or on-board CCS replacements for functional upgrades or life-cycle reasons.

If you are an organization interested in developing on-board CCS building blocks according to the OCORA standard, information provided in this document can be used as input for your development.

1.2 Applicability of the document

The present document is considered informative for OCORA compliant on-board CCS solutions. Subsequent releases of this document will be developed based on a modular and iterative approach, evolving within the progress of the proof of concept for SUBSET-149.

1.3 Context of the document

This document is published as part of an OCORA Release, together with the documents listed in the Release Notes [1]. Before reading this document, it is recommended to read the Release Notes. If you are interested in the context and the motivation that drives OCORA we recommend reading the Introduction to OCORA [5], the Guiding Principles [6], and the Problem Statements [7]. The reader should also be aware of the Glossary [2] and the Question and Answers [3].

2 Framework of proof of concept

Within the framework of this proof of concept, the specifications from SUBSET-149 [10] are to be implemented in two test vehicles and an OMS wayside environment is to be created.

After various discussions on the feasibility of implementation on vehicles operated internationally by DB AG, as a company involved in the OCORA project, it was decided to carry out the proof of concept with a Swiss operator. As a result, two vehicles with a Siemens Baseline 3 SUBSET-26 version 3.4.0 ETCS system could be equipped with the OMS prototypes. In regular operation, the vehicles run exclusively on ETCS Level 1 LS routes. ETCS Level 2 routes are only operated sporadically in the event of short-term changes to the vehicle circulation.

Version 0.0.6 of SUBSET-149 was used as the basis for the implementation. A list of the implemented functions is provided in chapter 6. Since the test vehicles are not equipped with an ATO system and no custom messages have been defined so far, the information to be transmitted to the server side is limited to the messages according to SUBSET-027 [11].

Because a defined interface for the transfer of OMS data from the EVC has not existed up to now, the solution for the proof of concept had to choose a different data access point. From a safety point of view, however, it was absolutely necessary that the data access is implemented without any retroactive effect and thus while maintaining the currently valid safety verification for the ETCS system.

For Railnova's solution, an extensive verification dossier was available, which also includes an expert opinion on the non-intrusiveness of the reading device, the interposer. This allows the reading of data on the ETCS internal bus.

The proof of concept implementation takes advantage of Railnova services both for the OMS unit on the vehicle and for storing, viewing and evaluating the OMS data. In principle, the structure corresponds to the “Alternative architecture” described in chapter 3.2.4 of SUBSET-149.

The first installation could finally be carried out on 12.01.2023, the second on 15.05.2023.

3 Installation and implementation

3.1 Installation and data acquisition

As already described in the concept description [8] the Railster UG2 installation on the vehicle is relatively simple. It requires a sniffing device to read the data between the EVC and JRU on the MVB, a connection to the power supply protected with an adequate circuit braker, an antenna to receive the GNSS data, as well as to transmit via mobile network data to the server as well as grounding of the potentially current-carrying surfaces and parts in the event of a fault.

The Railster UG2 is a hardware device containing a Linux computation unit with digital and analogue interfaces. The Railster functionality is to read and process data from various sources and forward the data to the server. In case it is required the Railster may also store data temporarily.
The Railster UG2 has a GNSS input and transmits the data collected and processed through public mobile networks.

For the purpose of this proof of concept, only one data input is required. Data is only read via a sniffing device called “MVB interposer”, collecting the data non-intrusively. This is based on a two-stage principle: First, the Railster UG2 is passive by design, as its internal MVB-dedicated FPGA is only reading the signals coming from the MVB Interposer cable. The Railster UG2 firmware doesn't include functions for implementing active MVB features. Second, the MVB interposer only sends a copy of the signals transmitted on the MVB network to the Railster UG2. This passivity by design ensures that the Railster UG2 cannot interfere with the MVB network. The Railster reads only the data from one of the two redundant MVB lines. The interposer is inserted as a DB9 connector at an existing connection point of the MVB.The absence of retroactive effects is supported by technical analysis and an expert opinion.

