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Work-Package 3: “Modeling”

openETCS System Architecture and Design Specification

Third iteration: Scope of openETCS ITEA2 Functions

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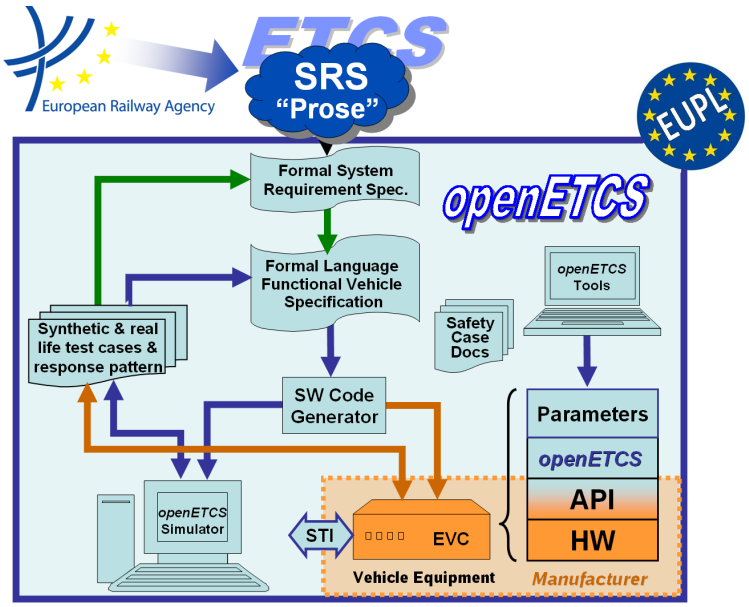
November 2014



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Document approbation

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Architecture and Functional Specification

Prepared for openETCS@ITEA2 Project

Abstract: This document gives an introduction to the architecture of openETCS. The functional scope is tailored to cover the functionality required for the openETCS demonstration as a target of the ITEA2 project: the Utrecht Amsterdam use-case. It has to be read as an add-on to the models in SysML, Scade and to additional reading referenced from the document.

Modification History

Version	Section	Modification / Description	Author
0.1	Document	Initial document providing the structure	Baseliyos Jacob
0.2	Document	Workshop Results included and some pretty-printing	Bernd Hekele

Table of Contents

Figures and Tables

Figures

Tables

1 Introduction

1.1 Motivation

1.2 Objectives

1.3 Roles, responsibilities and tasks

1.4 Process

1.5 Assumptions and preconditions

1.6 openETCS history and iterations

Glossary

Notation	Descr
application programming interface	
balise groupbalise group messagebalise telegramBalise Transmission Module	
Driver Machine Interface	
European Vital ComputerEURORADIO	
Juridical Recording Unit	
Last Relevant Balise Grouplinking informationlocationLoop Transmission Module	
odometryon-board unitorientation	
radio message	
service brakeSpecific Transmission Modulesystem requirement specificationSystems Modeling Language	
Train Interface Unittrain position	

2 Input documents

2.1 Document x

2.2 Document x

2.3 Document x

2.4 Document x

2.5 Document x

3 Use case description - proof of concept Utrecht - Amsterdam

3.1 User Stories 1 - 4

4 Architecture Description

4.1 System Architecture

4.2 Interfaces

5 Runtime API

5.1 Interfaces

5.2 Header - service functions

6 Design Description

6.1 F1: Receive information from Trackside

6.2 F2: ETCS Kernel

6.2.1 Receive Track Data

The block “Receive Track Data” is responsible for receiving Eurobalise-telegrams and Euroradio-messages from the API and perform several consistency checks on the input.

The block collects the telegrams of balises in order to build balise group messages. Euroradio messages are always delivered as a whole message.

On each message, a consistency check is performed, before the data is validated according to the driving direction of the train. In general, messages not designated for the current driving direction of the train are not forwarded to the further processing.

After applying consistency checks, the data direction is validated.

Information of the odometer is used to control for the train leaving the expectation window of the balises.

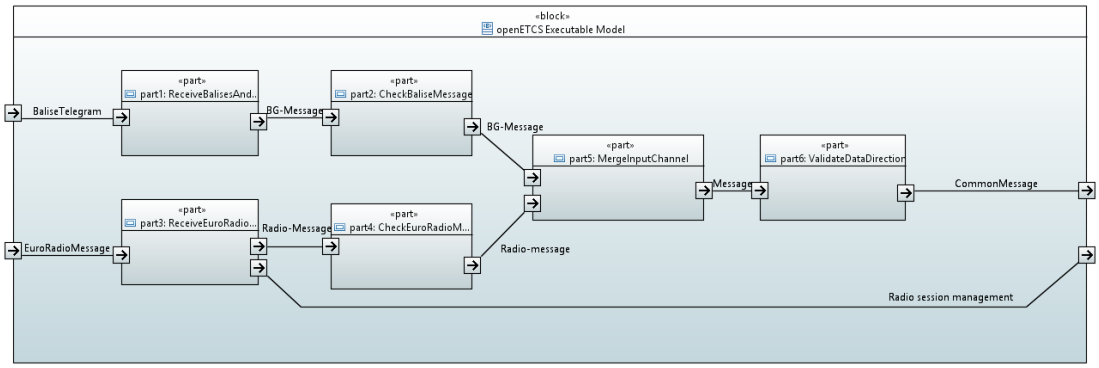

Figure 1. Structure of the Receive message and check consistency module

6.2.1.1 Input

For providing the output, the module needs different input data flows. An overview is provided in table 2

Index	Input name	Input type	Source
0	apiRtmMessage	apiRtmMessage_T	API
1	apiBaliseTelegram	API_Telegram_T	API
2	apiRadioDevice	int	API
3	connectionStatus	sessionStatus_Type	MoRC
4	lastRelevantEventTimestamp	T_internal_Type	MoRC or Database (?)
5	tNvContact	T_internal_Type	Database
6	currentOdometry	odometry_T	Odometry
7	lrbg	positionedBG_T	Database
8	reset	bool	internal

Table 2. Overview over input

Input 0: apiRtmMessage

The Euroradio-/Eurobalise-message is originated from the openETCS-API. The API is described in the section **??**.

In the current implementation, only messages with normal priority are used in the system. Emergency messages will not be processed.

The input not only transfers the radio message but also information, if a message is present and if this message was decoded correctly and passed the lowlevel checks performed by the API.

The radio message itself consists of a header and a payload-part. The header part contains all variables of the message. The payload-part consists of all packets in the message.

Input 1: apiBaliseTelegram

The telegram is build from

- a present flag (bool)
  Indicates the input decoded telegram parameter is “present”, i.e., the input has been updated by the API. Only if the telegram is present the position information (incenterOfBalise) is to be used.

- the decoded telegram including optional packets received from the balise.
- the centerOfBalisePosition parameter. This parameter is used to give the position where the BTM has recognised the center of the balise telegram.

Input 2: apiRadioDevice

The RTM-module may include multiple radio devices. When a handover between two RBCs is performed, messages can be received from both radio devices. The API provides information about the device, which received the message.

The values transmitted have to be defined by the API.

Input 3: connectionStatus

The input connectionStatus will give information about the radio connection. This input is delivered by the session management module, not from the API. The information is needed to perform the timing check, which is depending on the connection state.

Value	Interpretation
DISCONNECTED	The OBU is currently not connected to a RBC.
CONNECTING	The OBU is currently connecting to the RBC. Received messages belong to the process of establishing a connection.
CONNECTION_ESTABLISHED	The connection to RBC is established.

Table 3. Possible values for the input connectionStatus

Input 4: lastRelevantEventTimestamp

For monitoring the safe radio connection, it's necessary, that the time between two packets is less than the value of T_NVCONTACT.

In situations like level-changes or announced radioholes, not the timestamp of the last message is relevant for comparison, but the timestamp of the last relevant event. This can be e.g. the timestamp of the level change or the timestamp of the timestamp of the moment, when the train was passing the end of the radiohole.

For performing this check, the timestamp of the last relevant event is provided to the model as an T_internal_Type-type.

Input 5: tNvContact

For monitoring the safe radio connection, the national value T_NVCONTACT is needed as an input.

Input 6: currentOdometry

Current information giving the odometry of the train.

Input 7: lrbg

The Last Relevant Balise Group. The information has been collected before by the train position function.

Input 8: reset

To delete all data stored in the module (e.g. collected balise-telegrams, which do not yet form a complete message), a reset input can be used. If the input is set to true, all data kept in the module is deleted and no input is accepted.

Value	Interpretation
true	All data kept in the module is deleted and no input is accepted.
false	No action. Data at input is accepted.

Table 4. Possible values for the input `reset`

6.2.1.2 Output

The output of the module provides the received and processed Euroradio and Eurobalise messages. The module combines messages both from Eurobalises and from Euroradio to one common dataflow.

Additionally, status information is provided. The status information consists of the following data:

- Information, if the message has to be rejected in case of a consistency error, includeing further information about the error.
- Information, if an acknowledgement has to be sent to the RBC for the message
- Information about the radio connection. None or one of the following notifications:
  - Confirmation for establishing a connection or reconnection
  - Notification, that a established connection was lost, including the origin of the failure
  - Notification, that a connection could not be (re)established after 3 attempts, includeing the origin of the failure
  - Notification, that a connection could not be re-established after 3 attempts, includeing the origin of the failure

An overview over the output dataflows is provided in table 5.

Index	Output name	Output type
0	`present`	`bool`
1	`rejectionReason`	Boolean-Array (to be defined)
2	`acknowledgementRequired`	`bool`
3	`radioConnectionStatusFromAPI`	`RadioConnectionStatusFromAPI_T`
4	`radioDeviceOut`	`int`
5	`applyServiceBreak`	`bool`
6	`badBaliseMessageToDMI`	`bool`
7	`receivedMessage`	`ReceivedMessage_T`

Table 5. Dataflow at output

Output 0: `present` The present-flag specifies, if the data provided by the output `receivedMessage` is to be considered as present by the following modules or if it has to be ignored due to no new input data.

Value	Interpretation
false	The data in this element is not present and has to be ignored.
true	The data in this element is present and has to be processed by the following models.

Table 6. Possible values for the output `present`

Output 1: `rejectedReason` In case of an inconsistent message, the output `rejectedReason` is giving information to the system, which problem occured. This information also has to be sent to the RBC as an error report by the responsible module.

Output 2: `acknowledgementRequired` The `acknowledgementRequired`-dataflow indicates, whether the reception of the message has to be acknowledged to the RBC.

Value	Interpretation
true	An acknowledgement has to be sent to the RBC for the current message delivered at output `receivedMessage`
false	No acknowledgement has to be sent for the current message delivered at output `receivedMessage`

Table 7. Possible values for the output `AcknowledgementRequired`

Output 3: `radioConnectionStatusFromAPI` The output `radioConnectionStatusFromAPI` is used, when the RTM reports problems with the radio connection. The output is derived from the Alstom-API. The output can be one of the following values:

Value	Interpretation
CONNECTION_CONFIRMATION	Confirmation for establishing a connection or reconnection
CONNECTION_LOST	Notification, that a established connection was lost
CONNECTION_FAILURE	Notification, that a connection could not be (re-)established after 3 attempts, includeing the origin of the failure
CONNECTION_NOT_ESTABLISHED	Notification, that a connection could not be re-established after 3 attempts, includeing the origin of the failure

Table 8. Possible values for the output `radioConnectionStatusFromAPI`

Output 4: `radioDeviceOut` The output radio device will give information, which device received a radio message. Trains equipped with two or more radio devices may receive messages on two interfaces in situations of a RBC handover.

Output 5: `applyServiceBreak` The flag indicates the balise group the train just passed could not be processed correctly. The check results in the request for a service break.

Output 6: `badBaliseMessageToDMI` Information to be passed to the DMI to indicate the reception of a “bad balise” to the driver.

Output 7: `receivedMessage` The element `receivedMessage` consists of the type `ReceivedMessage_T` combines both balise and radio messages to one common datatype. This datatype contains all variables and packets, which are possible for the given scenario.

Name	Datatype	Description
`source`	Enumeration	Defines, if this is a Euroradio or Eurobalise message.
`valid`	`bool`	true, if no consistency errors were detected.
`metadata`	`Metadata_T`	contains the metadata of the packets
`BG_Common_Header`	`BG_Header_T`	Header of Eurobalise message
`Radio_Common_Header`	`Radio_TrackTrain_Header_T`	Header of Euroradio message
`Packets`	structure of possible packets	-

Table 9. Structure of `ReceivedMessage_T`

The Eurobalise-common-header `BG_Header_T` consists of the fields visible in the SCADE-declaration. The structure corresponds to the structure defined in the SRS chapter 8.4.2.1. Some fields were removed since they are not needed anymore for further processing after building messages from separate telegrams.

