

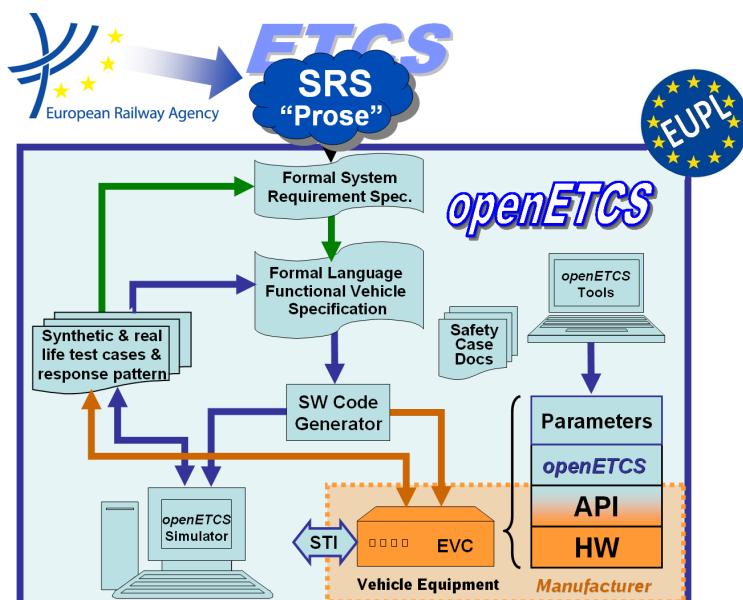
Work Package 3: "Modeling"

openETCS Design Specification

Software Component Design and Internal Interface Specification

Baseliyos Jacob, Peter Mahlmann, Bernd Hekele, Peyman Farhangi, Stefan Karg, Valerio D'Angelo, Uwe Steinke, Christian Stahl, Jakob Gärtner, Jos Holtzer, Jan Welvaarts, Vincent Nuhaan, Benjamin Beichler, Thorsten Schulz, Marielle Petit-Duche, Matthias Gudemann, Vernique Gontier, Ghristian Giraud, Fausto Cochetti and Alexander Stante

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Work Package 3: "Modeling"

OETCS/WP3/D3.5.2

June 2015

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Architecture and Design Specification

Abstract: This document gives an introduction to the software and component design of the openETCS OBU model. The functional scope is tailored to cover the functionality required for the openETCS demonstration as an objective of the ITEA2 project. The goal is to develop a formal model and to demonstrate the functionality during a proof of concept on the ETCS Level 2 Utrecht Amsterdam track with real scenarios. It has to be read as a complement to the models in SysML and Scade languages.

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Modification History

| Version | Section | Modification / Description | Author | Date |
|---------|----------|--------------------------------------|----------------|------------|
| 0.1 | Document | Initial document providing structure | Peter Mahlmann | 27.05.2015 |
| 0.2 | 2 | New template for design descriptions | Peter Mahlmann | 10.06.2015 |

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Part I

Functional Breakdown

1 openETCS API Runtime System and Input to the EVC)

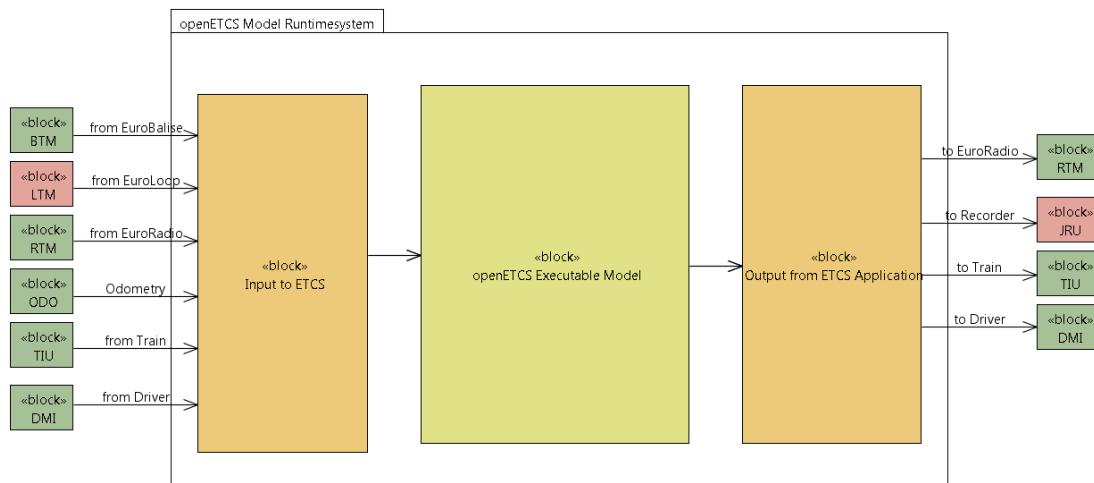


Figure 1. openETCS API Highlevel View

- 5 Figure 1 shows the structure of API with respect to the software architecture. Note that red
inputs and outputs modules were not yet implemented and thus are not part of the openETCS
OBUs model. The system covers functions for processing inputs from other units, functions for
processing outputs to other functions and a basic runtime system. Inputs are used to feed the input
to the executable model before calling it, outputs are used for collecting information provided by
the executable model to be passed to the relevant interfaces after the execution cycle has finished.
- 10

1.1 Principles for Interfaces (openETCS API)

Information is exchanged via asynchronous *messages*. A message is a set of information corresponding to an event of a particular unit, e.g. a balise message received from the BTM. For possible types of messages please refer to Chapter ??.

- 15 The information is passed to the executable model as parameters to the synchronous call of a procedure (Interface to the executable model). Since the availability of input messages to the application is not guaranteed the parts of the interfaces are defined with a "present" flag. In addition, fields of input arrays quite often is of variable size. Implementation in the concrete interface in this use-case is the use of a "size" parameter and a "valid"-flag.

1.2 ²⁰ openETCS Model Runtime System

The openETCS model runtime system also provides:

Input Functions From other Units In this entity messages from other connected units are received.

Output Functions to other Units The entity writes messages to other connected units.

25 **Conversation Functions for Messages (Bitwalker)** The conversion function are triggered by Input and Output Functions. The main task is to convert input messages from an bit-packed format into logical ETCS messages (the ETCS language) and Output messages from Logical into a bit-packed format. The logical format of the messages is defined for all used types in the openETCS data dictionary.

30 Variable size elements in the Messages are converted to fixed length arrays with an used elements indicator. Optional elements are indicated with an valid flag.

The conversion routines are responsible for checking the data received is valid. If faults are detected the information is passed to the openETCS executable model for further reaction.

Model Cycle The version management function is part of the message handling. This implies, 35 conversions from other physical or logical layouts of messages are mapped onto a generic format used in the EVC. Information about the origin version of the message is part of the messages.

The executable model is called in cycles. In the cycle

- First the received input messages are decoded
- The input data is passed to the executable model in a predefined order. (**Details for the interface to be defined**).
- Output is encoded according to the SRS and passed to the buffers to the units.

1.3 Input Interfaces of the openETCS API From other Units of the OBU

Interfaces are defined in the Scade project APITypes (package API_Msg_Pkg.xscade).

45 In the interfaces the following principles for indicating the quality of the information is used:

| Indicator | Type | Purpose |
|-----------|------|--|
| present | bool | True indicates the component has been changed compared to the previous call of the routine |
| valid | bool | True indicates the component is valid to be used. |

In the next table we can see the interfaces being used in the openETCS system. Details on the interfaces are defined further down.

| Unit | Name | Processing Function |
|-------------|--------------------------|--------------------------|
| BTM | Balise Telegram | Receive Messages |
| DMI | Driver Machine Interface | DMI Manager |
| EURORADIO | Communication Management | Communication Management |
| EURORADIO | Radio Messages | Receive Messages |
| ODO | Odometer | All Parts |
| System TIME | Time system of the OBU | All Parts |
| TIU | Train Data | All Parts |

50 Information in the following sections gives an more detailed overview of the structure of the interfaces.

1.4 Message based interface (BTM, RTM)

Balise Message (Track to Train)

| Message Name | Optional Packets | Restrictions in the current scope |
|-----------------|---|-----------------------------------|
| Balise Telegram | 3: National Values 41: Level Transition Order 42: Session Management 45: Radio Network registration 46: Conditional Level Transition Order 65: Temporary Speed Restriction 66: Revoke Temporary Speed Restriction 72: Packet for sending plain text messages 137: Stop if in Staff Responsible 255: End of Information | Used in Scenario |
| Balise Telegram | 0, 2, 3, 5, 6, 12, 16, 21, 27, 39, 40, 41, 42, 44, 45, 46, 49, 51, 52, 65, 66, 67, 68, 69, 70, 71, 72, 76, 79, 80, 88, 90, 131, 132, 133, 134, 135, 136, 137, 138, 139, 141, 145, 180, 181, 254 | Not Used in Scenario |