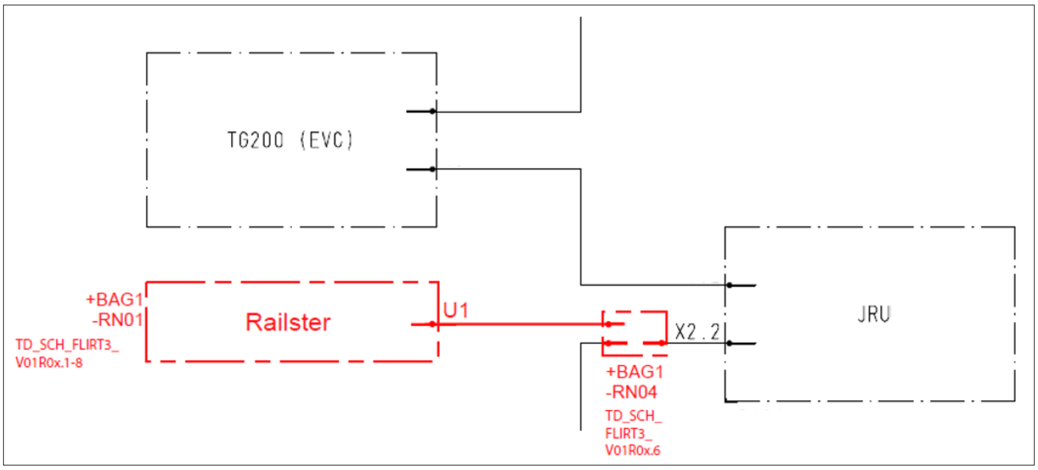

Figure 1 Excerpt from the red pencil drawing of the Railster and interposer integration in the MVB overview diagram [9]

The necessary GNSS/mobile radio combination antenna was placed under the GRP bonnet of the driver's cab. Sufficient distance to antennas of safety-relevant systems was ensured. The specifications of the GSM-R network operator and Swiss GSM-R system manager SBB Telecom are complied with.

The power supply is protected by a separate two-pole CB. The Railster is directly connected to the battery voltage and is thus charged even without the main switch being switched on.

Figure 2 Photo of the Railster installation in the ETCS cabinet
From top to bottom: the Railster UG2 mounted on a slide-in unit, the JRU HaslerRail Teloc 3000 as well as the MVB interposer installed on the JRU-MVB connection X2.2 and the Siemens EVC Trainguard 200.

For the installation, compliance with common railway standards (EN 50155, EN 45545 as well as IEC61375-3-1), as well as further specifications for EMC and antenna positioning of the GSM-R system leader in Switzerland were evaluated. Following each installation, commissioning tests and a SIOP-B were carried out.

3.2 Software implementation

To prove the functional suitability of the SUBSET-149, the existing Railnova SW suite was used. Adaptations were only implemented explicitly where the SUBSET-149 specifies a different solution.

As a general approach the Railnova SW stack is based as much as possible on open-source software subject to long term support releases and permissive licenses such as MIT or BSD. The data transfer between Railster and server is done via MQTT. The Railster devices communicate over the mobile network (GPRS/3G/4G) using TLS1.2 encryption. For the purposes of the SS-149 proof of concept, only mobile data transmission is used. When connected to the mobile network, the Railster is within a private IP network using Network Address Translation (NAT) to connect to Railnova's servers. More specifically, it means that the Railster has a local IP only.

The setup also offers the capability to check for, transmit and execute over the air updates of the firmware, OS patches and Linux Kernel updates to cope with security related updates.

The OMS data is stored on Railnova's servers. The view of the data is possible via a web-accessible dashboard. The platform also allows the creation of rules for the triggering of alerts.

To protect the on-board and off-board equipment from unauthorised access, Railnova has implemented extensive technical measures, specifications and processes, which will not be further elaborated.

As described above, the data of the MVB is read and decoded by the FPGA according to the different layers of the data stream, the relevant data is identified according to SUBSET-027 and the format is transposed according to SUBSET-149.

SUBSET-149 does not actually provide for decoding the message content.

```
"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
                            },
                  },
```

Figure 3 Specification for ETCS message content in SUBSET 149, chap. 3.3.3 [10]

In order to be able to generate the alarms in accordance with the specifications of the Swiss Online Monitoring System [12] within the proof of concept the message type NID = 6 and NID = 12 are also decoded, unlike in SUBSET-149. It is not necessary to make the complete content readable, but only those variables which are relevant for the Swiss OMS.

NID_Message 12 BALISE GROUP ERROR

- NID_C
- NID_ERRORBG
- M_ERROR

NID_Message 6 TELEGRAM FROM BALISE

- NID_C
- NID_BG
- M_COUNT
- NID_PACKET

For the NID = 6 messages, it must be taken into account that these can contain several telegrams (NID_PACKET). Decryption in the online dashboard was only agreed with Railnova in October 2023 and has not yet been rolled out.