The Euroradio-common-header `Radio_TrackTrain_Header_T` consists of the fields visible in the SCADE declaration. The structure corresponds to the structure defined in the SRS chapter 8.4.4.6.1. The structure contains all variables required by possible `NID_MESSAGE` values for the given scenario.

Note: Packet 44 not used (applications outside the ERTMS/ETCS system are not supported by this implementation).

6.2.1.3 Macrofunction ReceiveBaliseAndBuildBG in Receive Track Data

Reference to the SRS (or other requirements)

- Definition of the Balise Telegram: subset 26 section 7 and 8
- Interface to the BTM: Subset 36, section 4.2.2, 4.2.4, 4.2.9
- Handling of Balise Telegrams: Subset 26, sections 3.4.1 - 3.4.3, 3.16.2
- Check of the balise group Subset 26, section 3.16.2
- Determining the Orientation: 3.4.2
- Active Functions Table: 4.5.2

Short description of the functionality

This function defines the interface of the OBU model to the openETCS generic API for Eurobalise Messages. On the interface, either a valid telegram is provided or a telegram is indicated which

could not be received correct when passing the balise. The function passes the telegram without major changes of the information to the next entity for collecting the balise group information. This entity collects telegrams received via the interface into Balise Group Information.

Interface

Functional Design Description

Design Constraints and Choices

1. The decoding of balises is done at the API. Also, packets received via the interface are already transformed into a usable shape.
2. Only packets used inside the current model are passed via the interface:
   Packet 5: Linking Information.
   Linking Information is added to the linking array starting from index 0 without gaps. Used elements are marked as valid. Elements are sorted according to the order given by the telegram sequence.
3. Telegrams received as invalid are passed to the “Check-Function” to process errors in communication with the track side according to the requirements and in a single place. Telegrams are added to the telegram array starting from index 0 without gaps. Used elements are marked as valid. Elements are stored according to the order given by the telegram sequence.
4. This function does not process information from the packets. The information is passed to the check without further processing of the values.

Reference to the Scade Model

only in special case or link to the Scade model

6.2.1.4 Macrofunction Check BG Consistency in Receive Track Data

Reference to the SRS or other Requirements (or other requirements)

- Definition of the Balise Telegram: subset 26 section 7 and 8
- Handling of Balise Telegrams: Subset 26, sections 3.4.1 - 3.4.3, 3.16.2
- Check of the balise group Subset 26, section 3.16.2
- Active Functions Table: 4.5.2

Short description of the functionality

This function has the task to verify the completeness and correctness of the received messages from balis-groups.
A message consists of at least a telegram and a maximum of 8 telegrams.

- A message is still complete and correct, if a telegram is missing (or not decoded or incomplete decoded), and this telegram is duplicated within the balise group and the duplicating one is correctly read.
- By more than one telegram, the order of the telegrams must be either ascending (nominal) or Descending(reverse).

- A message is correct, if all message counters (M MCUNT) do not equal 254 (that means: The telegram never fits any message of the group).
  A message counter can be equal 255 (that means: The telegram fits with all telegrams of the same balise group) and all other values must be the same.

Interface

Functional Design Description

This function is active in certain modes and the output and reactions are dependent on if the linking information is used.
The orientation of the BG will also be calculated in this block. The check, if the message has been received in due time and the right at the right expected location, will be performed in "Calculate Train Position".
The checks on the validity of the data in the packets and the validity with respect to the direction of motion will be performed in other modules, e.g. "Validate Data Direction" .

Reference to the Scade Model

only in special case or link to the Scade model

6.2.1.5 Macrofunction ReceiveEuroRadioFromAPI in Receive Track Data

Reference to the SRS or other Requirements (or other requirements)

- SRS subset 26, chapter 8.4.4: Rules for Euroradio messages

Short description of the functionality

The function “ReceiveEuroRadioFromAPI” receives the radio message or status information from the API. The radio message is forwarded to the checking-processes. The status information is directly provided as an output of the “Receive message and check consistency” module.

Interface

Functional Design Description

Reference to the Scade Model

only in special case or link to the Scade model

6.2.1.6 Macrofunction CheckEuroradioMessage in Receive Track Data

Reference to the SRS or other Requirements (or other requirements)

- SRS subset 26, chapter 8.4.4: Rules for Euroradio messages
- SRS subset 26, chapter 3.16: Data consistency

Short description of the functionality

The function “CheckEuroradioMessage” has to perform several checks on the received radio message. These checks include checking of the message sequence, completeness of messages. Invalid messages are marked as invalid in the header.

The bitwalker is responsible for checking the validity of the values in fields. If a consistency error is detected by the bitwalker, it is signalled to the model. If the bitwalker marks a packet as valid, all variables are expected to contain a valid value.

Interface

Functional Design Description

- Content checks
  - The whole message must be complete and contains all necessary fields. (SRS 3.16.1.1)
  - The message must respect the ETCS language. (SRS 3.16.1.1)
  - The variables of the message does not contain invalid values. (SRS 3.16.1.1)
  - Check if the specified priority of message is equal to the priority with which the message was received. (SRS 3.16.3.1.3.1)
- Timing checks
  - Check if the timestamp of a message is greater than the timestamp of the former message (SRS 3.16.3.3.3)
  - If a message contains the timestamp “Unknown”, check if this message is part of the initiation of the communication session. (SRS 3.16.3.3.4)
  - Perform the check with the current packet n: $T\_TRAIN_n <= T\_TRAIN_{n-1}+T\_NVCONTACT$ (SRS 3.16.1.1). This ensures, that the packet was received in due time.

For inconsistent messages, the following actions need to be performed by the module:

- If a message is not consistent, it shall be rejected (SRS 3.16.3.1.1.1). For this purpose, the message is marked as invalid.
- The RBC shall be informed, when a message was rejected (SRS 3.16.3.1.1.2). Therefore the necessary information for creating an error report is provided as an output.
- If the RBC requested an ACK for a received message, message will be marked for the module to send a report to the RBC. (SRS 3.16.3.5)

- This module will not trigger the reaction for an interrupted radio connection to the RBC. The reaction sepcified by `M_NVCONTACT` will be triggered by the RBC session management module.

The check by the Euroradio-protocol (SRS 3.16.3.1.1) will not be performed by the model, but on a lower level (RTM or openETCS-API).

Safe connection supervision is not in the scope of this module. This functionality will be implemented by the “Manage Radio communication” module. The “Receive message and check consistency”-module will provide the necessary status data about the connection as an output.

Reference to the Scade Model

only in special case or link to the Scade model

6.2.1.7 Macrofunction MergeInputChannel in Receive Track Data

Reference to the SRS or other Requirements (or other requirements)

Short description of the functionality

The function “MergeInputChannel” is responsible for coordinating the output-dataflow of the module. Since the situation can occur that in one cycle of the model both a Euroradio-message and a Eurobalise-message are received, the output has to be synchronized.

Interface

Functional Design Description

At each cycle the following conditions can occur at the input:

1. No new Euroradio-message or Eurobalise-telegram is available.
2. A new Euroradio-message is available
3. A new Eurobalise-telegram is available
4. A new Euroradio-message and a new Eurobalise-telegram is available.

Reference to the Scade Model

only in special case or link to the Scade model

6.2.1.8 Macrofunction ValidateDataDirection in Receive Track Data

Reference to the SRS or other Requirements (or other requirements)

- The functionality is mainly described in [1, Chapter 3.6.3].

Short description of the functionality

This function determines for direction information of the LRBG or an (ordinary) balise group whether this information is valid or not. The function takes as an input the LRBG and the balise groups passed and outputs the input extended with validity information.

Interface

Functional Design Description

Reference to the Scade Model

only in special case or link to the Scade model

6.2.1.9 Macrofunction InformationFilter in Receive Track Data

Reference to the SRS or other Requirements (or other requirements)

- The functionality of Select Usable Info is described in Chapter 4.8 of subset-026 [1]. The following list gives an overview of the most important sections for each of the blocks in the model.
- § 4.8.2, § 4.8.2, § 4.8.3, § 4.8.4

Short description of the functionality

The function Select Usable Info filters information received from balises that have been passed, radio messages, and EUROLOOP messages. Filtering is done depending on the mode of the train, the current ETCS level, the type/content of the information, and the transition media of the information. As neither radio messages nor EUROLOOP are part of the first iteration of work, not all functionality of the filter described in the specification is currently implemented.

Interface

Input from: Receive MSG Check Consistency/Coordinate System - track messages and package Level and Mode Management - Mode and Level State

Output to: Build Data structure and Location Based/ Build Data Structures Drivers- forwarded packages, messages and variables

6.2.1.10 SysML Model

Functional Design Description

The fillter receives track information (balise an radio) and will filter them in dependency of the mode and level. Therefore the filter needs the input from level and mode management. The filtered information will be forwarded to the data strcuture.

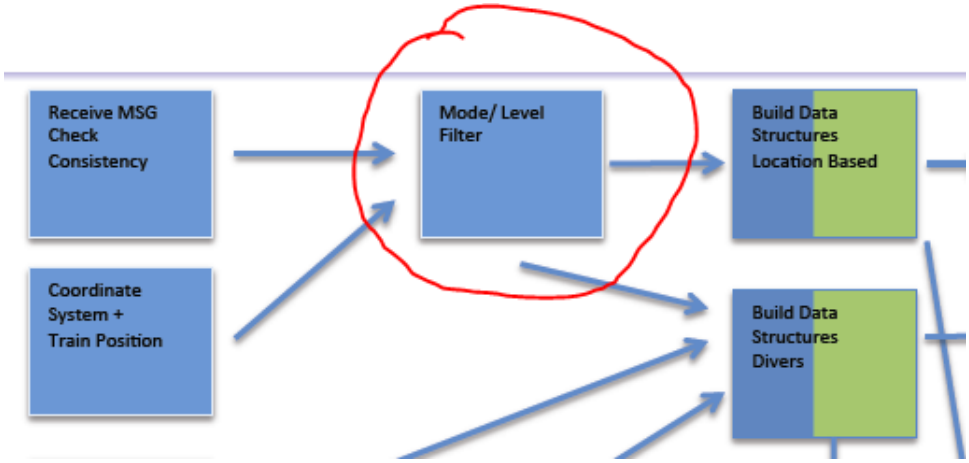

Figure 2. Filter In and out

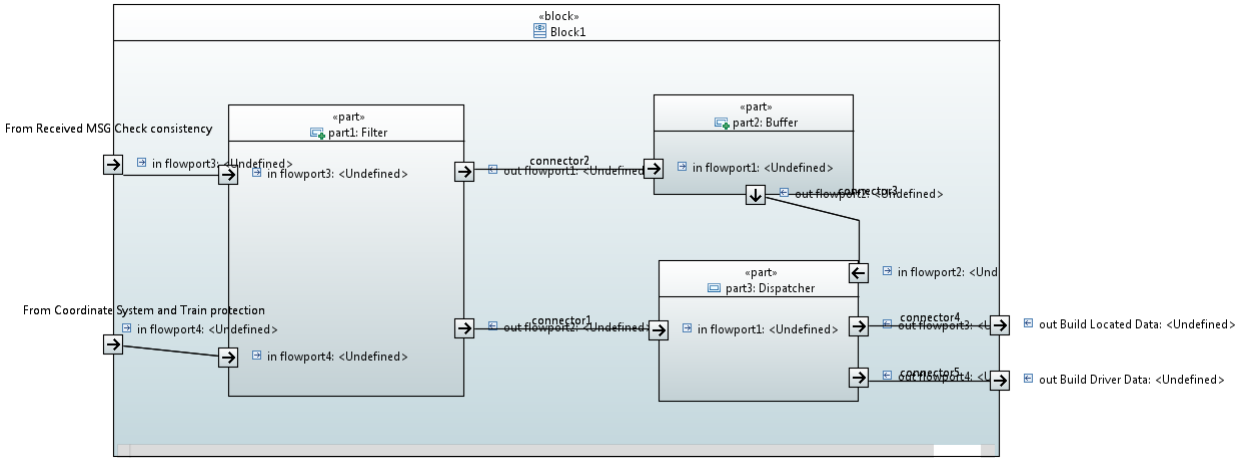

Figure 3. SysML Filter

First filter The first filter, i.e. the filter on the level, is described in [1, Chapter 4.8.3].

Second filter The second filter, i.e. the filter on the transition media, is described in[1, Chapter 4.8.3].

Third filter The third filter, i.e. the filter on the modes, is described in [1, Chapter 4.8.4].

Transition buffers Details on the handling of the transition buffers used in the first and the second filter are described in [1, Chapter 4.8.5].

Documentation of design From § 4.8.1.2 The following sections have to be interpreted by applying the filters and the assigned packets/messages as shown in Figure a and 2. The first filter is detailed in section § 4.8.3 (figure 1) "Accepted information depending on the level and transmission media", the third filter in section § 4.8.4 (figure 2) "Accepted information depending on the modes".