55 Radio Messages (Track to Train)

| Message Name | Optional Packets | Restrictions in the current scope |
|--------------------------|---|-------------------------------------|
| 2: SR Authorisation | 63: List of Balises in SR Authority | Message Not Supported |
| 3: Movement Authority | 21: Gradient Profile 27: International Static Speed Profile 49: List of balises for SH Area 80: Mode profile plus common optional packets | a |
| 9: Request To Shorten MA | 49: List of balises for SH Area 80: Mode profile | |
| 24: General Message | From RBC: 21: Gradient Profile 27: International Static Speed Profile plus common optional packets From RIU: 44, 45, 143, 180, 254 | Messages from RIU are not supported |

| | | |
|--|---|-----------------------|
| 28: SH authorised | 3, 44, 49 | |
| 33: MA with Shifted Location Reference | 21: Gradient Profile 27: International Static Speed Profile 49: List of balises for SH Area 80: Mode profile plus common optional packets | |
| 37: Infill MA | 5, 21, 27, 39, 40, 41, 44, 49, 51, 52, 65, 66, 68, 69, 70, 71, 80, 88, 138, 139 | Message Not Supported |
| List of common optional parameters | 3, 5, 39, 40, 51, 41, 42, 44, 45, 52, 57, 58, 64, 65, 66, 68, 69, 70, 71, 72, 76, 79, 88, 131, 138, 139, 140, 180 | |

The runtime system is in charge to transfer the messages from its stream mode first to compressed message format.

1.5 ⁶⁰ Interfaces to the Time System

The interface types are defined in the OBU_Basic_Types_Pkg Package. The system time is defined in the basic software.

The system TIME is provided to the executable model at the begin of the cycle. It is not refreshed during the cycle. The time provided to the application is equal to 0 at power-up of the EVC (it is not a “UTC time” nor a “Local Time”), then must increase at each cycle (unit = 1 msec), until it reaches its maximum value (i.e current EVC limitation = 24 hours)

- TIME (T_internal_Type, 32-bit INT)
Standardized system time type used for all internal time calculations: in ms. The time is defined as a cyclic counter: When the maximum is exceeded the time starts from 0 again.
- CLOCK (to be implemented)
The clocking system is provided by the JRU. A GPS based clock is assumed to provide the local time.

1.6 Interfaces to the Odometry System

The interface types are defined in the OBU_Basic_Types_Pkg Package. The odometer gives the current information of the positing system of the train. In this section the structure of the interfaces are only highlighted. Details, including the internal definitions for distances, locations speed and time are implemented in the package.

- Odometer (odometry_T)
 - valid (bool)
valid flag, i.e., the information is provided by the ODO system and can be used.
 - timestamp (T_internal_Type)
of the system when the odometer information was collected. Please, see also general remarks on the time system.

- Coordinate (odometryLocation_T)

85 * nominal (L_internal_Type) [cm]
 * min (L_internal_Type) [cm]
 * max (L_internal_Type) [cm]

The type used for length values is a 32 bit integer. Min and max value give the interval where the train is to be expected. The bounderies are determined by the inaccuracy of the positioning system. All values are set to 0 when the train starts.

- speed (OdometrySpeeds_T) [km/h]

90 * v_safeNominal (speed internal type) [km/h]

The safe nominal estimation of the speed which will be bounded between 98% and 100% of the upper estimation

95 * v_rawNominal (speed internal type) [km/h]

The raw nominal estimation of the speed which will be bounded between the lower and the upper estimations

100 * v_lower (speed internal type) [km/h]

The lower estimation of the speed

 * v_upper (speed internal type) [km/h]

The upper estimation of the speed

The type used for speed values is a 32 bit integer. Min and max value give the interval where the train is to be expected. The bounderies are determined by the inaccuracy of the positioning system. All values are set to 0 when the train starts.

- 105 - acceleration (A_internal_Type)[0.01 m/s²],

Standardized acceleration type for all internal calculations : in

- motionState (Enumeration)

indicates whether the train is in motion or in no motion

- motionDirection (Enumeration)

110 indicates the direction of the train, i.e., CAB-A first, CAB-B first or unknown.

1.7 Interfaces to the Train Interfaces (TIU)

The following infomration is based on the implementation of the Alstom API. The interface is organised in packets. The packets of the Alstom implementation are listed in the appendix to this document.

115 The description of interfaces needed for the current scope will be added according to the use.

1.8 Output Interfaces of the openETCS API TO other Units of the OBU

| From Function | Name | To Unit | Description |
|---------------|--------------------------|-----------|-------------|
| | Radio Output Message | EURORADIO | |
| | Communication Management | EURORADIO | |
| | Driver Information | DMI | |
| | Train Data | TIU | |

Packets: to be completed

Radio Messages to be completed

Part II

Design Description

2 F1: Receive information from Trackside

3 F2: ETCS Kernel

3.1 Manage_TrackSideInformation_Integration

¹²⁵ 3.1.1 Component Requirements

| | |
|------------------------|---|
| Component name | Manage_TrackSideInformation_Integration |
| Link to SCADE model | ??? |
| SCADE designer | [Name, affiliation] |
| Description | The block “Manage_TrackSideInformation_Integration” is responsible for receiving Eurobalise telegrams and Euroradio messages from the API and performs several consistency checks on the inputs. 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. |
| Input documents | See sub-components. |
| Safety integrity level | 4 |
| Time constraints | n/a |
| API requirements | n/a |

3.1.2 Interface

An overview of the interface of component Manage_TrackSideInformation_Integration is shown in Figure 2. The inputs and outputs are described in detail in Section 3.1.2.1 respectively 3.1.2.2.

3.1.2.1 Inputs

¹³⁰ 3.1.2.1.1 fullChecks

| | |
|-------------|--|
| Input name | fullChecks |
| Description | Indicates, if all checks on the message should be performed. |
| Source | Configuration |
| Type | bool |

Valid range of values

true All checks are performed.

false Component InformationFilter is deactivated.

Behaviour when value is n/a
at boundary

Behaviour for values out n/a
of valid range

3.1.2.1.2 API_trackSide_Message

| | |
|---|--|
| Input name | API_trackSide_Message |
| Description | Track side message received from the API. The API performs pre-processing of RTM and BTM messages and deliveres a maximum of a single message per cycle. |
| Source | API |
| Type | API_Msg_Pkg::API_TrackSideInput_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.3 ActualOdometry

| | |
|---|---|
| Input name | ActualOdometry |
| Description | Provided by the external odometry module of the train. It contains relative location information with inaccuracies. |
| Source | Odometer |
| Type | Obu_BasicTypes_Pkg::odometry_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

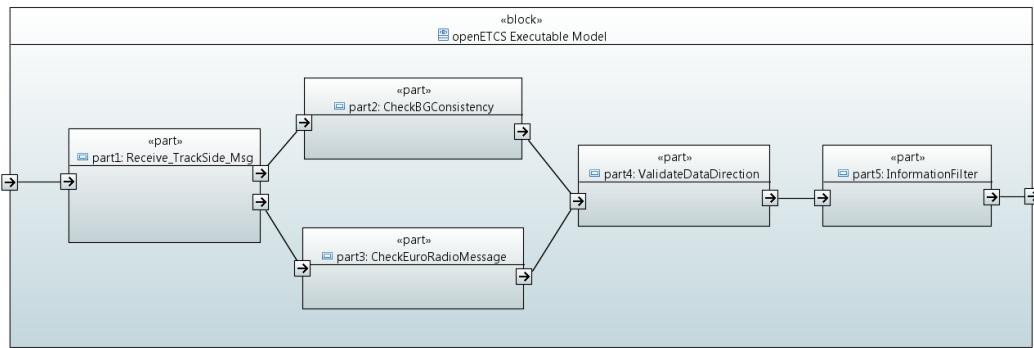


Figure 2. SysML diagram of Manage_TrackSideInformation_Integration module.