4 Proof of concept experience

4.1 Data validation

To reduce risks and ensure feasibility, Railnova as potential supplier for the proof of concept was invited to carry out tests on the vehicle in June 2022.

During this visit, based on Railnova's know-how and knowledge of the MVB implementation in other projects, an attempt was made to make the data on the MVB readable in relation to SUBSET-027. From this site visit, specific activities for the implementation of the readability of the necessary signals could be defined, the feasibility in principle was assessed as positive.

After the installation of the first unit and for data validation, JRU data was read from the vehicle, the data according to SUBSET-027 was converted into a readable format, and then compared with the records of the OMS. The comparison showed, however, that only roughly half of the data was processed by the OMS.

The situation will be exposed in more detail below in order to highlight the challenges of the non-proprietary solution that is independent of the OBU supplier.

Figure 4 represents the NID_MESSAGE of detected messages over the recording duration for the data of the first installation, whereas each point indicates a detected message. As defined in SUBSET-027, a message every five seconds would be expected. As can be clearly recognized in this specific example, there's a gap of approximately two-minutes in the data, which is repeated cyclically, meaning that this phenomenon occurs periodically.

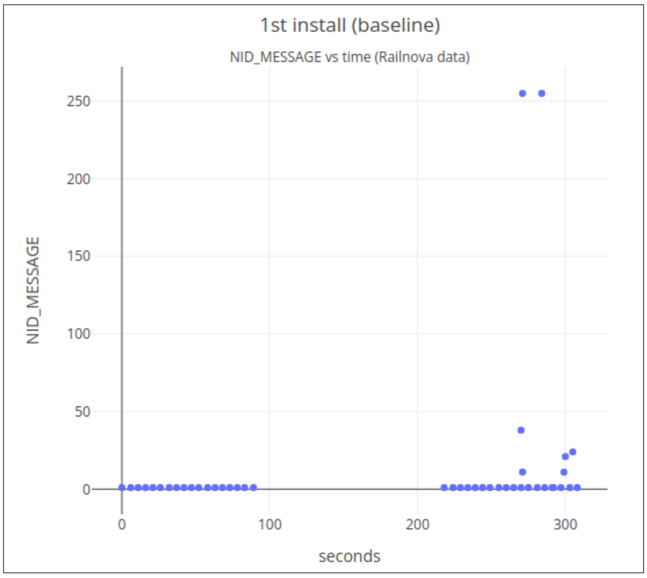

Figure 4 First installation: Representation of NID_MESSAGE of detected messages over the recording duration, each point describes a detected message.

The data acquisition alternates between high acquisition rates (>~95%) and low acquisition rates (~ 0%). In total only about 48% of the data packets are processed by the OMS (compared to the JRU data).

This was observed in both vehicles, but with different characteristics: While virtually no messages at all could be read in the two-minutes gaps in the first installation, this is not the case in the second installation, meaning that here other messages on the MVB, beside the messages according to SUBSET-027, could be detected. However, here too, no messages concerning the SUBSET-027 and the JRU could be read.

To further isolate the cause, a double interposer was used during the second installation so that the two redundant lines of the MVB could be read. Having the double interposer installed shouldn't have changed anything. But it did.

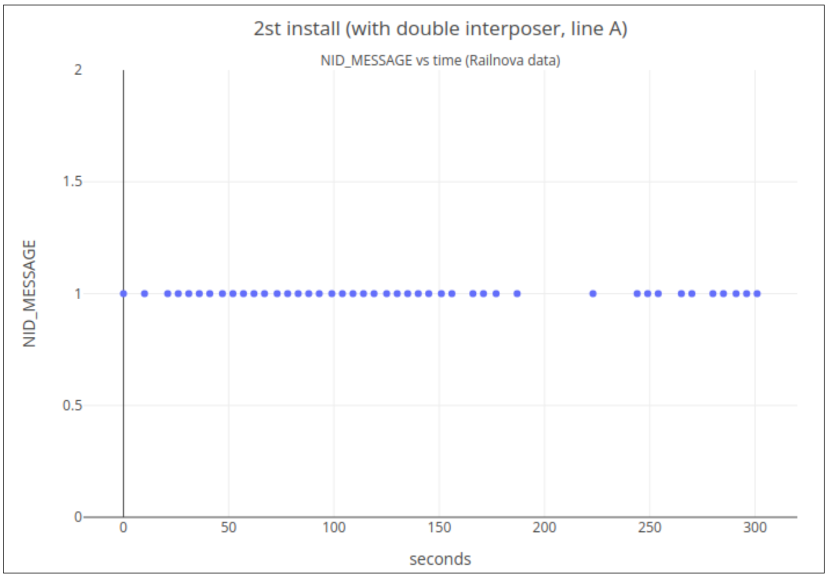

Figure 5 Second installation, double Interposer, MVB line A: Representation of NID_MESSAGE of detected messages over the recording duration