From § 4.8.1.3 If a message contains level transition information, any other information in that message shall be evaluated considering the level transition information. Explanation: If a message contains level transition information, all other information in that message shall be buffered and level transition shall be read first. Then the remained balise information shall be read from the buffer in the level that was announced to the balise.

From § 4.8.1.3.1 Information received in the same message as an immediate level transition order or a conditional level transition order that causes a level transition shall be evaluated first considering the on-board currently operated level, as if a level transition order for further location had been received (i.e. conditions [1], [2] or [6] of Figure 1, if applied, shall be automatically fulfilled). Then, if relevant, it shall be immediately extracted from the buffer and re-evaluated according to the new selected level.
Explanation: As described in Explanation of § 4.8.1.3 and figure 1 – First Filter conditions [1], [2] and [6])

From § 4.8.1.4 Note: As shown in Figure 1, information stored following an announcement of a change of level, is re-checked for acceptance when the level has changed. This implies that, when the level changes, the mode is - for a short moment – still unchanged, until the stored information has been processed. The consequence for the Third Filter is that information needs to be accepted for this short period also in modes in which this information is otherwise useless.
Explanation: when a level announced the level the mode change will be unchanged until the buffered information has been processed. The model change is the third filter (§ 4.8.3 figure 3).

table for the filter rules Assumptions from § 4.8.2 need to be considered
Explanation: See figure 1 and 2 – announced packets/messages/variables to the filter. Exception and explanation of the meaning of R and A please read § 4.8.3.
.

Filter rules: Filter will filter messages, packages and variables. Therefole a rule must be defined to cover all these inputs.

Explanation figure 1: will filtering the different inputs in dependency of the level
Explanation figure 2: will filtering the different inputs in dependency of thel mode

Package/Variables	Information	From RBC	Onboard operating level				
			0	NTC	1	2	3
Packet 3	National Values	No	A	A	A	A	A
		Yes	R [2]	R [2]	R [2]	A	A
Packet 5	Linking	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
V_Main Packet 12	Signalling Related Speed Restriction	No	R [1]	R [1]	A	R [1]	R [1]
		Yes					
Packet 12, 15 Packet 80 Packet 49	Movement Authority + (optional) Mode Profile + (optional) List of Balises for SH area	No	R [1]	R [1]	A [4]	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3] [4] [5]	A [3] [4] [5]
Packet 16	Repositioning Information	No	R	R	A	R	R
		Yes					
Packet 21	Gradient Profile	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 27	International SSP	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 51	Axle Load speed profile	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 41	Level Transition Order	No	A	A	A	A	A
		Yes	A	A	A	A	A
Packet 46	Conditional Level Transition Order	No	A [11]	A [11]	A [11]	A [11]	A [11]
		Yes					
Packet 42	Session Management	No	A	A	A	A	A
		Yes	A	A	A	A	A
Packet 45	Radio Network registration	No	A	A	A	A	A
		Yes	A	A	A	A	A
Packet 57	MA Request Parameters	No					
		Yes	A	A	A	A	A
Packet 58	Position Report parameters	No					
		Yes	A	A	A	A	A
Package 63 + Message Radio 2 + (optional) Packet 49	SR Authorisation + (optional) List of Balises in SR mode	No					
		Yes	R	R	R	A [3]	A [3]
Packet 137	Stop if in SR mode	No	R	R	A	A	A
		Yes					
D_SR in Packet 13	SR distance information from loop	No	R	R	A	R	R
		Yes					

Filter on Level

Packet 65	Temporary Speed Restriction	No	A	R [1] [2]	A	A [8]	A [8]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 66	Temporary Speed Restriction Revocation	No	A	R [1] [2]	A	A	A
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Package 64	Inhibition of revocable TSRs from balises in L2/3	No					
		Yes	R [2]	R [2]	R [2]	A	A
Packet 141	Default Gradient for TSR	No	A	R [1] [2]	A	A	A
		Yes					
Packet 70	Route Suitability Data	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 71	Adhesion Factor	No	R[1]	R[1]	A	R	R
		Yes	R[2]	R[2]	R[2]	A	A
Packet 72	Plain Text Information	No	A	R [1] [2]	A	A	A
		Yes	R [2]	R [2]	R [2]	A [12]	A [12]
Packet 76	Fixed Text Information	No	A	R [1] [2]	A	A	A
		Yes	R [2]	R [2]	R [2]	A [12]	A [12]
Packet 79	Geographical Position	No	A	R [1] [2]	A	A	A
		Yes	R [2]	R [2]	R [2]	A	A
Packet 131	RBC Transition Order	No	R	R	R	A	A
		Yes	R	R	R	A [3]	A [3]
Packet 132	Danger for SH information	No	A [13]	A [13]	A	A	A
		Yes					
Package 135	Stop Shunting on desk opening	No	A	A	A	A	A
		Yes					
Packet 133	Radio Infill Area information	No	R	R	A	R [1]	R [1]
		Yes					
Package 42	Session Management with neighbouring RIU	No	R	R	A	R	R
		Yes					
Packet 134	EOLM information	No	A	A	A	A	A
		Yes					
Messager 45	Assignment of Co-ordinate system	No					
		Yes	A [10]	A [10]	A [10]	A [10]	A [10]
Packet 136	Infill Location Reference	No	R	R	A	R [1]	R [1]
		Yes					
Packet 39, Packet 68	Track Conditions excluding big metal masses	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 67	Track condition big metal masses	No	A	A	A	A	A
		Yes					

Header Balise	Location Identity (NID_C + NID_BG transmitted in the balise telegram)	No	A	A	A	A	A
		Yes					
Radio Message 6	Recognition of exit from TRIP mode	No					
		Yes	R	R	R	A	A
Message Radio 8	Acknowledgement of Train Data	No					
		Yes	A	A	A	A	A
Message 9 Packet 80 Packet 49	Co-operative shortening of MA + (optional) Mode Profile + (optional) List of Balises for SH area	No					
		Yes	R	R	R	A [3] [4] [5]	A [3] [4] [5]
Message Radio 16	Unconditional Emergency Stop	No					
		Yes	R [2]	R [2]	R [2]	A	A
Message Radio 15	Conditional Emergency Stop	No					
		Yes	R [2]	R [2]	R [2]	A	A
Message Radio 18	Revocation of Emergency Stop (Conditional or Unconditional)	No					
		Yes	R	R	R	A	A
Message Radio 27	SH refused	No					
		Yes	R	R	R	A [3]	A [3]
Message Radio 28 + (optional) Packet 49	SH authorised + (optional) List of Balises for SH area	No					
		Yes	R	R	R	A [3]	A [3]
??	Trackside constituent System Version	No	A	A	A	A	A
		Yes	A	A	A	A	A
Packet 2	System Version order	No	A	A	A	A	A
		Yes					
Message Radio 34	Track Ahead Free Request	No					
		Yes	R	R	R	A [3]	A [3]
Packet 140 Track to train, Packet 40 Train to track	Train Running Number	No					
		Yes	R	R	R	A	A
Message Radio 38	Initiation of session	No					
		Yes	R	R	R	A	A
Message 39	Acknowledgement of session termination	No	A	A	A	A	A
		Yes	A	A	A	A	A

Message 40	Train Rejected	No					
		Yes	R	R	R	A	A
Message 41	Train Accepted	No					
		Yes	R	R	R	A	A
Message Radio 43	SoM Position Report Confirmed by RBC	No					
		Yes	R	R	R	A	A
Packet 138	Reversing Area Information	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 139	Reversing Supervision Information	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Packet 254	Default Balise/Loop/RIU Information	No	A	A	A	A	A
		Yes					
Packet 90	Track Ahead Free up to level 2/3 transition location	No	A [9]	A [9]	A [9]	R	R
		Yes					
Package 52	Permitted Braking Distance Information	No	R [1]	R [1]	A	R [1]	R [1]
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Package 88	Level Crossing information	No	R [1] [2]	R [1] [2]	A	A	A
		Yes	R [2]	R [2]	R [2]	A [3]	A [3]
Package 6(0)	Virtual Balise Cover order	No	A	A	A	A	A
		Yes					
Package 44	Data to be used by applications outside ERTMS/ETCS	No	A	A	A	A	A
		Yes	A	A	A	A	A
	Information from National System X through STM interface	Onboard operating level					
		0	NTC X	NTC Y	1	2	3
??	STM max speed	A [7]	R	R [6]	A [7]	A [7]	A [7]
??	STM system speed/distance	A [7]	R	R	A [7]	A [7]	A [7]

Figure 4. Level Filter

Filter on Modes

40	Packet 39, 68	Track conditions sound horn, non stopping areas, tunnel stopping areas	NR	A[2][4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A	R
41	Packet 67	Track condition big metal masses	NR	A[2][4]	A	A	A	A	A	A	A	A	A	A	A[1]	NR	NR	A	R
42	Header Balise	Location Identity (NID_C +NID_BG)	NR	A[2]	A	A	A	A	A	A	A	A	A	A	A	NR	NR	A	A
43	Message Radio 6	Recognition of exit from TRIP mode	NR	R	R	R	R	R	R	R	R	R	R	R	A	NR	NR	R	R
44	Message Radio 8	Acknowledgement of Train Data	NR	A[2]	R	R	A	A	A	A	R	R	A	A	A	NR	NR	A	A
45	Message 9	Co-operative shortening of MA	NR	R	R	R	A	A	R	A	R	R	R	R	R	NR	NR	R	R
46	Packet 80	+ (optional) Mode Profile																	
47	Packet 49	+ (optional) List of Balises for SH area																	
48	Message Radio 16	Unconditional Emergency Stop	NR	A[2]	R	R	A	A	A	A	R	R	A	R	R	NR	NR	A	R
49	Message Radio 15	Conditional Emergency Stop	NR	R	R	R	A	A	R	A	R	R	A	R	R	NR	NR	A	R
50	Message Radio 18	Revocation of Emergency Stop	NR	R	R	R	A	A	R	A	R	R	R	R	A[1]	NR	NR	R	R
51		(Conditional or Unconditional)																	
52	Message Radio 27	SH refused	NR	A[2]	R	R	A	A	A	A	R	R	R	R	A[1]	NR	NR	R	R
53	Message Radio 28 + (optional) Packet 49	SH authorised + (optional) List of Balises for SH area	NR	A[2]	R	R	A	A	A	A	R	R	R	R	A[1]	NR	NR	R	R
54	??	Trackside constituent System Version	NR	A	A	A	A	A	A	A	A	A	A	A	A	NR	NR	A	A
55	Packet 2	System Version order	NR	A	A	A	A	A	A	A	A	A	A	A	A	NR	NR	A	A
56	Message Radio 34	Track Ahead Free Request	NR	A[2]	R	R	R	A	A	A	R	R	R	R	A[1]	NR	NR	R	R
57	Packet 140 Track to train, Packet 40 Train to track	Train Running Number	NR	A[2]	R	R	A	A	A	A	R	A	R	A	A	NR	NR	R	A
58	Message Radio 38	Initiation of session	NR	A	R	R	A	A	A	A	A	A	R	A	A	NR	NR	R	A
59	Message 39	Acknowledgement of session termination	NR	A	A	A	A	A	A	A	A	A	A	A	A	NR	NR	A	A
60	Message 40	Train Rejected	NR	A[2]	R	R	R	R	R	R	R	R	R	R	R	NR	NR	R	R
61	Message 41	Train Accepted	NR	A[2]	R	R	R	R	R	R	R	R	R	R	R	NR	NR	R	R
62	Message Radio 43	SoM Position Report Confirmed by RBC	NR	A[2]	R	R	R	R	R	R	R	R	R	R	R	NR	NR	R	R
63	Packet 138	Reversing Area Information	NR	A[2][4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A	A
64	Packet 139	Reversing Supervision Information	NR	A[2][4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A	A
65	Packet 254	Default Balise/Loop/RIU Information	NR	A[2]	A	A	A	A	A	A	A	A	A	A	A	NR	NR	A	A
66	Packet 90	Track Ahead Free up to level 2/3 transition location	NR	A[2]	R	R	A	A	A	A	R	R	A	A	A	NR	NR	A	R
67	Package 52	Permitted Braking Distance Information	NR	A[2][4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A	R
68	Package 88	Level Crossing information	NR	A[2][4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A	R
69	Package 6(0)	Virtual Balise Cover order	NR	A	A	A	A	A	A	A	A	A	A	A	A	NR	NR	A	A
70	Package 44	Data to be used by applications outside ERTMS/ETCS	NR	A	A	A	A	A	A	A	A	A	A	A	A	NR	NR	A	A