3.1.2.1.4 reset

| | |
|---|---|
| Input name | reset |
| Description | 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. |
| Source | Environment |
| Type | bool |
| Valid range of values | <p>true All data kept in the module is deleted and no input is accepted.</p> <p>false No action. Data at input is accepted.</p> |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.5 trainPosition

| | |
|---|--|
| Input name | trainPosition |
| Description | Contains the current position of the train. |
| Source | CalculateTrainPosition |
| Type | TrainPosition_Types_Pck::trainPosition_T |
| Valid range of values | |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

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| | |
|---|--|
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.7 tNvContact

| | |
|---|--|
| Input name | tNvContact |
| Description | For monitoring the safe radio connection, this national value is needed as an input. |
| Source | Database |
| Type | Obu_BasicTypes_Pkg::T_internal_Type |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.8 lastRelevantEventTimestamp

| | |
|---|--|
| Input name | lastRelevantEventTimestamp |
| Description | For monitoring the safe radio connection, it is necessary that the time between two packets is less than the value of T_NVCONTACT. In situations like level-changes or announced radio holes, not the timestamp of the last message is relevant for comparison, but the timestamp of the last relevant event. This can for example be the timestamp of the level change or 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. |
| Source | Database |
| Type | Obu_BasicTypes_Pkg::T_internal_Type |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.9 connectionStatus

| | |
|-------------|--|
| Input name | connectionStatus |
| Description | Status information about the radio connection. The information is needed to perform the timing check, which depends on the connection state. |
| Source | ManageRadioCommunication |
| Type | Radio_Types_Pkg::sessionStatus_Type |

Valid range of values

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 the RBC is established.

| | |
|---|--|
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.10 inSupervisingRbcId

| | |
|---|--|
| Input name | inSupervisingRbcId |
| Description | For the sub component InformationFilter, the information which radio messages are sent by the supervising RBC is needed. To recognize these messages, the identifier of the supervising RBC is needed. |
| Source | Database |
| Type | int |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.11 inAnnouncedBGs

| | |
|---|--|
| Input name | inAnnouncedBGs |
| Description | Provides information about balise groups which will be passed by the train soon. This information is generated by Calculate Train Position based on the linking information received from trackside. |
| Source | CalculateTrainPosition |
| Type | TrainPosition_Types_Pck::positionedBGs_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.1.12 q_nvlocacc

| | |
|---|--|
| Input name | q_nvlocacc |
| Description | The national value determines the location accuracy. |
| Source | Database |
| Type | Q_NVLOCACC |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.1.2.2 Outputs

3.1.2.2.1 outputMessage

| | |
|-----------------------|--|
| Output name | outputMessage |
| Description | Combines both balise and radio messages to one common datatype. This datatype contains all variables and packets, which are possible for the given scenario. |
| Destination | [Name of the destination component(s)] |
| Type | Common_Types_Pkg::ReceivedMessage_T |
| Valid range of values | [Complete list of valid values] |

| | |
|---|---|
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.2.2.2 ApplyServiceBrake

| | |
|---|---|
| Output name | ApplyServiceBrake |
| Description | Indicates if the balise group the train just passed could not be processed correctly. The check results in the request for a service break. |
| Destination | [Name of the destination component(s)] |
| Type | bool |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

¹⁴⁵ **3.1.2.2.3 BadBALiseMessageToDMI**

| | |
|---|--|
| Output name | BadBALiseMessageToDMI |
| Description | Information to be passed to the DMI to indicate the reception of a “bad balise” to the driver. |
| Destination | DMI |
| Type | bool |
| Valid range of values | <p>true ???</p> <p>false ???</p> |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.2.2.4 errorLinkedBG

| | |
|-------------|--|
| Output name | errorLinkedBG |
| Description | [Brief description of the output] |
| Destination | [Name of the destination component(s)] |
| Type | [Type of the output] |

Valid range of values

true An error in a linked balise group was detected.

false No error in a linked balise group was detected.

| | |
|---|---|
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.2.2.5 errorUnlinkedBG

| | |
|-------------|--|
| Output name | errorUnlinkedBG |
| Description | [Brief description of the output] |
| Destination | [Name of the destination component(s)] |
| Type | bool |

Valid range of values

true An error in a unlinked balise group was detected.

false No error in a unlinked balise group was detected.

| | |
|---|---|
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.2.2.6 passedBG

| | |
|-------------|--|
| Output name | passedBG |
| Description | Provides the received balise group message in a special format needed by the component CalculateTrainPosition. |
| Destination | [Name of the destination component(s)] |

| | |
|---|---|
| Type | BG_Types_Pkg::passedBG_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.2.2.7 outPositionParams

| | |
|---|--|
| Output name | outPositionParams |
| Description | Provides the parameters for the position report in a special format needed by the component ProvidePositionReport. |
| Destination | [Name of the destination component(s)] |
| Type | Common_Types_Pkg::PositionReportParameter_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

¹⁵⁰ **3.1.2.2.8 outRadioManagement**

| | |
|---|--|
| Output name | outRadioManagement |
| Description | Provides the messages for radio session management in a special format needed by the component ManagementOfRadioCommunication. |
| Destination | [Name of the destination component(s)] |
| Type | Common_Types_Pkg::radioManagementMessage_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.2.2.9 radioSequenceError

| | |
|---|---|
| Output name | radioSequenceError |
| Description | [Brief description of the output] |
| Destination | [Name of the destination component(s)] |
| Type | bool |
| Valid range of values | |
| | true A sequence error or a timeout has been detected in the radio message. |
| | false No error in the radio message sequence was detected. |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.2.2.10 radioMessageConsistencyError

| | |
|---|---|
| Output name | radioMessageConsistencyError |
| Description | [Brief description of the output] |
| Destination | [Name of the destination component(s)] |
| Type | bool |
| Valid range of values | |
| | true A consistency error has been detected in the radio message. |
| | false No consistency error in the radio message was detected. |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

3.1.3 Sub Components

3.1.3.1 Receive_TrackSide_Msg

3.1.3.1.1 Component Requirements

| | |
|----------------|-----------------------|
| Component name | Receive_TrackSide_Msg |
|----------------|-----------------------|

| | |
|------------------------|--|
| Link to SCADE model | https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/Receive_TrackSide_Msg |
| SCADE designer | [Name, affiliation] |
| Description | <p>This function defines the interface of the OBU model to the openETCS generic API for Eurobalise and Euroradio messages. On the interface, either a valid telegram/message is provided or a telegram/message is indicated which could not be received correct when passing the balise or receiving the radio message. The function passes a balise 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. In case of a radio message, the message is converted to an internal format for further processing and passed without changing the information contained.</p> <ul style="list-style-type: none"> • The decoding of balises is done at the API. Also, packets received via the interface are already transformed into a usable shape. • Only packets used inside the current model are passed via the interface. • Treatment of 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. • 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. • This function does not process information from the packets. The information is passed to the check without further processing of the values. |
| Input documents | <p>Subset-026, Chapter 7 and 8: Definition of the Balise Telegram Subset-026, Chapter 4.2.2, 4.2.4, 4.2.9: Interface to the BTM Subset-026, Chapter 3.4.1 - 3.4.3, 3.16.2: Handling of Balise Telegrams Subset-026, Chapter 3.16.2: Check of the balise group Subset-026, Chapter 3.4.2: Determining the orientation Subset-026, Chapter 4.5.2 Active Functions Table Subset-026, Chapter 8.4.4: Rules for Euroradio messages</p> |
| Safety integrity level | 4 |
| Time constraints | n/a |

| | |
|------------------|-----|
| API requirements | n/a |
|------------------|-----|

3.1.3.1.2 Interface

For an overview of the interface of this internal component we refer to the SCADE model (c.f. link above) respectively the SCADE generated documentation.

3.1.3.2 CheckBGConsistency

¹⁶⁰ 3.1.3.2.1 Component Requirements

| | |
|------------------------|--|
| Component name | CheckBGConsistency |
| Link to SCADE model | https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/CheckBGConsistency |
| SCADE designer | [Name, affiliation] |
| Description | <p>This function verifies the completeness and correctness of the received messages from balise groups. A message consists of at least a telegram and a maximum of 8 telegrams.</p> <ul style="list-style-type: none"> • 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. <p>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".</p> |
| Input documents | Subset-026, Chapter 7 and 8: Definition of the Balise Telegram Subset-026, Chapter 3.4.1-3, 3.16.2: Handling of Balise Telegrams Subset-026, Chapter 3.16.2: Check of the balise group Subset-026, Chapter 4.5.2: Active Functions Table |
| Safety integrity level | 4 |
| Time constraints | n/a |
| API requirements | n/a |

3.1.3.2.2 Interface

For an overview of the interface of this internal component we refer to the SCADE model (c.f. link above) respectively the SCADE generated documentation.

3.1.3.3 CheckEuroradioMessage

¹⁶⁵ **3.1.3.3.1 Component Requirements**

| | |
|------------------------|---|
| Component name | CheckEuroradioMessage |
| Link to SCADE model | https://github.com/openETCS/modeling/tree/b9c31ce6fdf702b412bbeab3032a8a4dc7c92e5c/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/CheckEuroRadioMessage |
| SCADE designer | Stefan Karg, DB Netz AG |
| Description | The component “CheckEuroradioMessage” performs 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 message header. |
| Input documents | Subset-026, Chapter 3.16 Subset-026, Chapter 8.4.4 |
| Safety integrity level | 4 |
| Time constraints | n/a |
| API requirements | n/a |

3.1.3.3.2 Interface

For an overview of the interface of this internal component we refer to the SCADE model (c.f. link above) respectively the SCADE generated documentation.