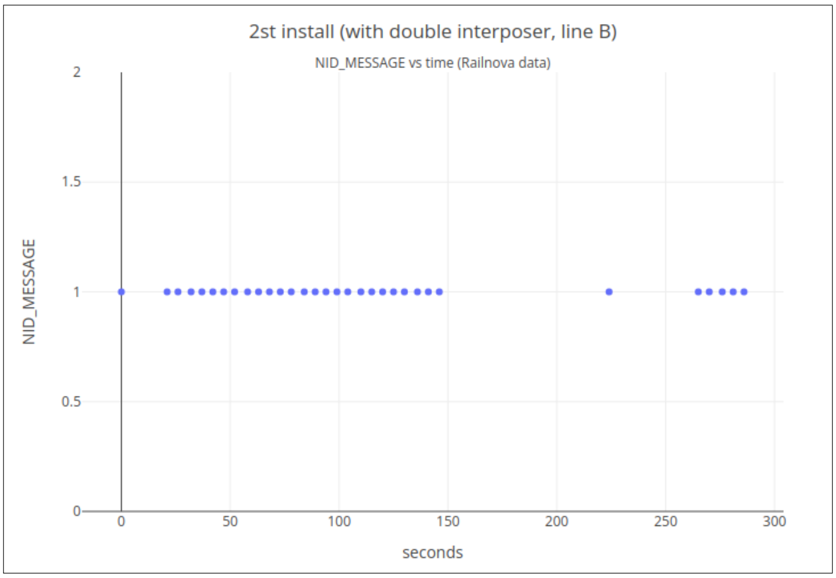

Figure 6 Second installation, double Interposer, MVB line B: Representation of NID_MESSAGE of detected messages over the recording duration

Figure 5 and **Figure 6** show the messages according to SUBSET-027 received over time with the double interposer installed within the same period. The "Line A" figure shows the data on the A line of the MVB; "Line B", on the B line of the MVB. Sensibly it was expected that the data on the two different lines would be the same.

Also, when looking at the detection rate of the overall MVB messages with the double interposer installed, the data acquisition rate is much better on “Line A” than on “Line B”. And both are better than with the simple interposer installed. Again, assuming no significant difference regarding transmitted data and signal quality between both lines, the only varying factor is the cabling / interposer.

To conclude, it can be stated that the MVB signal quality at the specific connection points fluctuates with a two-minute periodicity. These variations are not significant enough to affect the JRU data acquisition, but somehow, they do impact the MVB interposers to different extents. This suggests a signal loss on the analog level that isn't considered in the implemented setup, yet, but also isn't present in any other fleet Railnova is familiar with.

However, the next steps would be to change the data access point, checking whether the same occurrences can be seen also there. Further, it would be required to collect extensive analog-level data to pinpoint where exactly the signal is losing integrity.

In a further vehicle test on the vehicle on 07.07.2023, the interposer was placed at other interfaces, directly at the MVB port of the EVC (X4) and at the second port of the JRU (X3.2). The tests were repeated with both, the standard and the double interposer, which records both MVB lines.

During the tests, the same behaviour was observed as before as shown in **Figure 7**. Accordingly, the involvement of the ETCS supplier Siemens was driven forward following the test. Following consultation with the operator of the vehicles, a further vehicle test is currently being planned. This is scheduled to take place at the beginning of December 2024.

The test programme has not yet been finalised. The main focus will be on measuring the analogue signals at various points from the MVB to the processing unit in the Railster. In addition, comparative recordings will be made with other MVB readers.