	Packet, Message	Information	Modes																	
			NP	SB	PS	SH	FS	LS	SR	OS	SL	NL	UN	TR	PT	SF	IS	SN		RV
1	Packet 3	National Values	NR	A[2]	A	A	A	A	A	A	A	A	A	A	A[1]	NR	NR	A		A
2	Packet 5	Linking	NR	AD[4]	R	R	A	A	A	A	R	A	A	R	A[1]	NR	NR	A		R
3	V_Main in Packet 12	Signalling Related Speed Restriction	NR	AD[4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
4	Packet 12, 15	Movement Authority + (optional) Mode Profile + (optional) List of Baliises for SH area	NR	AD[4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
5	(optional) Packet 80																			
6	(optional) Packet 49																			
7	Packet 16	Repositioning Information	NR	R	R	R	A	A	R	A	R	R	R	R	R	NR	NR	R		R
8	Packet 21	Gradient Profile	NR	AD[4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
9	Packet 27	International SSP	NR	AD[4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
10	Packet 51	Axle load speed profile	NR	AD[4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
11	??	STM max speed	NR	A[2]	R	R	A	A	A	A	R	R	A	A	A[1]	NR	NR	A		R
12	??	STM system speed/distance	NR	A[2]	R	R	A	A	A	A	R	R	A	A	A[1]	NR	NR	R		R
13	Packet 41	Level Transition Order and Conditional Level Transition Order	NR	A[2]	A[7]	A[7]	A	A	A	A	A	A	A	A	A[1][5]	NR	NR	A		R
14	Packet 42	Session Management	NR	A	A[3]	A[3]	A	A	A	A	A	A	A	A	A[1]	NR	NR	A		A
15	Packet 49	Radio Network registration	NR	A[2]	A	A	A	A	A	A	A	A	A	A	A[1]	NR	NR	A		A
16	Packet 57	MA Request Parameters	NR	A[2]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
17	Packet 58	Position Report parameters	NR	A[2]	R	R	A	A	A	A	R	A	A	R	A[1]	NR	NR	A		A
18	Package Radio 63 + Message Radio 2 + (optional) Packet 49	SR Authorisation+ (optional) List of Baliises in SR mode	NR	AD[4]	R	R	R	R	A	R	R	R	R	R	A[1]	NR	NR	R		R
20	Packet 137	Stop if in SR mode	NR	R	R	R	R	R	A	R	R	R	R	R	R	NR	NR	R		R
21	D_SR in Packet 13	SR distance information from loop	NR	R	R	R	R	R	A[6]	R	R	R	R	R	R	NR	NR	R		R
22	Packet 65	Temporary Speed Restriction	NR	AD[14]	R	R	A	A	A	A	R	R	A	A	A[1]	NR	NR	A		R
23	Packet 66	Temporary Speed Restriction Revocation	NR	AD[4]	R	R	A	A	A	A	R	R	A	A	A[1]	NR	NR	A		R
24	Package 64	Inhibition of revocable TSRs from balises in L2/3	NR	A[2]	R	R	A	A	A	A	R	R	A	A	A[1]	NR	NR	A		R
25	Packet 141	Default Gradient for TSR	NR	AD[4]	R	R	A	A	A	A	R	R	A	A	A[1]	NR	NR	A		R
26	Packet 70	Route Suitability Data	NR	AD[4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
27	Packet 71	Adhesion Factor	NR	AD[4]	R	R	A	A	A	A	R	R	A	R	A[1]	NR	NR	A		R
28	Packet 72	Plain Text Information	NR	A[2]	R	R	A	A	A	A	R	A	A	A	A[1]	NR	NR	A		A
29	Packet 76	Fixed Text Information	NR	A[2]	R	R	A	A	A	A	R	A	A	A	A[1]	NR	NR	A		A
30	Packet 78	Geographical Position	NR	A[2]	R	R	A	A	A	A	R	A	A	A	A[1]	NR	NR	A		R
31	Packet 131	RBC Transition Order	NR	AD[4]	A[8]	A[8]	A	A	A	A	A	A	R	A	A[1]	NR	NR	R		R
32	Packet 132	Danger for SH information	NR	R	R	A	R	R	R	R	R	R	R	R	R	NR	NR	R		R
33	Package 135	Stop Shunting on desk opening	NR	R	A	R	R	R	R	R	R	R	R	R	R	NR	NR	R		R
34	Package 133	Radio Infill Area information	NR	R	R	R	A	A	A	A	R	R	R	R	R	NR	NR	R		R
35	Package 42	Session Management with previous RBC	NR	R	R	R	A	A	A	A	R	R	R	R	R	NR	NR	R		R
36	Package 134	ESUM information	NR	R	R	A	A	A	A	A	A	A	A	A	R	NR	NR	A		A
37	Message Radio 45	Assignment of Co-ordinate system	NR	A[2]	R	R	R	R	A	R	R	A	A	R	A[1]	NR	NR	A		R
38	Package 136	Infill Location Reference	NR	R	R	R	A	A	R	R	R	R	R	R	R	NR	NR	R		R
39	Packet 39, 68	Track Conditions excluding sound horn, non stopping areas, tunnel stopping areas and big metal masses	NR	AD[4]	R	R	A	A	A	A	R	A	A	A	A[1]	NR	NR	A		R

Figure 5. Mode Filter

Filtering (Mode/Level) - One packet per type ISSUE: HOW MANY PKT 44, 65 AND 66 PER MESSAGE ARE MAXIMALLY SUPPORTED? (BH: who made this comment??)

- Check on announced and immediate level transition orders in the messages to be filtered (needed for further criteria for filtering, to decide if the data shall be stored in the transition buffer).
- Filter data stored in the transition buffer according to the current level (what to do if similar information is available in the new message??). Data can be rejected, accepted or kept in the transition buffer. (Filtering according to new level will be done directly afterwards in the next cycle)
- Filter new received messages according to the current level (new level will be done in the next cycle as according to system requirement specification (SRS) data first has to be filtered according to old level and afterwards to new level). Data can be rejected, accepted or stored in the transition buffer.
- Filter (level) accepted data according to originating RBC (supervising or other). Information from balise group (BG)'s, loops or RIU is not filtered with this filter.
- Filter (level and RBC) accepted data according to the current mode (only reject or accept)

Reference to the Scade Model

only in special case or link to the Scade model

6.2.2 Train Supervision

The task of block "Train Supervision" is to monitor the speed of the train and the train location and as such to ensure that the speed remains within the given speed and distance limits. This block is mainly based on [1, Chapt. 3.13].

The block "Train Supervision" takes as input (1) movement related information such as train speed, train position and acceleration, (2) train related information such as brake information and train length, and (3) track related information such as speed and distance limits and national values.

Based on this information a list of targets is calculated and, for each such target, the speed the train should have. Braking curves calculate at which location at the track the train has to accelerate and to perform the brake, respectively. These calculations lead to commands being sent to the driver and the brake system.

For a more detailed analysis of "Train Supervision" and a functional breakdown, we refer to the appendix.

6.2.2.1 Input

For providing the output, the module needs different input data flows. Table 10 gives an overview.

Index	Input name	Input type	Source
0	MRSP	MRSP_Profile_t	??
1	MA	MAs_t	??
2	NationalValues	P3_NationalValues_T	???
3	TrainPosition	trainPosition_T	Manage Track Data
4	V_ura	V_internal_Type	??
5	odometry	odometry_T	Odometry
6	m_level	M_LEVEL	Mode and Level
7	trainProps	trainProperties_T	Database
8	MA_updated	bool	internal
9	MRSP_updated	bool	internal

Table 10. Overview of input

Input 0: MRSP

This input is the most restrictive speed profile.

Input 1: MA

This input is a movement authority.

Input 2: NationalValues

This input is packet 3 of [1, Chapt. 8], describing the national values.

Input 3: TrainPosition

This input is the current train position.

Input 4: V_ura

This input is the speed under reading amount.

Input 5: odometry

This input is the odometry data.

Input 6: m_level

This input is the current level of the train.

Input 7: trainProps

This input is a set of train related properties.

Input 8: MA_updated

This flag is true if the movement authority has been updated in this clock cycle and false otherwise.

Input 9: MRSP_updated

This flag is true if the most restrictive speed profile has been updated in this clock cycle and false otherwise.

6.2.2.2 Output

Based on the input the block produces the following output. Table 11 gives an overview.

Index	Output name	Output type
0	sdmToDMI	speedSupervisionForDMI_T
1	target	Target_T
2	sdmCommands	SDM_Commands_T
3	brakeCmd	Brake_command_T
4	EOA_overpassed	bool
5	Target_Speed_Reached	bool

Table 11. Overview of output

Output 0: sdmToDMI

This output contains information about different speeds and positions, on the one hand and the current supervision status, on the other hand. This information shall be displayed to the driver.

Output 1: target

This output is the most restrictive displayed target (MRDT).

Output 2: sdmCommands

This output gives some intermediate results of operator SDM_Commands. It is currently used for test purposes only.

Output 3: brakeCmd

This output is the brake command, indicating whether performing the service brake or the emergency brake have been commanded.

Output 4: EOA_overpassed

This output is true if the end of authority has been overpassed and false otherwise.

Output 5: Target_Speed_Reached

This output is true if the current speed is greater than or equal the target speed and false otherwise.

6.2.2.3 SDM_InputWrapper in Train Supervision

Reference to the SRS or other Requirements (or other requirements)

- [1, Chapt. 3.13]: Speed and distance monitoring

Short description of the functionality

The motivation for this operator is to convert all inputs of block “Speed Supervision” that contain information about length, speed, distance, and acceleration defined as integer into real to allow for highest precision in the calculations. In addition, to ease the modeling, inside block “Speed Supervision” only units meters, seconds, and meters per square second are used.

Interface

Functional Design Description

This operator forwards input messages, takes data from complex data types or transforms inputs messages into an internal type thereby converting int to real.

Reference to the Scade Model

only in special case or link to the Scade model

6.2.2.4 TargetManagement in Train Supervision

Ben

Reference to the SRS or other Requirements (or other requirements)

- [1, Chapt. 3.13.8.2]: Determination of the supervised targets

Short description of the functionality

This operator calculates/updates the list of targets to be supervised by the block “Train Supervision”. Taking the current movement authority and the most restrictive speed profile as an input, the operator outputs a list of locations corresponding to the most restrictive speed profile, a list of locations corresponding to a limit of authority, the location of an end of authority, or the location of supervised location.

Interface

Functional Design Description

Reference to the Scade Model

only in special case or link to the Scade model

6.2.2.5 CalcBrakingCurves_Integration in Train Supervision

Ben

Reference to the SRS or other Requirements (or other requirements)

- [1, Chapt. 3.13.8.3]: Emergency Brake Deceleration curves (EBD)

- [1, Chapt. 3.13.8.4]: Service Brake Deceleration curves (SBD)
- [1, Chapt. 3.13.8.5]: Guidance curves (GUI)

Short description of the functionality

For each type of target a certain braking curve has to be calculated. This curve enables us, given a target speed, to calculate the destination when this speed will be reached. In addition, given a target location, also the speed of the train at this location can be calculated.

Interface

Functional Design Description

Some details about how the curves are calculated ...

Currently, the model supports the calculation of the following braking curves:

- the Emergency Brake Deceleration curve for the most restrictive speed profile,
- the Emergency Brake Deceleration curve for the limit of authority,
- the Emergency Brake Deceleration curve for the end of authority, and
- the Service Brake Deceleration curve for the end of authority

Reference to the Scade Model

only in special case or link to the Scade model

6.2.2.6 SDMLimitLocations in Train Supervision

Reference to the SRS or other Requirements (or other requirements)

- [1, Chapt. 3.13.9]: Supervision Limits

Short description of the functionality

This operator calculates the various locations needed to determine the speed and distance monitoring commands.

Interface

Functional Design Description

Reference to the Scade Model

only in special case or link to the Scade model

6.2.2.7 CalcSpeeds in Train Supervision

Reference to the SRS or other Requirements (or other requirements)

- [1, Chapt. 3.13.9]: Supervision Limits

Short description of the functionality

This operator calculates the various speeds needed to determine the speed and distance monitoring commands.

Interface

Functional Design Description

This operator will be integrated into other operators in the next iteration.

Reference to the Scade Model

only in special case or link to the Scade model

6.2.2.8 SDM_Commands in Train Supervision

Reference to the SRS or other Requirements (or other requirements)

- [1, Chapt. 3.13.10]: Speed and distance monitoring commands

Short description of the functionality

This operator models the speed and distance monitoring commands. More precisely, it triggers the service or emergency brake and outputs the current supervision status of the OBU together with information on speeds and locations to the driver.

Interface

Functional Design Description

The OBU can be in any of three types of speed and distance monitoring modes: ceiling speed monitoring, release speed monitoring and target speed monitoring. We use a state machine to model the switching between the three modes: each state models a mode and a transition between to states is enabled if the condition two switch between the two corresponding modes is evaluated to true. In each mode, the OBU can be in up to five different supervision stati. The behavior of changing from one status to another is also modeled as a state machine. As a result, the model is a hierarchical state machine.