3.1.3.4 ValidateDataDirection

¹⁷⁰ **3.1.3.4.1 Component Requirements**

| | |
|---------------------|---|
| Component name | CheckEuroradioMessage |
| Link to SCADE model | https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/ValidateDataDirection |
| SCADE designer | ??? |

| | |
|-------------|---|
| Description | <p>The component filters an input message in order to mark all elements as invalid, which are not designated for the current driving direction of the train.</p> <ul style="list-style-type: none"> • The operator contains two processing paths for different message types. Radio messages and balise group messages are handled in a different way. For validating the data direction of a radio message, the check is performed using the balise group referenced in the radio message header as relevant balise group. For balise group message, the LRBG is used. • The metadata of packets, which are recognized as not valid for the current driving direction, is invalidated. |
|-------------|---|

| | |
|------------------------|---------------------------|
| Input documents | Subset-026, Chapter 3.6.3 |
| Safety integrity level | 4 |
| Time constraints | n/a |
| API requirements | n/a |

3.1.3.4.2 Interface

For an overview of the interface of this internal component we refer to the SCADE model (c.f. link above) respectively the SCADE generated documentation.

3.1.3.5 InformationFilter

¹⁷⁵ 3.1.3.5.1 Component Requirements

| | |
|---------------------|---|
| Component name | CheckEuroradioMessage |
| Link to SCADE model | https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/InformationFilter |
| SCADE designer | Alexander Stante, FhG |

| | |
|-------------------------|--|
| Description | The filter receives track information (balise and radio) and filters them depending of the mode, level and source of the message. Only messages that pass the filter are valid and should be considered by other ETCS subsystems. Figure 8 shows the highlevel decomposition of the functionality. The filter is consists of four components: FirstFilter, SecondFilter, ThirdFilter and TransitionBuffer. |
| FirstFilter | This filter performs filtering of messages based on the current ETCS level. The decisions taken process is described via a big decision table which contains rows for every packet and columns for every ETCS level. This table encodes also if certain additional information is necessary to filter a message like pending ETCS Level transitions. Based on this filter packets of an incoming message is either rejected, accepted or the whole message is put in the TransitionBuffer. Messages are put in the TransitionBuffer if there is an announced level transition and the received message is only valid for the upcoming level. |
| SecondFilter | The SecondFilter mainly considers messages that are received via Euroradio. Certain messages are directly rejected while other may be stored in the TransitionBuffer. The buffer is used to store messages that are received from non supervising RBCs, but will be reevaluated after a RBC transition. |
| ThirdFilter | The last filter is functionally very similiar the the FirstFilter, however it filters depending on the mode. It also contains a decision table with rows for every packet but the columns are modes. |
| TransitionBuffer | The InformationFilter uses two TransitionBuffers. One is used to store up to three messages for the ETCS level transition and the other buffer is used for RBC transitions. The buffer is designed as a ring buffer and message are read in FIFO order. |

| | |
|------------------------|-------------------------|
| Input documents | Subset-026, Chapter 4.8 |
| Safety integrity level | 4 |
| Time constraints | n/a |
| API requirements | n/a |

3.1.3.5.2 Interface

For an overview of the interface of this internal component we refer to the SCADE model (c.f. link above) respectively the SCADE generated documentation.

3.2 Train_Supervision

3.2.1 Component Requirements

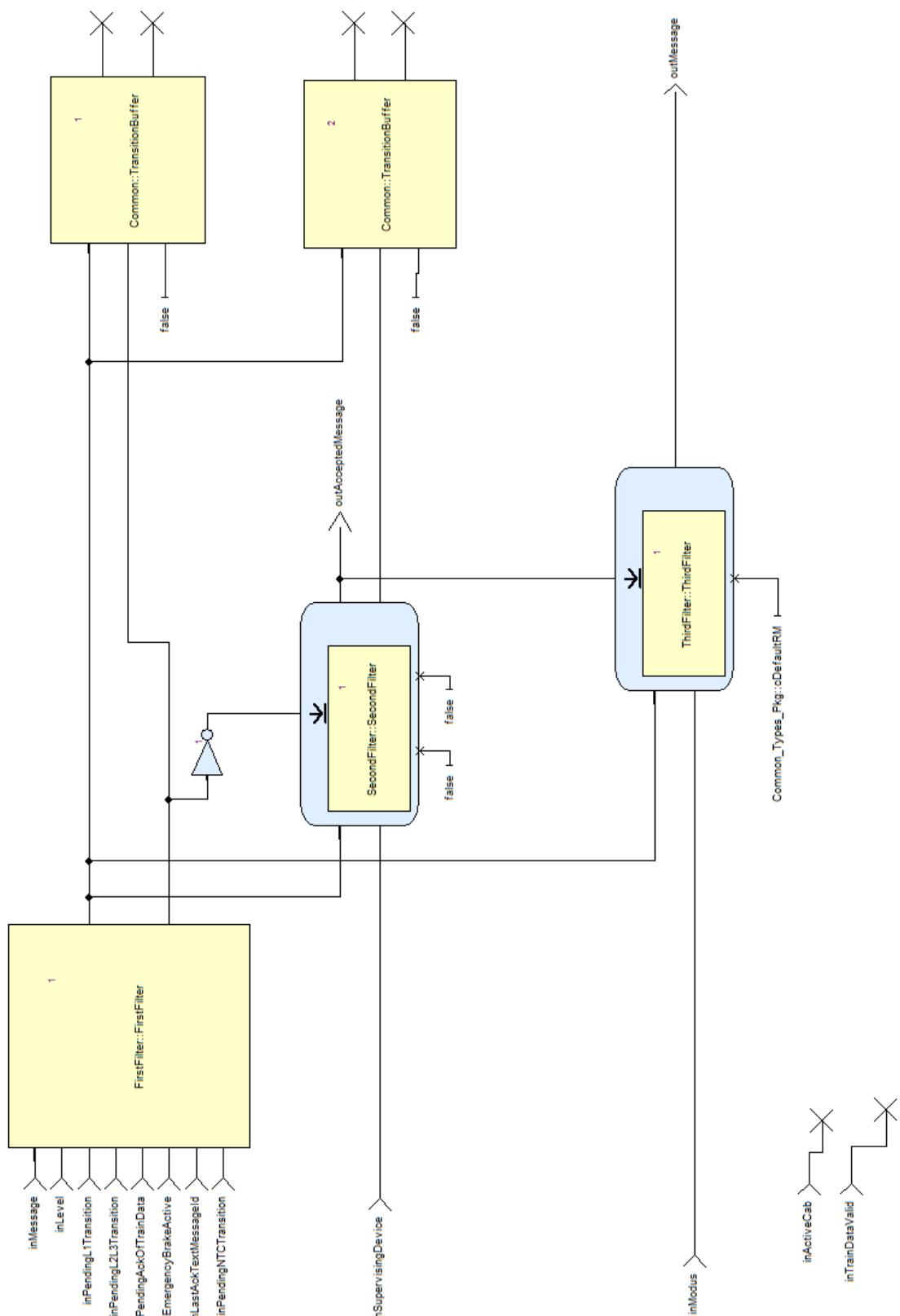


Figure 3. High level overview of the InformationFilter components.

| | |
|------------------------|--|
| Component name | TrainSupervision |
| Link to SCADE model | ??? |
| SCADE designer | Christian Stahl, TWT |
| Description | <p>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].</p> <p>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.</p> <p>Based on this information a speed profile is calculated. Speed restrictions create target speeds (targets) that have to be followed. For each such target braking curves are generated to supervise at which location of the track the train must perform the brake. In case of no target restrictions the train may accelerate to the supervised maximum speed of the speed profile. These calculations lead to commands being sent to the driver and the brake system.</p> <p>The functionality is modeled using eight operators, as shown in Figure 4, which are explained below.</p> <p>The current status of the analysis of “Train Supervision” and a functional breakdown can be found in a separate document, <i>SpeedSupervision_analysis.pdf</i>.</p> |
| Input documents | Subset-026, Chapter 3.13: Speed and distance monitoring |
| Safety integrity level | 4 |
| Time constraints | [If applicable description of time constraints, otherwise n/a] |
| API requirements | [If applicable description of API requirements, otherwise n/a] |

3.2.2 Interface

An overview of the interface of component [component name] is shown in Figure 4. The inputs and outputs are described in detail in Section 11.2.1 respectively 11.2.2.