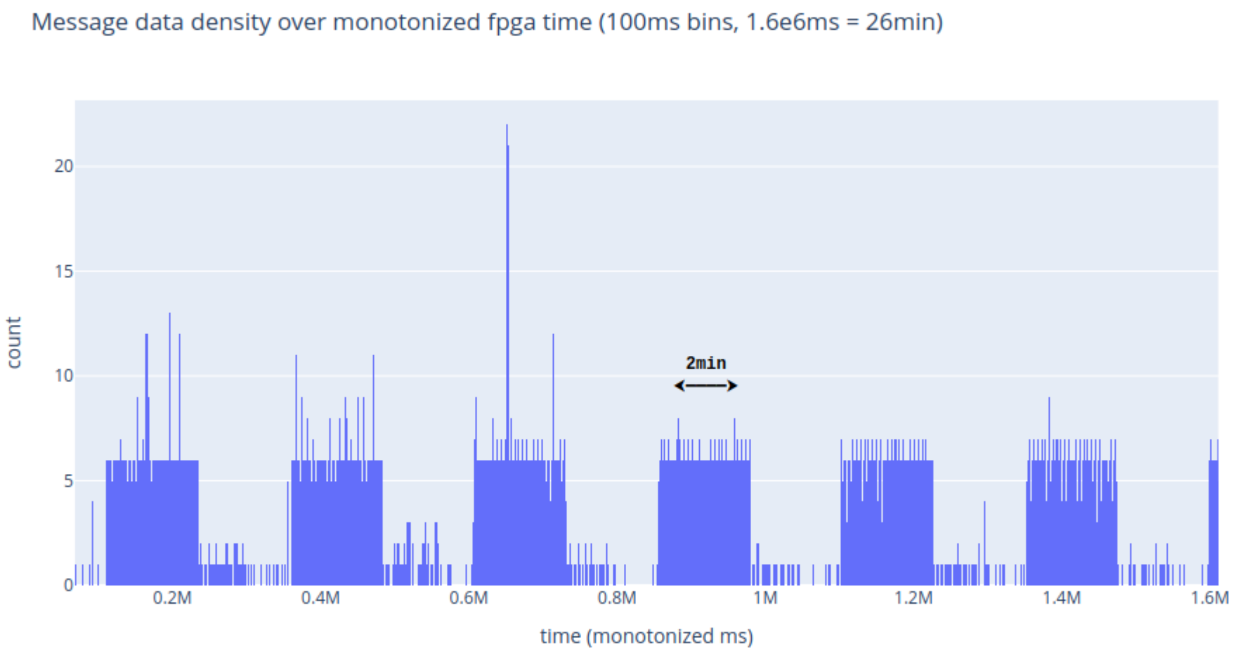

Figure 7 Additional vehicle test: Message density at port X4

For the SUBSET-149, it can be summarized that without the possibility to implement a specific and standardized interface with a corresponding specification, for third-party providers it is a challenge to acquire the requested data in the given format and in its completeness.

4.2 Observed anomalies

4.2.1 Infrastructure monitoring

As part of the proof of concept, alerts on infrastructure faults have not yet been compared with data from the SBB Infrastructure - Online Monitoring System. The reason for this is that data validation has not yet been completed.

Over the observation period, based on the available stored data of the OMS, so far only one event could be evaluated: inconsistent balise telegrams with the generation of the SUBSET-027 telegram with NID_MESSAGE = 12, BALISE GROUP ERROR.

- **Date, Time:** **28.05.2023**, **23:35:52**
  NID_LRBG: 453-8922

By using in the evaluation the vehicle's GNSS data it can be remarked that the error messages appeared immediately after a direction change. As a result, it is assumed that the ETCS balise antenna of the vehicle came to a stop between two balises of a balise group, before the change of direction occurred.

No further message with NID_MESSAGE = 12 could be detected in the further course of the PoC.

4.2.2 Onboard monitoring

To identify the added value of the SUBSET-149 in terms of detecting issues on the onboard side, it was possible to compare the stored data with the vehicle diagnostics recording.

Regarding the ETCS system, the following issues are relevant over the observation period:

- **Date, Time**: **11.05.2023 12:11:05**
  ETCS: Time disturbed
- **Date, Time: 03.05.2023 09:44:36**
  ETCS: Level not plausible
- **Date, Time: 02.05.2023 15:46:59**
  ETCS: Time disturbed

These issues occurred during periods when there were no records of OMS data available due to the two minutes gaps.

- **Date, Time: 11.04.2023 16:19:14**
  ETCS: Internal error of the NVC
- **Date, Time: 25.07.2023 06:52:32**
  ETCS: Failure subsystems (NVC)

For these issues, no conspicuous message is stored in OMS data either. This and the fact that no forced reaction is triggered may be related to the fact that the message is generated in the non-safe part of the ETCS (Non Vital Computer, contains functionalities regarding the diagnosis and the non-safe data transmission).

- **Date, Time: 30.06.2023 04:30 & 12.08.2023 06:45**
  ETCS: No acoustic confirmation for entries

No messages according to SS-027 could be found for these reported malfunctions. As a result, the displays were replaced.