Reference to the Scade Model

only in special case or link to the Scade model

6.2.2.9 SDM_OutputWrapper in Train Supervision

Reference to the SRS or other Requirements (or other requirements)

- [1, Chapt. 3.13]: Speed and distance monitoring

Short description of the functionality

This operator is the counterpart to operator SDM_OutputWrapper—that is, it converts all internal outputs of block “Speed Supervision” that contain information about length, speed, distance, and acceleration defined as real into int, such that all other blocks can stick to their types and also performs the calculation into units used by the environment.

Interface

Functional Design Description

This operator forwards input messages and transforms inputs messages into an internal type thereby converting real to int.

Reference to the Scade Model

only in special case or link to the Scade model

6.2.3 Manage ETCS Procedures

6.2.3.1 Macrofunction x in Manage ETCS Procedures

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.3.2 Macrofunction x in Manage ETCS Procedures

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.3.3 Macrofunction x in Manage ETCS Procedures

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.3.4 Macrofunction x in Manage ETCS Procedures

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.4 Manage Track Data

6.2.4.1 F.2.2 Calculate Train Position

Short Description of Functionality

The main purpose of the function is to calculate the locations of linked and unlinked balise groups (BGs) and the current train position while the train is running along the track.

In detail, the calculateTrainPosition function provides a couple of essential subfunctions for the onboard unit. These are mainly

- creating and maintaining an obu internal coordinate system for all types of location based data
- storing all linked and unlinked balise groups resulting from over passing or from announcements (linking information) from the track
- calculating and maintaining the locations of all stored balise groups during the train trip, based on odometry and linking information

- permanently calculating the current train position based on odometry and passed balise group information
- providing the last recently passed linked balise group as the LRBG
- providing additional position attribute information
- deleting stored balise groups, when appropriate
- detecting linking consistency errors
- determining, if linking is used on board

The calculation algorithms for locations and positions are implemented as specified in `https://github.com/openETCS/SRS-Analysis/blob/master/System%20Analysis/WorkingRepository/Group4/SUBSET_26_3-6/DetermineTrainLocationProcedures.pdf` .

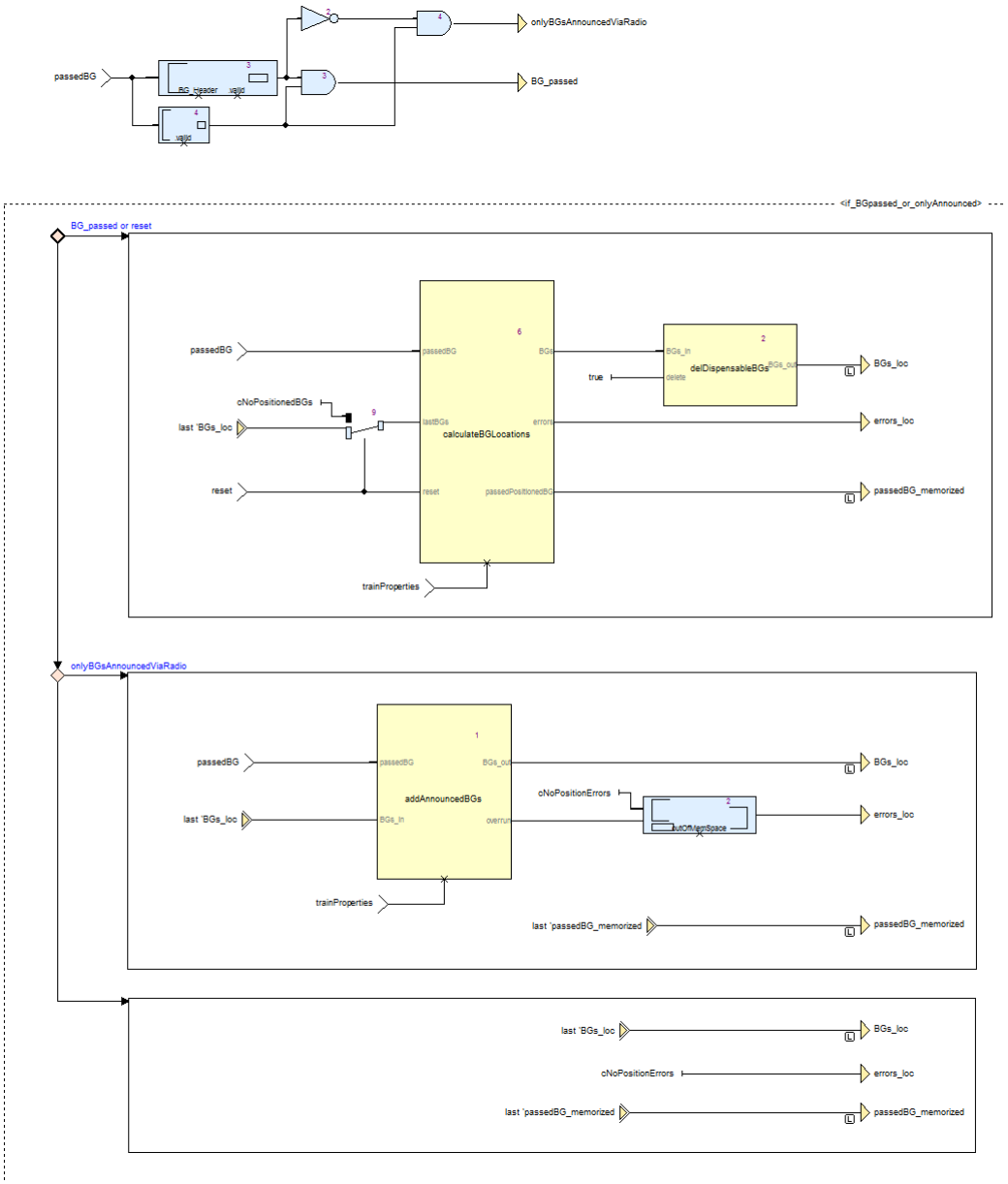

Figure 6. Calculating the balise group locations

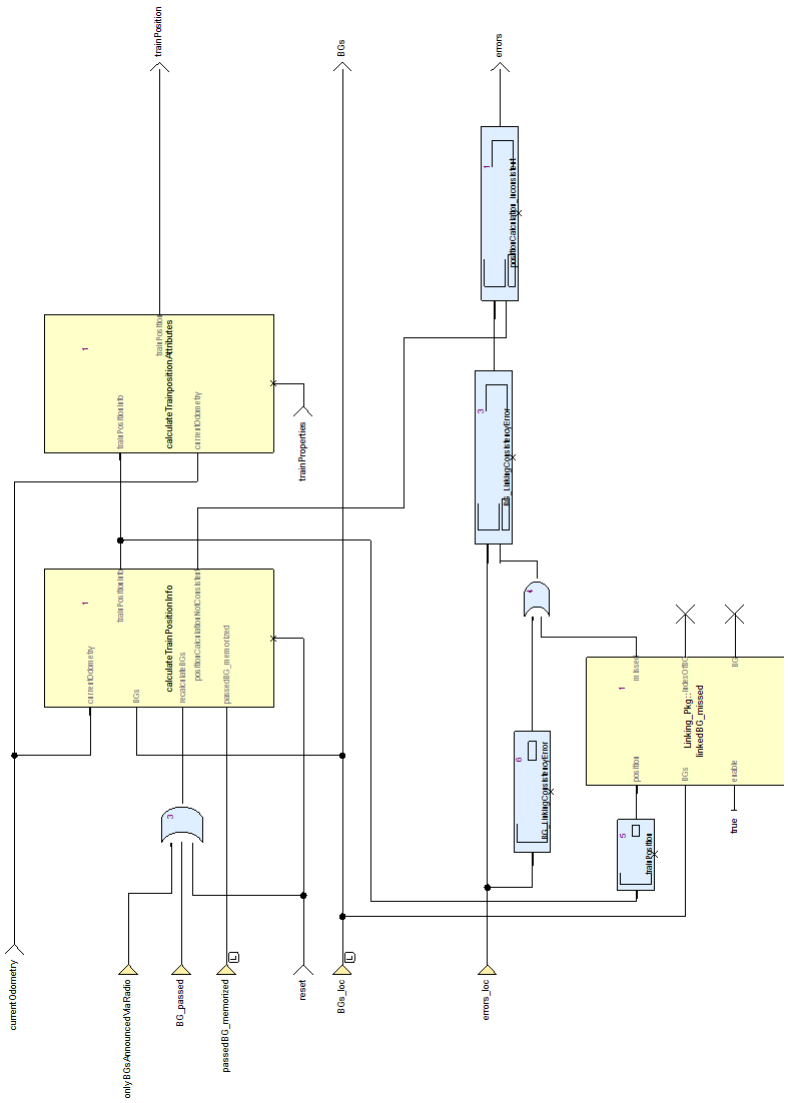

Figure 7. Calculating the current train position and attributes

Functional Structure in Stages

calculateTrainPositions receives its input information via its passedBG entry as an event. The first decicion to be made is, if an input event is available and if it origins from a balise group just over passed or from the RBC via radio.

If the passedBG input events is caused by over passing a balise group, the balise group gets an OBU coordinate system location assigned ("calculateBGLocations") and is stored internally. If the just passed balise group announces more balise groups ahead via linking, they are stored with their locations calculated.

If the passedBG input event origins from RBC data received ("addAnnouncedBGs"), it only announces balise groups ahead. These announced balise groups get their locations calculated with reference to the LRBG and are stored as well.

"calculateBGLocations" and "addAnnouncedBGs" produce a list of known balise groups ("BGs").

The following stages "calculateTrainPositionInfo" and "calculateTrainpositionAttributes" all the time calculate the current train position by using the list of known balise groups (including the LRBG) and the current odometry information and determine additional position attributes.

In parallel "linkedBG_missed" is part of linking consistency supervision. It detects, when an announced balise group is not found within its expectation window.

In more detail, "calculateTrainPosition" is divided into a data flow of different stages, which are being performed sequentially:

1. ***calculateBGLocations***: Calculate the balise group locations
   The stage is triggered each time the train passes a balise group (input *passedBG*). It takes the balise group header with the BG identification, the linking information (Subset 26, packet 5) and the current odometry values as inputs and calculates the location of the passed balise group. If the passed BG has been announced via linking information previously, it takes into account the linking as well as the odometry information. If the passed BG does not meet the expectation window announced by linking, an error flag is set. If the passed BG is an unlinked BG, its location is determined by odometry only, but related to the next previously passed linked BG (LRBG), if there is one.
   Then, if the passed BG is a linked BG comprising linking information for BGs ahead, the linking information is evaluated by creating the announced BGs and computing their locations from the linking distances.
   The passed and the announced BGs are stored in a list *BGs* in the order they are passed and by their announced nominal location on the track.
   Afterwards the locations of all BGs are further improved by re-adjusting their locations with reference to the just passed BG. This optimizes the BG location inaccuries around the current train position (= location of the passed BG).

2. ***delDispensableBGs***: Delete dispensable balise groups
   The function removes balise groups supposed not to be needed any longer from the list of *BGs*.
   If the number of stored passed linked BGs exceeds the maximum number as specified in [1, Chapter 3.6.2.2.2 c], all BGs astern are deleted. If only (passed) unlinked BGs are in the list

and exceed the number of *cNoOfAtLeast_x_unlinkedBGs*, all passed BGs astern to those are removed from the list.

3. ***addAnnouncedBGs***: This function is executed once each time balise groups ahead are announced by the RBC. The locations of the announced *BGs* are calculated with reference to the LRBG reported by the RBC.

4. ***calculateTrainPositionInfo***: Calculate train position information.
   This stage takes the list of stored BGs and the current odometry values as inputs and steadily provides the current train position. Additionally, it watches the list of announced *BGs* and provides the "Linking information is used" information as specified in chapt. 3.4.4.2.1.1 of the SRS.

5. ***calculateTrainpositionAttributes***: Calculate train position attribute information.
   This stage provides several additional position related attributes that might conveniently be used by subsequent consumers in the architecture. It in addition provides the current LRBG and the previous LRBG from the list *BGs*.

6. ***linkedBG_missed***: This function observes the list of *BGs* and the current train position. If an announced balise group is not found within its expectation window, an error flag will be raised.

Reference to the SRS (or other requirements)

The component calculateTrainPosition determines the location of linked and unlinked balise groups and the current train position during the train trip as specified mainly in [1, Chapter 3.6].

Design Constraints and Choices

The following constraints and prerequisites apply:

1. The input data received from the balises groups or via radio must have been checked and filtered for validity, consistency and the appropriate train orientation before delivering them to calculateTrainPosition.

2. The storage capacity for balise groups is finite. calculateTrainPosition will raise an error flag when a balise group cannot be stored due to capacity limitations.