3.2.2.1 Inputs

¹⁸⁵ 3.2.2.1.1 NationalValues

| | |
|-------------|--|
| Input name | NationalValues |
| Description | This input is packet 3 of [1, Chapt. 8], describing the national values. |
| Source | ??? |
| Type | P3_NationalValues_T |

| | |
|---|--|
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.2.2.1.2 TrainPosition

| | |
|---|--|
| Input name | TrainPosition |
| Description | This input is the current train position. |
| Source | Manage Track Data |
| Type | trainPosition_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

3.2.2.1.3 odometry

| | |
|---|--|
| Input name | odometry |
| Description | This input is the odometry data. |
| Source | Odometry |
| Type | odometry_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

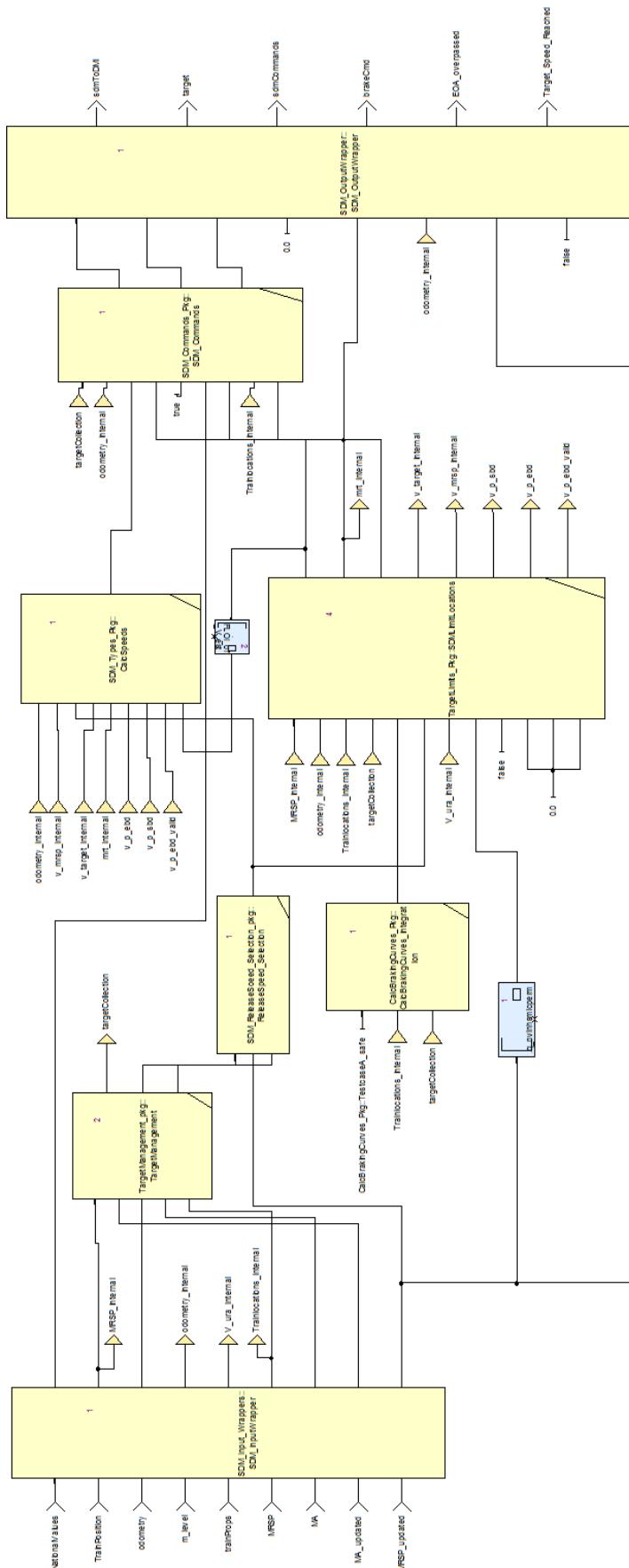


Figure 4. Structure of component ProvidePositionReport.

4 [Input 2 name]

4.0.0.1.4 m_level

| | |
|---|--|
| Input name | m_level |
| Description | This input is the current level of the train. |
| Source | Mode and Level |
| Type | M_LEVEL |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

5₁₉₀ [Input 2 name]

5.0.0.1.5 trainProps

| | |
|---|--|
| Input name | trainProps |
| Description | This input is a set of train related properties. |
| Source | Database |
| Type | trainProperties_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

6 [Input 2 name]

6.0.0.1.6 MRSP

| | |
|---|--|
| Input name | MRSP |
| Description | This input is the most restrictive speed profile. |
| Source | ??? |
| Type | MRSP_Profile_t |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

7 [Input 2 name]

195 7.0.0.1.7 MA

| | |
|---|--|
| Input name | MA |
| Description | This input is a movement authority. |
| Source | ??? |
| Type | MAs_t |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

8 [Input 2 name]

8.0.0.1.8 MA_updated

| | |
|---|---|
| Input name | MA_updated |
| Description | This flag is true if the movement authority has been updated in this clock cycle and false otherwise. |
| Source | internal |
| Type | bool |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

8.0.0.1.9 MRSP_updated

| | |
|---|---|
| Input name | MRSP_updated |
| Description | This flag is true if the most restrictive speed profile has been updated in this clock cycle and false otherwise. |
| Source | internal |
| Type | bool |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

8.0.0.2 Outputs

200 8.0.0.2.1 sdmToDMI

| | |
|-------------|----------|
| Output name | sdmToDMI |
|-------------|----------|

| | |
|---|--|
| Description | 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. |
| Destination | [Name of the destination component(s)] |
| Type | speedSupervisionForDMI_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

8.0.0.2.2 target

| | |
|---|---|
| Output name | target |
| Description | This output is the most restrictive displayed target (MRDT). |
| Destination | [Name of the destination component(s)] |
| Type | Target_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

8.0.0.2.3 sdmCommands

| | |
|---|--|
| Output name | sdmCommands |
| Description | This output gives some intermediate results of operator SDM_Commands. It is currently used for test purposes only. |
| Destination | [Name of the destination component(s)] |
| Type | SDM_Commands_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

8.0.0.2.4 brakeCmd

| | |
|---|---|
| Output name | brakeCmd |
| Description | This output is the brake command, indicating whether performing the service brake or the emergency brake have been commanded. |
| Destination | [Name of the destination component(s)] |
| Type | Brake_command_T |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

8.0.0.2.5 EOA_overpassed

| | |
|---|--|
| Output name | EOA_overpassed |
| Description | This output is true if the end of authority has been overpassed and false otherwise. |
| Destination | [Name of the destination component(s)] |
| Type | bool |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

8.0.0.2.6 Target_Speed_Reached

| | |
|-------------------------------------|---|
| Output name | Target_Speed_Reached |
| Description | This output is true if the current speed is greater than or equal the target speed and false otherwise. |
| Destination | [Name of the destination component(s)] |
| Type | bool |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |

Behaviour for values out [Description of components behaviour when output value is out of
of valid range valid range]

9 F3: Measure Train Movement

10 F4: Manage Radio Communication

Part III

Deprecated Design Description

11 Component Design Template

11.1 Component Requirements

| | |
|------------------------|---|
| Component name | [Component name] |
| Link to SCADE model | https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/Receive_TrackSide_Msg |
| SCADE designer | [Name, affiliation] |
| Description | [Brief description of the components functionality] |
| Input documents | Subset-026, version, chapter ?? Subset-026, version, chapter ?? Subset-026, version, chapter ??? |
| Safety integrity level | 4 |
| Time constraints | [If applicable description of time constraints, otherwise n/a] |
| API requirements | [If applicable description of API requirements, otherwise n/a] |

11.2 Interface

An overview of the interface of component [component name] is shown in Figure 5. The inputs and outputs are described in detail in Section 11.2.1 respectively 11.2.2.

215 11.2.1 Inputs

11.2.1.1 [Input 1 name]

| | |
|-------------------------------------|---|
| Input name | [Name of the input] |
| Description | [Brief description of the input] |
| Source | [Name of the source component] |
| Type | [Type of the input] |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |

[Put SysML diagram of component here]

Figure 5. Component SysML diagram

| | |
|---|--|
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |
|---|--|

11.2.1.2 [Input 2 name]

| | |
|---|--|
| Input name | [Name of the input] |
| Description | [Brief description of the input] |
| Source | [Name of the source component] |
| Type | [Type of the input] |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when input value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when input value is out of valid range] |

11.2.2 Outputs

11.2.2.1 [Output 1 name]

| | |
|---|---|
| Output name | [Name of the output] |
| Description | [Brief description of the output] |
| Destination | [Name of the destination component(s)] |
| Type | [Type of the output] |
| Valid range of values | [Complete list of valid values] |
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

220 11.2.2.2 [Output 2 name]

| | |
|-----------------------|--|
| Output name | [Name of the output] |
| Description | [Brief description of the output] |
| Destination | [Name of the destination component(s)] |
| Type | [Type of the output] |
| Valid range of values | [Complete list of valid values] |

| | |
|---|---|
| Behaviour when value is at boundary | [Description of components behaviour when output value is at boundary] |
| Behaviour for values out of valid range | [Description of components behaviour when output value is out of valid range] |

12 F1: Receive information from Trackside

13 F2: ETCS Kernel

13.1 Manage_TrackSideInformation_Integration

The block “Manage_TrackSideInformation_Integration” is responsible for receiving Eurobalise telegrams and Euroradio messages from the API and perform several consistency checks on the input.
225

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, 230 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.