- **Date, Time: 31.07.23 07:11**
  ETCS: Forced braking, when passing an open signal

The emergency braking could be traced in the ETCS data, but no cause could be identified.

A reliable statement about which disturbances can be detected by the SUBSET-149 in the basic configuration is therefore not yet possible.

4.3 Volume of data stream and storage

Within the setup of the proof of concept, the data volumes indicated in **Table 1** were handled with regard to data acquisition and storage.

	Date of OMS activation	OMS operating time	# of OMS messages		Volume of OMS data	
			measured	corrected	measured	corrected
Vehicle #1	2023-03-29 15:25	82 d, 21 h	737’600	1’536’700	647 MB	1’348 MB
Vehicle #2	2023-05-15 11:32	36 d, 01 h	358’600	747’083	315 MB	656 MB

Table 1 Representation of the volume of data stream and storage, the corrected values respect a data acquisition rate of 48 %

The operating time of the OMS can be simplified as the operating time of the vehicle. The vehicles are not switched off even when stationary, so that at least GENERAL MESSAGES are generated every 5 seconds.

If we also consider the availability of the OMS data for only about 48% of the whole generated data, the following averaged values for one hour of operation result, based on OMS data exclusively containing messages according to SUBSET-027:

- Number of messages ca. 850 messages per hour
- Volume of OMS data 0.7 MB per hour

4.4 SUBSET-149 analysis from monitoring and operationalisation perspective

4.4.1 Feasibility for infrastructure monitoring: Comparison with the requirements of Swiss ETCS System Manager's Online Monitoring System

In the generic ETCS System Manager's Guide for Online Monitoring on ETCS Rolling Stock in Switzerland, which is used as part of the Notified National Technical Rules in Switzerland (NNTR CH-TSI CCS-026 "Online Monitoring of Trackside Equipment on Rolling Stock", version 2.1), the functional requirements for fault and positive messages from OMS systems, implemented on rolling stock with ETCS BL3-OBU, are defined in chapters 3.1 and 3.2.

The notifications to be generated are based on Track-To-Train telegrams (or messages) content, as well as on status parameters of the ETCS system (train number, time and date, train position reports).

For the SUBSET-149 it can be summarized, as the information is part of the data transmitted to the JRU according to SUBSET-027, that this data is available in the messages according to SUBSET-149. From a Swiss point of view, this allows implementing the monitoring function of the ETCS offboard elements at least to the same level as it is done today.

The main difference between the currently operational solution and the SUBSET-149 is that currently the data is evaluated onboard, and the concentrated results are then sent to trackside. With SUBSET-149 the whole data is sent to trackside where the evaluation process has then to be performed. Basically, the entity responsible for the data evaluation (and the required computation resources) has been moved from on- to offboard.

4.4.2 Feasibility for Onboard monitoring

In addition to the monitoring of fix defined messages according to the SUBSET-027, additional messages can be recorded with the NID_MESSAGE 255 - ETCS ON-BOARD PROPRIETARY JURIDICAL DATA. These messages can also be defined on behalf of a vehicle owner by the OBU supplier. The practicability of this implementation, respective the consideration of a possibility to configure these messages in the context of the gradual further development, conditional recertification, and the associated costs, depends on the implementation of the OBU supplier.

For the SUBSET-149, it can be stated, that the subset also allows the generation of additional messages with the creation of custom messages. However, it must be taken into account that this is done by the onboard device of the OMS, thus only data transmitted by the EVC or other onboard sources are available for the message generation.

On any account, a flexible technical solution should be implemented for the management of the OMS onboard application regarding custom messages.

4.4.3 SUBSET-149 operationalisation

So far, the operationalization of SUBSET-149, and thus also legal issues, is not part of the working group. Also, in the context of the proof of concept, the situation of the vehicles could not be emulated according to the complexity of international traffic. The following considerations are therefore based on indications of the previous version of the SUBSET-149 (available at the setup time). The latest version 0.0.7, which was issued on 16.06.2023, does not include these points yet, but the need for agreements to enable the exchange of data between the involved parties is included as remarks.

Due to the internationalization and liberalization of rail transport, especially rail freight transport, in recent years there has been a market segregation in fleet responsibility. As a result, the business model of the classical integrated operator, which is owner, keeper (and ECM) and exclusive operator of the vehicles, is becoming increasingly rare. Instead, transports are handled in partnerships of several RUs across national borders with the common use of the same traction unit. Further, traction units are rented from leasing companies on a short or medium-term basis, whereby the keeper responsibility mostly remains with the keeper.