3. calculateTrainPosition will raise an error flag if a just passed balise group is not found where announced by linking information or if an announced balise group is missed when the end of its expectation window is reached. It does not yet implement all conditions of linking consistency.

4. calculateTrainPosition is not yet prepared for train movement direction changes.

5. calculateTrainPosition does not yet consider repositioning information.

6.2.4.2 Provide Position Report

Short Description of Functionality

This function takes the current train position and generates a position report which is sent to the RBC. The point in time when such a report is sent is determined by events, on the one hand,

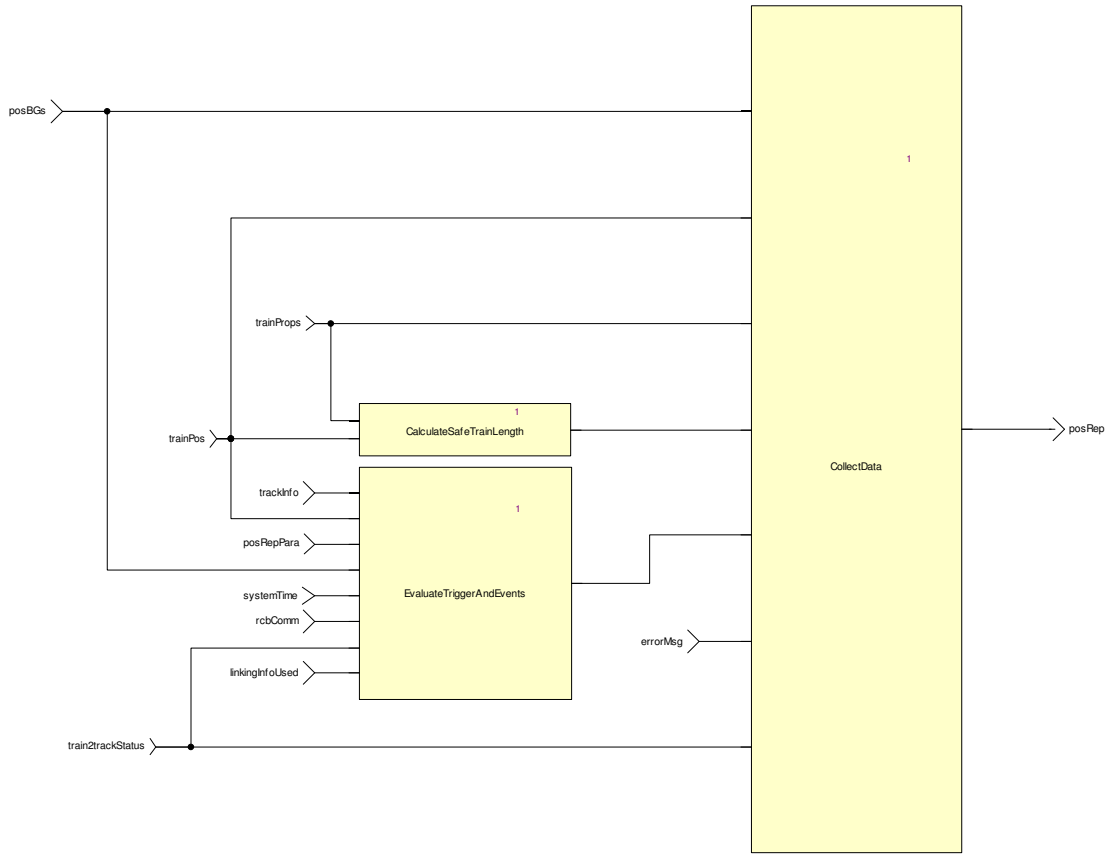

Figure 8. Structure of component ProvidePositionReport

and position report parameters—which are basically triggers—provided by the RBC or a balise group passed, on the other hand. The functionality is modeled using four operators, as shown in Figure 8, which are explained below.

CalculateSafeTrainLength Calculates the the safeTrainLength and the MinSafeRearEnd according to [1, Chapter 3.6.5.2.4/5].
`safeTrainLength = absolute(EstimatedFrontEndPosition - MinSafeRearEnd)`, where `MinSafeRearEnd = minSafeFrontEndPosition - L_TRAIN`.

EvaluateTriggerAndEvents Returns a Boolean modelling whether the sending of the next position report is triggered or not. This value is the conjunction of the evaluation of all triggers (PositionReportParameters, i.e., Packet 58) and events (see [1, Chapter 3.6.5.1.4]).

ErrorManager Takes a boolean flag for each possible error that has been occurred and outputs the respective error using type `M_ERROR`

CollectData This operation aggregates data of Packet 0, ..., Packet 5 and the header to a position report.

Reference to the SRS (or other requirements

Most of the functionality is described in [1, Chapter 3.6.5].

Design Constraints and Choices

1. The message length (i.e., attribute `L_MESSAGE`) is by default set to 0; the actual value will be set by the Bitwalker/API.
2. The attribute `Q_SCALE` is assumed to be constant; that is, all operations using this attribute do not convert between different values of that attribute.
3. *PositionReportHeader*: The time stamp (i.e., attribute `T_TRAIN`) is not set; this should be done once the message is being sent by the API.
4. *Packet 4*: When aggregating data for this packet, an error message might be overwritten by a succeeding error message. Because the specification allows only to sent one error in one position report, errors are not being stored in a queue, for instance.
5. *Packet 44*: This packet is currently not contained in a position report as it is not part of the kernel functions.
6. The usage of attributes `D_CYCLOC` and `T_CYCLOC` as part of the triggers specified by the position report parameters (i.e., Packet 58 sent by the RBC) may lead to unexpected results if a big clock cycle together with small values for the attributes is used. The cause is that at every clock cycle the current model increments the reference value for the distance and time by at most `D_CYCLOC` and `T_CYCLOC`, respectively and not a factor of it.
7. The *ErrorHandler* is currently restricted to deal with a single error. As a consequence, as for each error reported a report has to be sent to the RBC, the number of reports is limited to one.

Open Issues

1. The specification requires to store the last eight balise groups for which a position report has been sent (see [1, Chapter 3.6.2.2.2.c]).
2. For all reports that contain Packet 1 (i.e., report based on two balise groups), the RBC sends a coordinate system. It is unclear where this has to be stored (i.e., somehow the balise groups have to be stored in a database which has then to be updated), see [1, Chapter 3.4.2.3.3.6]. Moreover, such a coordination system can be invalid and then has to be rejected (see [1, Chapter 3.4.2.3.3.7-8]). On a more abstract level, we need to think about the interface between the RBC and the OBU or a proper abstraction thereof.

6.2.4.3 Macrofunction x in Manage Track Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.4.4 Macrofunction x in Manage Track Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.4.5 Macrofunction x in Manage Track Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.4.6 Macrofunction x in Manage Track Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.5 Manage Data

6.2.5.1 Macrofunction x in Manage Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.5.2 Macrofunction x in Manage Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.5.3 Macrofunction x in Manage Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.5.4 Macrofunction x in Manage Data

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.6 Manage Outputs

6.2.6.1 Macrofunction x in Manage Outputs

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.6.2 Macrofunction x in Manage Outputs

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.6.3 Macrofunction x in Manage Outputs

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.6.4 Macrofunction x in Manage Outputs

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.7 Mode and Level

The "Management of Modes and Levels" function is mainly described in chapter 4 and 5 of [1]. Modes and levels define the status of the ETCS regarding on-board functional status and track infrastructure.

Figure 9. High level Architecture

6.2.7.1 Function Level Management

Reference to the SRS or other Requirements

see [1] section 5.10

Short description of the functionality

The level management subsystem receives level transition order tables and selects the order with the highest probability. It stores the information about the selected transition order and transits to the requested level once the train passes the location of the level transition.

If required, the driver is asked to acknowledge the transition, in case of no acknowledge or if conditions for the level transition are not fulfilled, the train gets tripped.

Interface

The interface consists of the following inputs:

- *conditional transitions:* a priority table containing the conditional level transition orders (from paquet 46)
- *level transition priority table:* a priority table containing the (non-conditional) level transition orders (from paquet 41)
- *train standstill:* a Boolean value indicating whether the train is at standstill (from odometry)
- *driver level transition:* a level transition order selected by the driver (from DMI)
- *ERTMS capabilities:* the ERTMS capabilities of the track
- *getAck:* Boolean input that signals the acknowledgment of the driver (from DMI)
- *resetIdle:* Boolean input to reset without acknowledge
- *currentDistance:* the current position of the train given with the same reference as the position of the level transition order (train position , from localisation)
- *ackDistance:* the maximal distance for driver acknowledge after the level transition (from paquet 41)
- *immediateAck:* a Boolean that signals that an immediate acknowledge is required
- *received L2 L3 MA:* a Boolean that indicates that a level 2 or level 3 movement authority for the track behind the level transition has been received (from paquet 15)

- *received L1 MA:* a Boolean that indicates that a level 1 movement authority for the track behind the level transition has been received (from paquet 12)
- *received target speed:* a Boolean indicating that a target speed for the track behind the level transition has been received (from paquet 27) ?

and the following outputs:

- *next level:* the next level after this computation cycle
- *Trip train:* a Boolean indicating whether the train should be tripped
- *previous level:* the previous level before this computation cycle
- *needsAckFromDriver:* a Boolean that indicates whether an acknowledgment from the driver is necessary

Functional Design Description

On the most abstract level the design consists of the *manage_priorities* function which takes the level transition order priority tables as inputs and computes the highest priority transition.

This transition order is the fed to the *computeLevelTransitions* operator. This operator consists of three main parts. The *ComputeTransitionConditions* operator that emits the fulfilled conditions to change from a given level to a new level, the *LevelStateMachine* that stores the current level and takes the computed change conditions as input for possible level transitions and finally the *driverAck* operator which contains a state machine that stores the information whether the system is currently waiting for a driver acknowledge and emits the train trip information if necessary.

Reference to the Scade Model

The Scade model is available on github: `https://github.com/openETCS/modeling/tree/master/openETCSArchitectureAndDesign/WorkGroups/Group3/SCADE/LevelManagement/`

6.2.7.2 Function Mode Management

Reference to the SRS or other Requirements

see [1] sections 4.4, 4.6, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.11, 5.12, 5.13, 5.19

Short description of the functionality

This function is in charge of the computation of new mode to apply according to conditions from inputs (track information, driver interactions, train data,...) and other functions.

Interface

The inputs are the following:

- *Cab* identification of the current cabin (A or B)

- *Continue_shunting_Function_Active*: boolean to describe the activation state of the shunting function
- *Current_Level*: outputs of the Level management function
- *Data_From_DMI*: set of data received from the driver via the DMI interface, indeed:
  - *Ack_LS : bool* Driver acknoledges LS mode
  - *Ack_OS : bool*
  - *Ack_RV : bool*
  - *Ack_SH : bool*
  - *Ack_SN : bool*
  - *Ack_SR : bool*
  - *Ack_TR : bool*
  - *Ack_UN : bool*
  - *Req_Exit_SH : bool* driver selects exit of shunting
  - *Req_NL : bool* Driver requests NL mode
  - *Req_Override : bool* Driver requests override function
  - *Req_SH : bool* driver requests SH mode
  - *Req_Start : bool* Driver requests start of mission
  - *ETCS_Isolated: bool*: isolation status of the ETCS
- *Data_From_Localisstion*: set of data received from the function in charge of localistion of the train, indeed:
  - *BG_In_List_Expected_BG_In_SR : bool*: the identity of the overpass balise group is in the list of expected balises related to SR mode (from SR to trip mode condition 36)
  - *BG_In_List_Expected_BG_In_SH : bool*: the identity of the overpass balise group is in the list of expected balises related to SH mode (from SH to trip mode condition 52)
  - *Linked_BG_In_Wrong_Direction : bool* balise group contained in the linking information is passed in the unexpected direction (from FS, LS, OS to trip mode condition 66) *Localisaion function ?*
  - *Train_Position*: output provided by function in charge of computation of train possition (type TrainPosition_Types_Pck::trainPosition_T)
  - *Train_Speed : Obu_BasicTypes_Pkg::Speed_T* provided by odometry function
  - *Train_Standstill : bool* provided by odometry function
- *Data_From_Speed_and_Supervision*: set of data received from the function in charge of speed and supervision management, indeed:
  - *Estim_front_End_overpass_SR_Dist : bool*: the train overpass the SR distance with its estimated front end (from SR to trip mode condition 42)
  - *Estim_Front_End_Rear_SSP : bool*: estimated front end is rear of the start location of either SSP or gradient profile stored on-board (from FS, LS, OS to trip mode condition 69)
  - *Override_Function_Active*: boolean to indicate the state of the activation function
  - *EOA_Antenna_Overpass : bool*: the train overpasses the EOA with min safe antenna position Level 1 (from FS, LS, OS to trip mode condition 12)