13.1.1 Inputs

For providing the output, the module needs different input data flows. An overview is provided in table 50.

| Index | Input name | Input type | Source |
|-------|----------------------------|--|----------------------------|
| 0 | fullChecks | bool | Configuration |
| 1 | API_trackSide_Message | API_Msg_Pkg::API_TrackSideInput_T | API |
| 2 | ActualOdometry | Obu_BasicTypes_Pkg::odomentry_T | Odometer |
| 3 | reset | bool | Environment |
| 4 | trainPosition | TrainPosition_Types_Pck::trainPosition_T | Calculate Train Position |
| 5 | modeAndLevel | BG_Types_Pkg::ModeAndLevelStatus_T | Mode and Level |
| 6 | tNvContact | Obu_BasicTypes_Pkg::T_internal_Type | Database |
| 7 | lastRelevantEventTimestamp | Obu_BasicTypes_Pkg::T_internal_Type | Database |
| 8 | connectionStatus | Radio_Types_Pkg::sessionStatus_Type | Manage Radio Communication |
| 9 | inSupervisingRbcId | int | Database |
| 10 | inAnnouncedBGs | TrainPosition_Types_Pck::positionedBGs_T | Calculate Train Position |
| 11 | q_nvlocacc | O_NVLOCACC | Database |

Table 50. Overview over input

13.1.1.1 Input 0: fullChecks

The boolean indicates, if all checks on the message should be performed. The possible values are given in table 51.

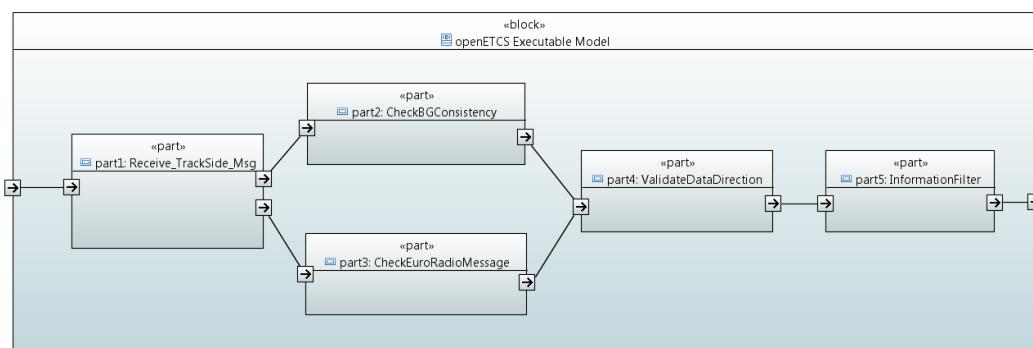


Figure 6. Structure of the Manage_TrackSideInformation_Integration module with submodules.

| Value | Interpretation |
|-------|--|
| true | All checks are performed. |
| false | The module Information Filter is deactivated. |

Table 51. Possible values for the input **fullChecks**240 **13.1.1.2 Input 1: API_trackSide_Message**

The **API_trackSide_Message** is the message received from the API. The API performs pre-processing of RTM and BTM messages and deliveres a maximum of a single message per cycle to the SCADE model.

13.1.1.3 Input 2: Actual0dometry

245 The input **Actual0dometry** is provided by the external odometry module of the train. It contains location information with inaccuracies.

13.1.1.4 Input 3: reset

250 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 52. Possible values for the input **reset**.**13.1.1.5 Input 4: trainPosition**

The input **trainPosition** is generated by the “Calculate Train Position” module and contains the current position of the train.

255 **13.1.1.6 Input 5: modeAndLevel**

The input is generated by the “Mode and level management” module. It provides the current level and mode of the EVC.

13.1.1.7 Input 6: tNvContact

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

260 **13.1.1.8 Input 7: 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

- 265 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.

13.1.1.9 Input 8: connectionStatus

- 270 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 53. Possible values for the input `connectionStatus`.

13.1.1.10 Input 9: inSupervisingRbcId

- 275 For the submodule “Information Filter”, the information is needed, which radio messages are sent by the supervising RBC. To recognize these messages, the identifier of the supervising RBC is needed.

13.1.1.11 Input 10: inAnnouncedBGs

- 280 This input provides information about balise groups which will be passed by the train soon. This information is generated by “Calculate Train Position” based on the linking information received from trackside.

13.1.1.12 Input 11: q_nvlocacc

The national value determines the location accuracy and is delivered by the database.

13.1.2 Outputs

- 285 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.

An overview over the output dataflows is provided in table 54.

| Index | Output name | Output type |
|-------|------------------------------|---|
| 0 | outputMessage | Common_Types_Pkg::ReceivedMessage_T |
| 1 | ApplyServiceBrake | bool |
| 2 | BadBALiseMessageToDMI | bool |
| 3 | errorLinkedBG | bool |
| 4 | errorUnlinkedBG | bool |
| 5 | passedBG | BG_Types_Pkg::passedBG_T |
| 6 | outPositionParams | Common_Types_Pkg::PositionReportParameter_T |
| 7 | outRadioManagement | Common_Types_Pkg::radioManagementMessage_T |
| 8 | radioSequenceError | bool |
| 9 | radioMessageConsistencyError | bool |

Table 54. Dataflow at output

290 **13.1.2.1 Output 0: outputMessage**

The element **outputMessage** 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 |
|---------------------|--|--|
| valid | bool | true, if no consistency errors were detected. |
| source | Common_Types_Pkg::MsgSource_T | Defines, if this is a Euroradio or Eurobalise message. |
| packetMetadata | Common_Types_Pkg::Metadata_T | contains the metadata of the packets |
| radioMetadata | Common_Types_Pkg::RadioMetadata_T | contains the metadata of the radio specific header variables |
| BG_Common_Header | BG_Types_Pkg::BG_Header_T | Header of Eurobalise message |
| Radio_Common_Header | Radio_Types_Pkg::Radio_TrackTrain_Header_T | Header of Euroradio message |
| packets | Common_Types_Pkg::Packets_T | Structure of packets in messages |

Table 55. Structure of ReceivedMessage_T

295

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.

300

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. Which values are valid is defined in the field **radioMetadata**.

13.1.2.2 Output 1: 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.

13.1.2.3 Output 2: BadBALiseMessageToDMI

Information to be passed to the DMI to indicate the reception of a “bad balise” to the driver.

13.1.2.4 Output 3: errorLinkedBG

| Value | Interpretation |
|-------|---|
| true | A error in a linked balise group was detected. |
| false | No error in a linked balise group was detected. |

Table 56. Possible values for the input **errorLinkedBG**310 **13.1.2.5 Output 4: errorUnlinkedBG**

| Value | Interpretation |
|-------|--|
| true | A error in an unlinked balise group was detected. |
| false | No error in an unlinked balise group was detected. |

Table 57. Possible values for the input **errorUnlinkedBG****13.1.2.6 Output 5: passedBG**

The output **passedBG** provides the received balise group message in a special format needed by the module “Calculate train position”.

315 **13.1.2.7 Output 6: outPositionParams**

The output **outPositionParams** provides the parameters for the position report in a special format needed by the module “Provide Position Report”.

13.1.2.8 Output 7: outRadioManagement

The output **outRadioManagement** provides the messages for radio session management in a special format needed by the module “Management of Radio Communication”. 320

13.1.2.9 Output 8: radioSequenceError

| Value | Interpretation |
|-------|---|
| true | A sequence error or a timeout has been detected in the radio message. |
| false | No error in the radio message sequence was detected. |

Table 58. Possible values for the input **radioSequenceError****13.1.2.10 Output 9: radioMessageConsistencyError**

| Value | Interpretation |
|-------|---|
| true | A consistency error has been detected in the radio message. |
| false | No consistency error in the radio message was detected. |

Table 59. Possible values for the input **radioMessageConsistencyError**325 **13.1.3 Receive_TrackSide_Msg in Manage_TrackSideInformation_Integration****13.1.3.1 Reference to the SRS (or other requirements)**

- [1, Chapt. 7 and 8]: Definition of the Balise Telegram

- [2, Chapt. 4.2.2, 4.2.4, 4.2.9]: Interface to the BTM
- [1, Chapt. 3.4.1 - 3.4.3, 3.16.2]: Handling of Balise Telegrams
- 330 ● [1, Chapt. 3.16.2]: Check of the balise group
- [1, Chapt. 3.4.2]: Determining the orientation
- [1, Chapt. 4.5.2]: Active Functions Table
- [1, Chapt. 8.4.4]: Rules for Euroradio messages

13.1.3.2 Short description of the functionality

335 This function defines the interface of the OBU model to the openETCS generic API for Eurobalise and Euroradio messages. On the interface, either a valid telegram/message is provided or a telegram/message is indicated which could not be received correct when passing the balise or receiving the radio message. The function passes a balise telegram without major changes of the information to the next entity for collecting the balise group information. This entity collects
 340 telegrams received via the interface into Balise Group Information. In case of a radio message, the message is converted to an internal format for further processing and passed without changing the information contained.