According to chapter 5.3.1.1 of SUBSET-149, the data of an OMS should always be transmitted to the same server without handover between different servers. The server address is subsequently part of the (static) configuration data, see chapter 5.3.1.2. Implicitly, the responsibility for the OMS wayside server is thus attributed to the vehicle owner.

Since the train operations are in the responsibility of the RU which has registered the train journey at the respective infrastructure manager, to the specific users only access to the data is granted relevant for the train journey they are considered as responsible for. To implement this in an automated way, the train routing information must be provided by the IM. The assignment of the OMS SUBSET-149 data of a specific vehicle to the respective RU can then be realized depending on the implementation of the signaling infrastructure by evaluating either the train number, or the timestamp and the GNSS position data from the header of the SUBSET-149 messages, alternatively the train position data (NID_LRBG) from the header of the SUBSET-027 message can be used.

To pass the information from journey data to the infrastructure managers, agreements between the RUs and IMs and possibly between keeper and RU are also necessary. This can be done via obligations in the form of NNTRs, or the inclusion of corresponding requirements in the network access agreement, and/or possibly via separate bilateral agreements. At the same time, from a data privacy point of view, it is not realistic that IMs have access to the complete data according to SUBSET-149, but only have access to information that is relevant for the provision of their infrastructure services.

The same applies to additional custom messages, which can be defined by the OBU manufacturers (or others). The forwarding of these messages to the designated party also requires corresponding agreements between the parties with access rights related to the data and the onboard equipment.

It can therefore be summarized, that in addition to agreements between the parties regarding data access and transmission, the OMS wayside application needs to provide functions for OMS data management, filtering and forwarding. Besides general issues such as security, these specific functions can be summarized based on the above considerations as follows:

- acquisition and processing of routing data from the infrastructure managers. This is used for allocation of the SUBSET-149 data to the relevant RU.
- allocation and forwarding of SUBSET-149 data to the responsible RUs.
- filtering of SUBSET-149 data and provision of information according to the agreements to the relevant infrastructure managers.
- forwarding of custom messages from the SUBSET-149 to the OBU manufacturers (or others).
- flexible configuration of the interfaces for data and information forwarding in terms of recipient, active period, data provided and information depending on country of operation, RU and network operator.

5 Further proceeding

After the positive validation, there is a regular evaluation and exchange with the keeper and IM about anomalies to support and evaluate the benefit of SUBSET-149 regarding ETCS monitoring.

After a sufficiently long period of operation, the collected findings are synchronized in workshops and the task of the workstream is reported based on this.

The publication of the final results is planned for the OCORA Release 6.

6 Appendix

Functionalities of SUBSET-149 considered in the proof of concept, according to SUBSET-149 version 0.0.5, but already including the proposal of JSON formatting are shown in **Table 2**. In terms of content, the differences between the SUBSET versions 0.0.6. and this version 0.0.5 are exclusively of editorial nature.

Furthermore, it should be noted that the changes in version 0.0.7 mainly concern editorial adjustments and restructuring of the chapters. In terms of content, the requirements from version 0.0.5 considering also the JSON format are congruent with version 0.0.7 in the relevant points.

Chapter	Reference	Description	Comment in implementation
3		OMS Architecture	
3.1		Logical architecture	
	3.1.1.1		OK
3.2		Physical architecture	
3.2.1		OMS On Board	
	3.2.1.1	OMS On Board	OK
	3.2.1.2	OMS On Board	OK
	3.2.1.3	OMS On Board	OK
	3.2.1.4	OMS On Board	OK
3.2.2		Radio Infrastructure	
	3.2.2.1	Radio Infrastructure	OK
	3.2.2.2	Radio Infrastructure	OK
	3.2.2.3	Radio Infrastructure	Not part of this phase
	3.2.2.4	Radio Infrastructure	Not part of this phase
	3.2.2.5	Radio Infrastructure	OK
3.2.3		OMS Wayside	Railnova's backend is used the Wayside of the "OMS alternative architecture".
	3.2.3.1	OMS Wayside	Not part of this phase, same server will be used for all countries
	3.2.3.2	OMS Wayside	OK
	3.2.3.3	OMS Wayside	Connection between Railster and Wayside is based on MQTTS, TLS encrypted
	3.2.3.4	OMS Wayside	Not part of this phase
3.2.4		Alternative architecture	
	3.2.4.1	Alternative architecture	OK. This is the architecture used for this phase
4		OMS On Board Interfaces	
4.1		OMS - ETCS Interface	
	4.1.1.1	OMS - ETCS Interface	Not part of this phase
	4.1.1.2	OMS - ETCS Interface	Not part of this phase
	4.1.1.3	OMS - ETCS Interface	Not part of this phase
	4.1.1.4	OMS - ETCS Interface	OK
	4.1.1.5	OMS - ETCS Interface	Not part of this phase
4.2		OMS – GPS Interface	
	4.2.1.1	OMS – GPS Interface	OK