  - *EOA_Front_End : bool* the train overpasses the EOA with min safe front end, Level 2 or 3 (from FS, LS, OS to trip mode condition 16)
  - *Train_Speed_Under_Overide_Limit : bool* supervision when override function is active (to SR mode condition 37)

- *Data_From_TIU : TIU_Types_Pkg::Message_Train_Interface_to_EVC_T*:message provided by TIU interface
- *Data_From_Track*: set of data received from track side (via RBC or Balises telegram), indeed:
  - *MA_SSP_Gradiant_Available : bool* MA, SSP and gradient have been received, checked and stored on-board from paquet 12, 15, 21 and 27 or message 3 or 33
  - *Mode_Profile_On_Board : Level_And_Mode_Types_Pkg::T_Mode_Profile* from packet 80
  - *Shunting_granted_By_RBC : bool* from message 27 and 28
  - *Trip_Order_Given_By_Balise : bool*
  - *List_Bg_Related_To_SR_Empty : bool* from packet 63
  - *Stop_If_In_shunting : bool* from packet 135
  - *Stop_If_In_SR : bool* from packet 137
  - *Error_BG_System_Version : bool*
  - *Linking_Reaction_To_Trip : bool*
  - *RBC_Ack_TR_EB_Revocked : bool* from message 6
  - *RBC_Authorized_SR : bool* from message 2
  - *Reversing_Data : Level_And_Mode_Types_Pkg::T_Reversing_Data* from packet 138/ 139
  - *T_NVCONTACT_Overpass : bool* Maximal time without new safe message overpass
  - *Emergency_Stop_Message_Received*: boolean to describe the reception of Emergency Stop message from message 15 or 16
- *Failure_Occured*: boolean to indicate safety failure occurence
- *Interface_To_National_System*: boolean to indicate existance of an interface to a national system
- *National_Trip_Order*: boolean to indicate reception of a trip order from a national system
- *OnBoard_Powered*: boolean to indicate the poxering state of the system
- *Stop_Shunting_Stored*: boolean to store the information in regards of shunting function
- *Valid_Train_Data_Stored*: boolean to indication train data are available and valid.

The outputs are the following:

- *currentMode* the new computed mode (typeis Level_And_Mode_Types_Pkg::T_Mode, default value is Level_And_Mode_Types_Pkg::SB)
- *EB_Requested* boolean to request triggering of emergency brake
- *Service_Brake_Command* boolean to request command of service brake

- *Data_To_DMI*: set of data provided to the DMI Level_And_Mode_Types_Pkg::T_Data_To_DMI :
  - *Ack_LS : bool* Driver acknoledges LS mode
  - *Ack_OS : bool*
  - *Ack_RV : bool*
  - *Ack_SH : bool*
  - *Ack_SN : bool*
  - *Ack_SR : bool*
  - *Ack_TR : bool*
  - *Ack_UN : bool*
  - *Req_Exit_SH : bool* driver selects exit of shunting
  - *Req_NL : bool* Driver requests NL mode
  - *Req_Override : bool* Driver requests override function
  - *Req_SH : bool* driver requests SH mode
  - *Req_Start : bool* Driver requests start of mission
  - *ETCS_Isolated: bool*: isolation status of the ETCS
- *Data_To_BG_Management*: set of date to trackside Level_And_Mode_Types_Pkg::T_Data_To_BG_Management :
  - *EoM_Procedure_req : bool* request of end of mission procedure indeed end of the communication session for message 150
  - *Clean_BG_List_SH_Area : bool* request to clean the BG list when entering an SH area §5.6.2
  - *MA_Req : bool* for message 132
  - *Req_for_SH_from_driver : bool* for message 130

Functional Design Description

Three subfunctions are defined:

Inputs proceeds to inputs check and preparation.

ComputeModesCondition performs all specific procedure linked to mode management and defined in [1] sections 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.11, 5.12, 5.13, 5.19 and specifies the conditions to define a mode transition according condition table of section 4.6.3 of [1]

SwitchModes performs the mode selection according the conditions and priorities defined in transition table section 4.6.2 of [1]

Outputs prepares paquet of outputs.

Reference to the Scade Model

The Scade model is available on github: `https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLevelsAndModes/Modes`

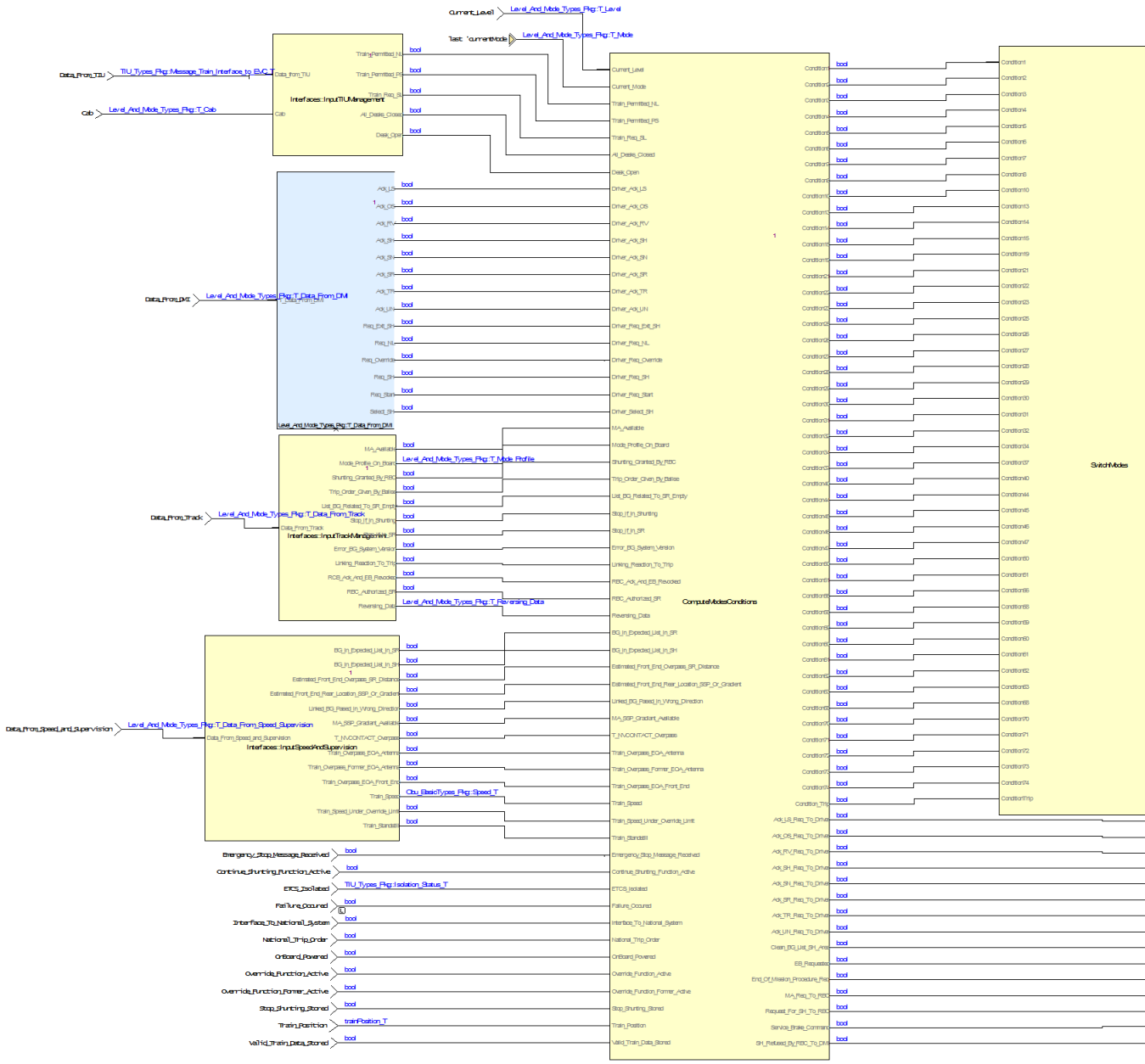

Figure 10. Modes subfubction architecture

6.2.7.3 Function Check and Provide Level and Mode

Reference to the SRS or other Requirements

see [1] section 3.6.5

Short description of the functionality

checks compatibility between mode and level and provides outputs

Interface

To design

Functional Design Description

To design

Reference to the Scade Model

To design

6.2.8 Manage RBC Procedure

6.2.8.1 Macrofunction x in Manage RBC Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.8.2 Macrofunction x in Manage RBC Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.8.3 Macrofunction x in Manage RBC Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.8.4 Macrofunction x in Manage RBC Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.9 Manage DMI Procedure

6.2.9.1 Macrofunction x in Manage DMI Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.9.2 Macrofunction x in Manage DMI Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.9.3 Macrofunction x in Manage DMI Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.2.9.4 Macrofunction x in Manage DMI Procedure

Reference to the SRS or other Requirements (or other requirements)

Short descriptoiin of the functionality

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

6.3 F3: Measure Train Movement

6.4 F4: Manage Radio Communication

6.4.1 Manage Radio Communication

6.4.1.1 Management of Radio Communication (*MoRC*)

Reference to the SRS

The management of radio communication is specified in Subset-026, chap. 3.5.

Short description of the functionality

The management of radio communication *MoRC* implements the on board management part of a single communication session with the track, i.e. a single RBC. It controls the establishing, maintaining and termination process of a radio communication session and steers the underlying

communication safety layer and the mobile device. Those and the data transfer itself are not part of the function.

Interface

Inputs The MoRC function takes as inputs datagrams received from track, OBU internal phases and status information and configuration data:

- Datagrams received from track (*inMessage*):
  - Packet 42 (session management) received from balise group or RBC
  - Packet 45 (radio network registration) received from balise group or RBC
  - Message 32 (RBC/RIU System Version) received from RBC: *MoRC* only needs to know if the system version received from track side is supported by the OBU.
  - Message 38 (initiation of a communication session) received from RBC
  - Message 39 (acknowledgement of termination of a communication session)
- *obuEventsAndPhases*: information about OBU internal events and OBU internal phases:
  - *atPowerDown*
  - *atPowerUp*
  - *atStartOfMission*
  - *startOfMissionProcedureIsGoingOn*
  - *startOfMissionProcedureCompleted*
  - *trainIsRejectedByRBC_duringStartOfMission*
  - *endOfMissionIsExecuted*
  - *driverClosesTheDeskduringStartOfMission*
  - *driverHasManuallyChangedLevel*
  - *afterDriverEntryOfANewRadioNetworkID*
  - *triggerDecisionThatNoRadioNetworkIDAvailable*
  - *isPartOfAnOngoingStartOfMissionProcedure*
  - *trainPassesALevelTransitionBorder*
  - *trainPassesA_RBC_RBC_border_WithItsFrontEnd*
  - *trainExitedFromAnRBCArea*
  - *modeChangeHasToBeReportedToRBC*
  - *trainFrontInsideInAnAnnouncedRadioHole*
  - *trainFrontReachesEndOfAnnouncedRadioHole*
  - *OBU_hasToEstablishANewSession*
  - *isInCommunicationSessionWithAnRIU*
  - *errorConditionRequiringTerminationDetected*
- Current OBU internal states:
  - *currentTime*: current OBU system time

  - *t_train*: current trainborne clock (T_TRAIN) as specified in Subset-026, chap. 7
  - *mode*: current OBU mode
  - *level*: current OBU level

- *statusOfMobile*: status of the associated mobile device
- configuration parameters:
  - *onboardPhoneNumbers* (NID_RADIO)
  - *radioNetworkIDs*: Identities of radio networks (NID_MN): default, memorized or from driver
  - *nid_engine*: Onboard ETCS identity (NID_ENGINE)
  - *connectionStatusTimerInterval*: Connection status timer period

Outputs MoRC generates a couple of outputs:

- *MessageToRBC*: messages to be sent to the RBC:
  - Message 155 (initiation of a communication session)
  - Message 156 (termination of a communication session)
  - Message 159 (session established)
  - Message 154 (no compatible version supported)
- Action triggers:
  - *sendAPositionReport*: triggers a position report to be sent to the RBC
  - *memorizeTheLastRadioNetworkID*: triggers to store the last radio network ID for later use
  - *orderTheRegistrationOfItsConnectedMobiles*
  - *rejectOrderToContactRBC_or_RIU*
  - *InformTheDriverThatNoConnectionWasSetup*
  - *requestTheSetupOfASafeRadioConnection*: initiate the setup of a safe radio connection
  - *requestReleaseOfSafeRadioConnectionWithTrackside*: initiate the release of a safe radio connection
  - *ignoreMessagesFromRBC_except_m39_AckOfTerminationOfCommunicationSession*
  - *sessionSuccessfullyEstablished*
- *cmdsToMobile*: control commands to the mobile device
- Status information:
  - *sessionStatus*: current session status
  - *mobileSWStatus*: connection status
  - *currentRadioNetworkID*: current radio network ID