13.1.3.3 Interface

13.1.3.4 Functional Design Description

345 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.
3. Treatment of 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.
 350
4. 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.
- 355 5. This function does not process information from the packets. The information is passed to the check without further processing of the values.

13.1.3.5 Reference to the Scade Model

The SCADE model can be found on GitHub under the following path: https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/Receive_TrackSide_Msg
 360

13.1.4 CheckBGConsistency in Manage_TrackSideInformation_Integration

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

- [1, Chapt. 7 and 8]: Definition of the Balise Telegram
- 365 • [1, Chapt. 3.4.1 - 3.4.3, 3.16.2]: Handling of Balise Telegrams
- [1, Chapt. 3.16.2]: Check of the balise group
- [1, Chapt. 4.5.2]: Active Functions Table

13.1.4.2 Short description of the functionality

This function has the task to verify the completeness and correctness of the received messages
370 from balise 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.
- 375 • 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.

380 **13.1.4.3 Interface**

An input of the operator is a list of received telegrams. After consistency check of the telegrams' list, the function generates the balise-group-message. This function is active in certain modes and the output and reactions are dependent on if the linking information is used.

13.1.4.4 Functional Design Description

385 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" .

13.1.4.5 Reference to the Scade Model

390 The SCADE model can be found on github under the following path: <https://github.com/openETCS/modeling/tree/master/model1/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/CheckBGConsistency>

13.1.5 CheckEuroradioMessage in Manage_TrackSideInformation_Integration

13.1.5.1 Component Requirements

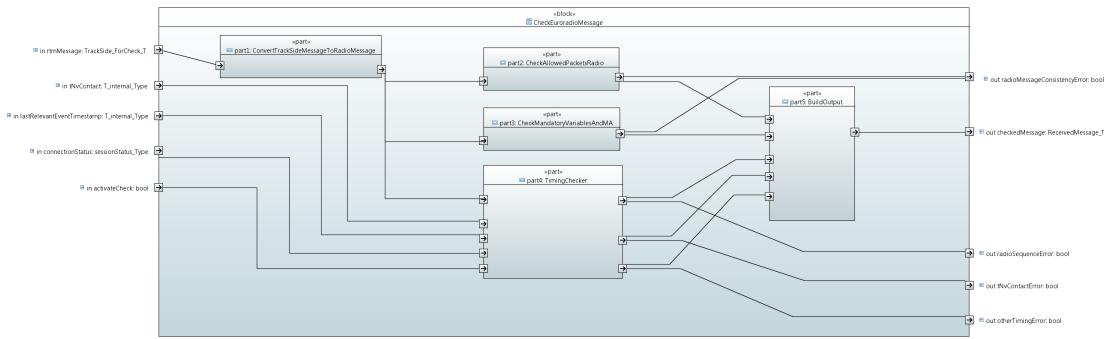


Figure 7. Component SysML diagram

| | |
|------------------------|---|
| Component name | CheckEuroradioMessage |
| Link to SCADE model | https://github.com/openETCS/modeling/tree/b9c31ce6fdf702b412bbeab3032a8a4dc7c92e5c/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/CheckEuroRadioMessage |
| SCADE designer | Stefan Karg, DB Netz AG |
| Description | The operator “CheckEuroradioMessage” performs 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 message header. |
| Requirements realized | Subset-026, Chapter 3.16 Subset-026, Chapter 8.4.4 |
| Safety integrity level | 4 |
| Time constraints | n/a |
| API requirements | n/a |

395 13.1.5.2 Interface

An overview of the interface of component CheckEuroradioMessage is shown in Figure 7. The inputs and outputs are described in detail in section 13.1.5.2.1 respectively 13.1.5.2.2.

13.1.5.2.1 Inputs

rtmMessage

| | |
|-------------|---|
| Input name | rtmMessage |
| Description | Input message from API |
| Source | Receive_TrackSide_Msg_Pkg::Receive_TrackSide_Msg |
| Type | Common_Types_Pkg::TrackSide_ForCheck_T |

| | |
|-----------------------|-----|
| Valid range of values | n/a |
|-----------------------|-----|

| | |
|-------------------------------------|-----|
| Behaviour when value is at boundary | n/a |
|-------------------------------------|-----|

| | |
|---|-----|
| Behaviour for values out of valid range | n/a |
|---|-----|

400 tNvContact

| | |
|------------|------------|
| Input name | tNvContact |
|------------|------------|

| | |
|-------------|--|
| Description | National value which defines the maximum time difference between a radio message or some defined special conditions. |
|-------------|--|

| | |
|--------|--------------------------------|
| Source | Current set of national values |
|--------|--------------------------------|

| | |
|------|-------------------------------------|
| Type | Obu_BasicTypes_Pkg::T_internal_Type |
|------|-------------------------------------|

| | |
|-----------------------|-------|
| Valid range of values | 0-255 |
|-----------------------|-------|

| | |
|-------------------------------------|---|
| Behaviour when value is at boundary | Message is always accepted (tNvContactError = false), see 7.5.1.148 |
|-------------------------------------|---|

| | |
|---|--|
| Behaviour for values out of valid range | All messages are rejected (tNvContactError = true) |
|---|--|

lastRelevantEventTimestamp

| | |
|------------|----------------------------|
| Input name | lastRelevantEventTimestamp |
|------------|----------------------------|

| | |
|-------------|--|
| Description | The input "lastRelevantTimestamp" is needed in order to check timeouts. In most of the cases, the timestamp of the last relevant event is the timestamp of the last message received. But the SRS defines special cases like driving through a defined radio hole. In this case, the timestamp of the last relevant event is the point of time, when the EVC has a radio connection again. |
|-------------|--|

| | |
|--------|----------|
| Source | Database |
|--------|----------|

| | |
|------|-------------------------------------|
| Type | Obu_BasicTypes_Pkg::T_internal_Type |
|------|-------------------------------------|

| | |
|-----------------------|-----------------------|
| Valid range of values | dependent on hardware |
|-----------------------|-----------------------|

| | |
|-------------------------------------|-----|
| Behaviour when value is at boundary | n/a |
|-------------------------------------|-----|

| | |
|---|-----|
| Behaviour for values out of valid range | n/a |
|---|-----|

connectionStatus

| | |
|---|--|
| Input name | connectionStatus |
| Description | Status of the secure Euroradio session |
| Source | Management of Radio Communication |
| Type | <code>Radio_Types_Pkg::sessionStatus_Type</code> |
| Valid range of values | { <code>morc_st_inactive</code> , <code>morc_st_establishing</code> , <code>morc_st_maintaining</code> , <code>morc_st_terminating</code> } |
| Behaviour when value is n/a at boundary | |
| Behaviour for values out of valid range | n/a |

activateCheck

| | |
|---|---|
| Input name | activateCheck |
| Description | If true, the Euroradio messages are checked, if false, the message is just passed without any modifications |
| Source | Debug settings |
| Type | <code>bool</code> |
| Valid range of values | { <code>true</code> , <code>false</code> } |
| Behaviour when value is n/a at boundary | |
| Behaviour for values out of valid range | n/a |

13.1.5.2.2 Outputs**405 checkedMessage**

| | |
|-----------------------|--|
| Output name | checkedMessage |
| Description | The message, which was checked with an updated valid flag. |
| Destination | ValidateDataDirection |
| Type | <code>Common_Types_Pkg::ReceivedMessage_T</code> |
| Valid range of values | n/a |

radioSequenceError

| | |
|-----------------------|---|
| Output name | <code>radioSequenceError</code> |
| Description | Indicates if the current message violated the sequence of radio messages. |
| Destination | <code>ProvidePositionReport</code> |
| Type | <code>bool</code> |
| Valid range of values | {true, false} |

tNvContactError

| | |
|-----------------------|---|
| Output name | <code>tNvContactError</code> |
| Description | Indicates if a timeout on the radio channel occurred. |
| Destination | <code>ProvidePositionReport</code> |
| Type | <code>bool</code> |
| Valid range of values | {true, false} |

otherTimingError

| | |
|-----------------------|---|
| Output name | <code>otherTimingError</code> |
| Description | Indicates if other errors in the timing were detected, e.g. no last valid timestamp is available. |
| Destination | <code>ModeAndLevelManagement</code> |
| Type | <code>bool</code> |
| Valid range of values | {true, false} |

radioMessageConsistencyError

| | |
|-----------------------|--|
| Output name | <code>radioMessageConsistencyError</code> |
| Description | Indicates, if a consistency error was detected in the Euroradio message. |
| Destination | EVC internal |
| Type | <code>bool</code> |
| Valid range of values | {true, false} |

⁴¹⁰ **13.1.6 ValidateDataDirection in Manage_TrackSideInformation_Integration**

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

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

13.1.6.2 Short description of the functionality

The operator will filter an input message in order to mark all elements as invalid, which are not designated for the current driving direction of the train.