Chapter	Reference	Description	Comment in implementation
	4.2.1.2	OMS – GPS Interface	OK
	4.2.1.3	OMS – GPS Interface	Not part of this phase
	4.2.1.4	OMS – GPS Interface	Not part of this phase
	4.2.1.5	OMS – GPS Interface	Not part of this phase
	4.2.1.6	OMS – GPS Interface	OK
	4.2.1.7	OMS – GPS Interface	OK
4.3		OMS Wayside Interface	Railnova's backend is used the Wayside of the "OMS alternative architecture".
	4.3.1.1	OMS Wayside Interface	OK
	4.3.1.2	OMS Wayside Interface	Not part of this phase
	4.3.1.3	OMS Wayside Interface	OK
	4.3.1.4	OMS Wayside Interface	OK
5		Functional Requirements	
5.1		OMS On Board	
5.1.1		OMS On Board	
	5.1.1.1	OMS On Board	Full real-time is a question mark, buffering strategy depending on feasibility
	5.1.1.2	OMS On Board	Not part of this phase
	5.1.1.3	OMS On Board	Not part of this phase
	5.1.1.4	OMS On Board	OK
	5.1.1.5	OMS On Board	Not part of this phase
	5.1.1.6	OMS On Board	OK
	5.1.1.4	OMS On Board	OK
	5.1.1.7	OMS On Board	Full real-time is a question mark, buffering strategy depending on feasibility
	5.1.1.8	OMS On Board	OK
	5.1.1.9	OMS On Board	Not part of this phase
	5.1.1.10	OMS On Board	OK
	5.1.1.11	OMS On Board	Not part of this phase
	5.1.1.12	OMS On Board	OK
	5.1.1.13	OMS On Board	Not part of this phase
	5.1.1.14	OMS On Board	Not part of this phase
	5.1.1.15	OMS On Board	Not part of this phase
	5.1.1.16	OMS On Board	Not part of this phase
	5.1.1.17	OMS On Board	Not part of this phase
	5.1.1.18	OMS On Board	Not part of this phase
	5.1.1.19	OMS On Board	OK
5.1.2		Data packets header Fields Description	The data is formatted according to specifications on the server. The POC is according to the "Alternative Architecture" described in 3.2.4
JSON format Draft07a	1 1.1		
	1.1.1.1		SS-140 not applicable

Chapter	Reference	Description	Comment in implementation
	1.1.1.2		OK
	1.1.1.3		OK, see 1.1.2 onwards
	1.1.2		
	1.1.2.1		OK. GNSS latency not applicable
	1.1.2.2		OK
	1.2		
	1.2.1.1		OK
	1.2.2		
	1.2.2.1		OK
	1.2.2.2		OK
	1.3		
	1.3.1.1		Not part of this phase
	1.3.2		
	1.3.2.1		Not part of this phase
	1.3.2.2		Not part of this phase
	1.4		
	1.4.1.1		OK
	2		
	2.1		OK
	2.2		OK
5.2		OMS Wayside	
	5.2.1.1	OMS Wayside	OK
	5.2.1.2	OMS Wayside	OK
	5.2.1.3	OMS Wayside	OK (through different data tables, see offer "Data access segregated per country with user rights management")
	5.2.1.4	OMS Wayside	Not part of this phase
	5.2.1.5	OMS Wayside	OK
	5.2.1.6	OMS Wayside	OK
	5.2.1.7	OMS Wayside	OK
	5.2.1.8	OMS Wayside	OK
	5.2.1.9	OMS Wayside	Not part of this phase
	5.2.1.10	OMS Wayside	Not part of this phase
	5.2.1.11	OMS Wayside	Not part of this phase
6.0		Safety and Cybersecurity requirements	
	6.1.1.1	Safety and Cybersecurity requirements	OK
	6.1.1.2	Safety and Cybersecurity requirements	Not part of this phase

Table 2 Functionalities of the SUBSET-149 (based on version 0.0.5, including additionally the proposal for JSON formatting) considered in the proof of concept