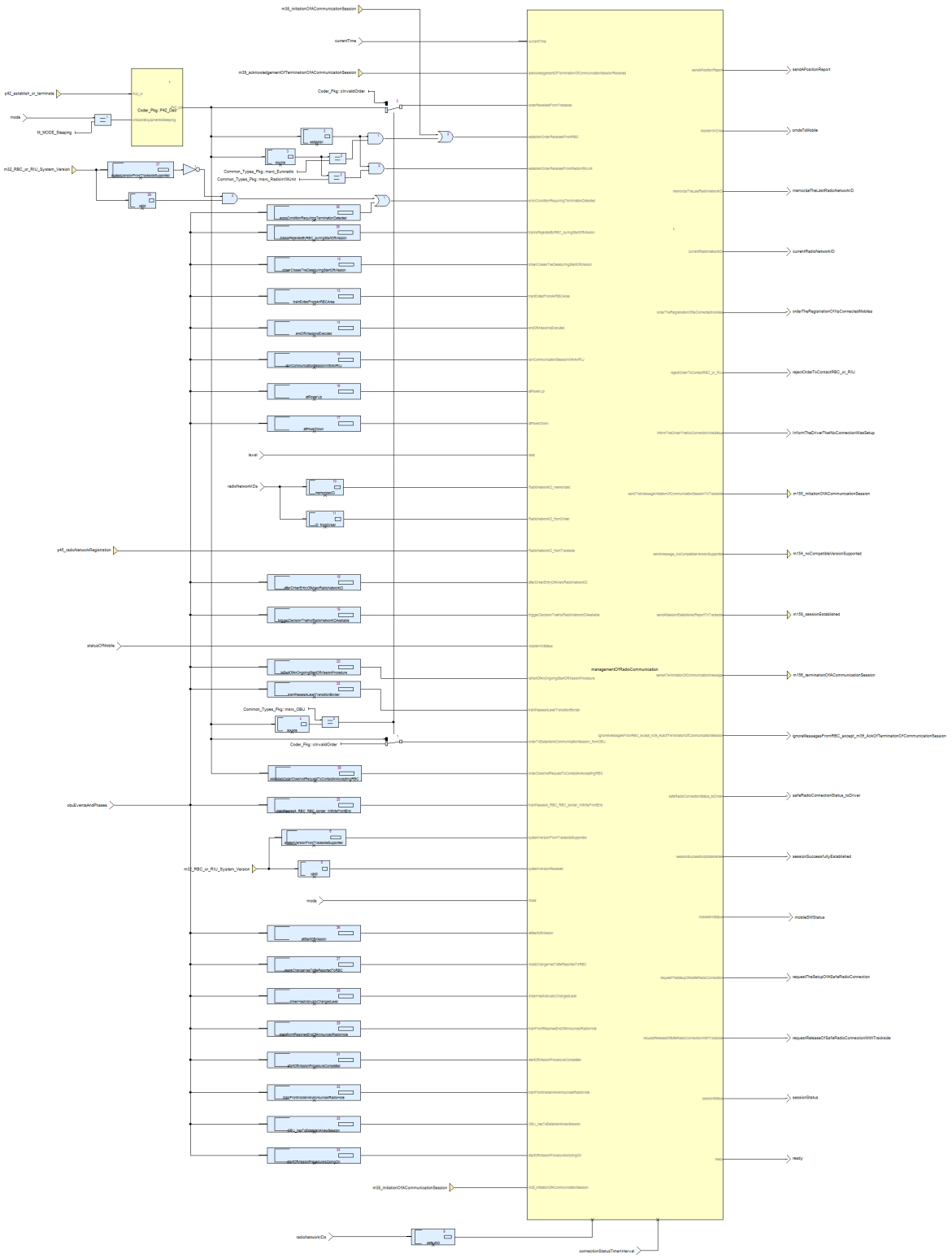

Figure 11. Main function of *MoRC*

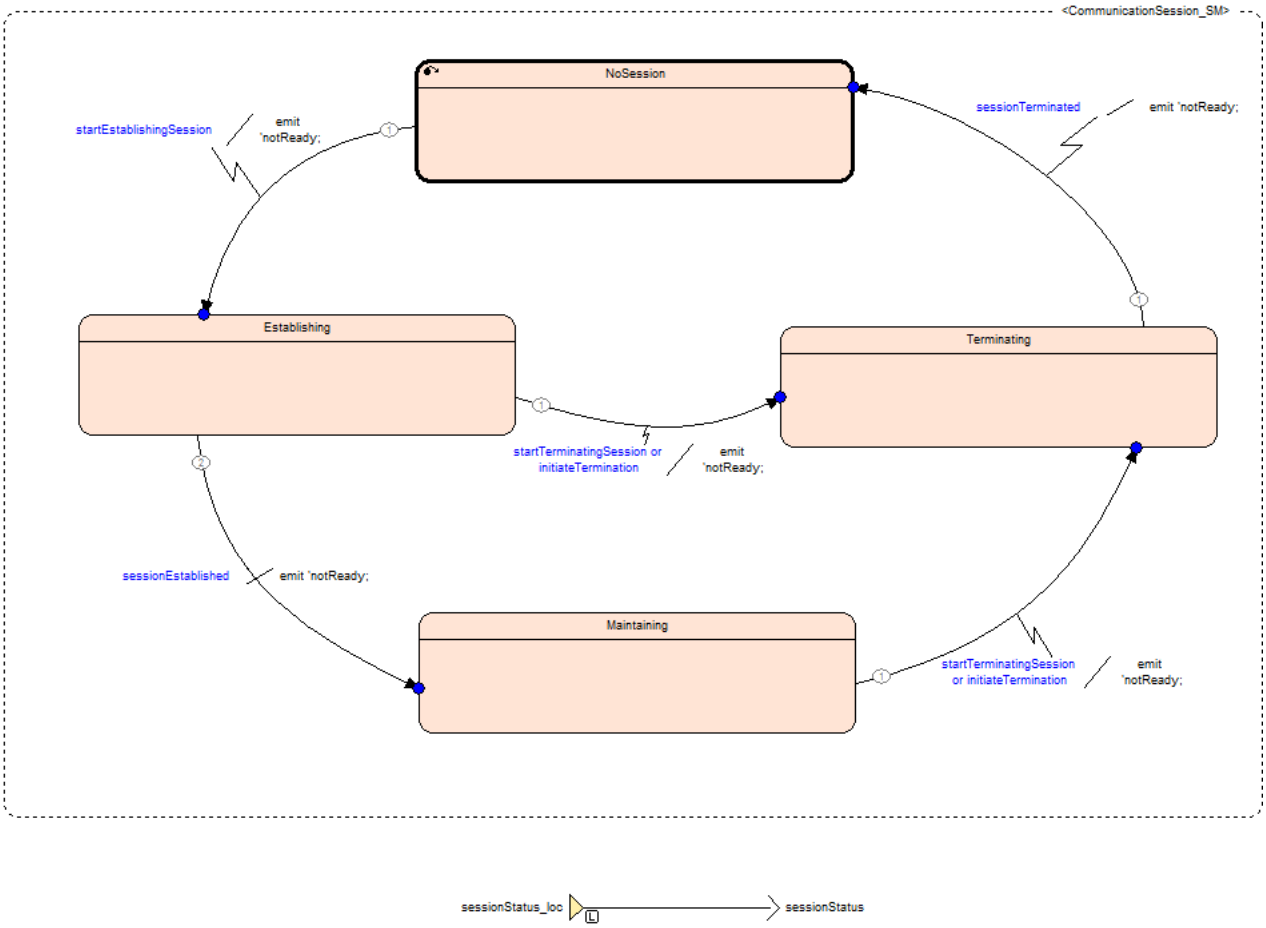

Figure 12. Implementation of session states

Functional Design Description

The kernel function of the *MoRC* component is *managementOfRadioCommunication* (figure ???). The implementation is kept close to the prose of Subset-026, chap. 3.5. Since chap. 3.5 rarely refers to terms, variable types, packets and messages of the ETCS language as specified in Subset-026, chap. 7 and 8, *managementOfRadioCommunication* does neither.

To be capable of being integrated with other OBU software components, *MoRC* had to be wrapped with a transformer between the ETCS and the "chap. 3.5" language. This is the purpose of the main function of *MoRC*, *MoRC_Main*.

The function *managementOfRadioCommunication* implements the session states establishing, maintaining and termination as described in Subset-026, chap. 3.5. A SCADE state machine reflects this state model (figure ???) accurately. Within each of the states, the activities needed as long as the state is active, are performed. When there is no communication session (state *NoSession*) currently, the state machine waits for events that initiate a session (subfunction *initiate_a_Session*). When the appropriate conditions are fulfilled, the state machine moves to the *Establishing* state. Here in, it runs through the sequence required fore establishing a session (subfunction *establish_a_Session*. Dependent on the results, the state machine changes over to the *Maintaining* or *Terminating* state. While in *Maintaining*, the communication connection is monitored. When an event triggering the session termination occurs, the state machine switches to the state *Terminating* with the subfunction *terminating_a_CommunicationSession* and performs the session termination sequence.

In parallel to the main state machine, *managementOfRadioCommunication* monitors all the time whether the session has to be terminated (subfunction *initiateTerminatingASession*) or if the session has the be terminated and subsequently established (subfunction *terminateAndEstablishSession*). *registeringToTheRadioNetwork* is responsible for connection to the radio network. *safeRadioConnectionIndication* controls the radio connection indication for the driver.

Reference to the Scade Model

The MoRC SCADE model resides at `https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/Radio/MoRC` .

only in special case or link to the Scade model

6.5 F5: Manage JRU

6.6 F6: DMI Controller

6.6.1 DMI Controller

Reference to the SRS or other Requirements (or other requirements)

§ 4.7, § 5.4, § 3.12.3

§ F I1: Packet 72: this packet will inclsude the information received from the track for the entered section with the display and display conditions depending from:
- train status Level ETCS

- train status modus ETCS
- distance
- timeperiod
- acknowledgement from the driver on the DMI display

The displaying of this information can be ordinary or multiple (combination of several conditions).

§ F I2: Missing acknowledgement: for the case that a acknowledgement from the driver in combination with another condition is expected at the end, and the acknowledge is missing, the ETCS on-board unit will trigger the service brake.(missing acknowledgement).

§ F I3: Packet 76: this package contains information for sending fixed messages.

Short descriptoiin of the functionality

The DMI controller interact with the DMI display and is responsible for alls procedures between the DMI display and Driver. Furthermore the DMI controller will interact with the DMI Management to compute the receive information (e.g. driver number request, ...) and send, if necessary, data or reports ot the DMI Management (acknowledge, text messages, ..).

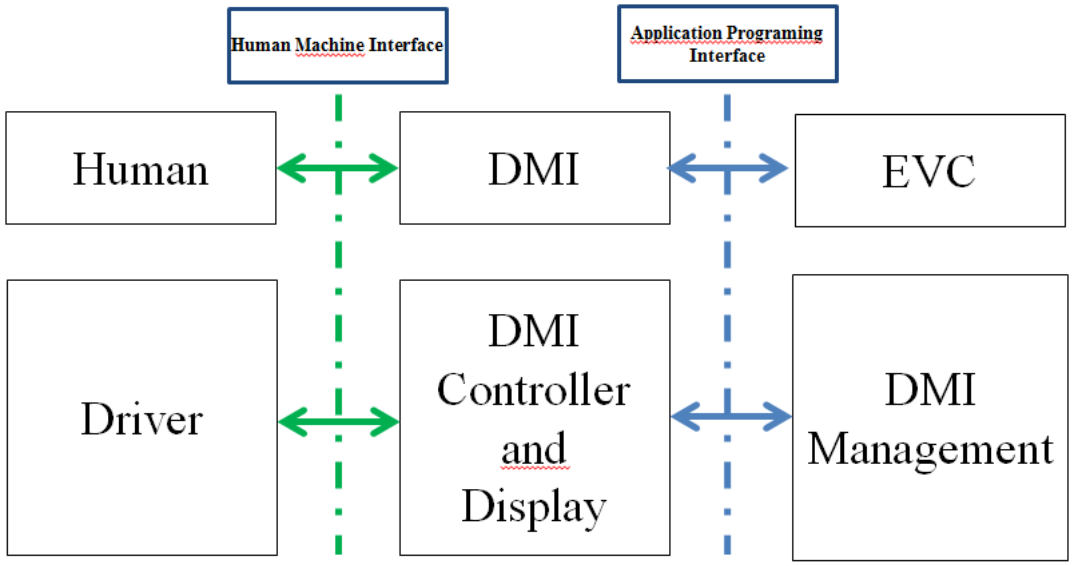

Figure 13. DMI Interfaces

Interface

Functional Design Description

Refernce to the Scade Model

only in special case or link to the Scade model

References

[1] ERA. *System Requirements Specification, SUBSET-026*, v3.3.0 edition, March 2012.