13.1.6.3 Interface

The operator expects a message and information about the LRBG, passed balises and the current train position. As output, the message with packets valid for the current direction of driving is provided.

⁴²⁰ **13.1.6.4 Functional Design Description**

- The operator contains two processing paths for different message types. Radio messages and balise group messages are handled in a different way. For validating the data direction of a radio message, the check is performed using the balise group referenced in the radio message header as relevant balise group. For balise group message, the LRBG is used.
- The metadata of packets, which are recognized as not valid for the current driving direction, is invalidated.

13.1.6.5 Reference to the Scade Model

The SCADE model can be found on github under the following path: <https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInfor>

⁴³⁰ [BaliseGroup/ValidateDataDirection](#)

13.1.7 InformationFilter

13.1.7.1 Reference to the SRS and other requirements

- The functionality of the InformationFilter is described in [1, Chapter 4.8].

13.1.7.2 Short description of the functionality

⁴³⁵ The function InformationFilter filters incoming information received from Eurobalise, Euroradio, and Euroloop. The information is received via messages and filtering is done depending on the criteria described in [1, Chapter 4.8]. Messages are only allowed to pass the filter if specified criteria are met like for example the correct mode of the train (e.g. Full Supervision, Shunting, etc.) or the ETCS level. Some messages have to be stored in a TransitionBuffer to be later reevaluated by the filter again.

13.1.7.3 Interface

The interface of the information filter contains mainly the incoming message and inputs to check for the conditions described in the SRS. The complete interface is shown in table 71.

| Name | Direction | Description |
|-------------------------|-----------|---|
| inMessage | IN | Received message that is valid for the train direction |
| inLevel | IN | The current ETCS Level |
| inMode | IN | The current train mode |
| inSupervisingDevice | IN | The device id which communicates with the current supervising RBC |
| inPendingL1Transition | IN | Information if an ETCS Level 1 transition is pending |
| inPendingL1L2Transition | IN | Information if an ETCS Level 2/3 transition is pending |
| inPendingNTCTransition | IN | Information if a NTC transition is pending |
| inPendingAckOfTrainData | IN | Information if the acknowledgement of train data is pending |
| inEmergencyBrakeActive | IN | Information if the emergency brake is active |
| inLastAckTextMessageId | IN | The id of the last acknowledged message ID |
| inActiveCab | IN | Information if the cab is active |
| inTrainDataValid | IN | Information if the train data is valid |
| outMessage | OUT | The filtered input message |

Table 71. Overview of the InformationFilter interface

13.1.7.4 Functional Design Description

The filter receives track information (balise and radio) and filter them depending of the mode, level and further information. Only messages that pass the filter are valid and should be considered by other ETCS subsystems. The figure 8 show the highlevel decomposition of the functionality. The filter functionality can be decomposed into a FirstFilter, SecondFilter, ThirdFilter an TransitionBuffer.

13.1.7.4.1 FirstFilter

This filter performs filtering of messages based on the current ETCS level. The decisions taken process is described via a big decision table which contains rows for every packet and columns for every ETCS level. This table encodes also if certain additional information is necessary to filter a message like pending ETCS Level transitions. Based on this filter packets of an incoming message is either rejected, accepted or the whole message is put in the TransitionBuffer. Messages are put in the TransitionBuffer if there is an announced level transition and the received message is only valid for the upcoming level.

13.1.7.4.2 SecondFilter

The SecondFilter mainly considers messages that are received via Euroradio. Certain messages are directly rejected while other may be stored in the TransitionBuffer. The buffer is used to store messages that are received from non supervising RBCs, but will be reevaluated after a RBC transition.

13.1.7.4.3 ThirdFilter

The last filter is functionally very similiar the the FirstFilter, however it filters depending on the mode. It also contains a decision table with rows for every packet but the columns are modes.

13.1.7.4.4 TransitionBuffer

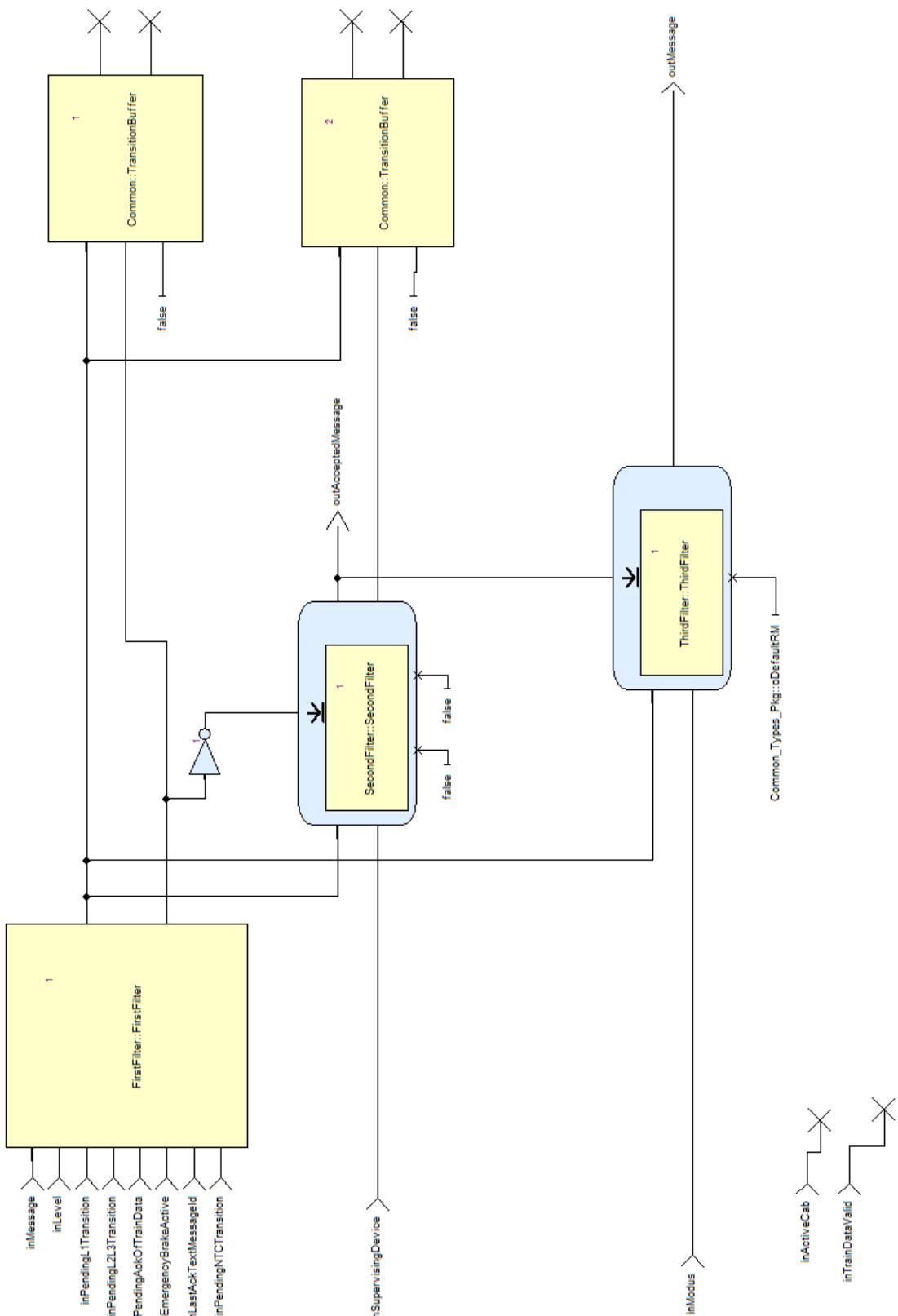


Figure 8. High level overview of the InformationFilter components.

The InformationFilter uses two TransitionBuffers. One is used to store up to three messages for the ETCS level transition and the other buffer is used for RBC transitions. The buffer is designed as a ring buffer and message are read in FIFO order.

A detailed list of packages and their handling depending of ETCS level or mode can be seen in table 9 and 10.

13.1.7.5 Reference to the Scade Model

The SCADE model can be found on github under the following path: <https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformationBaliseGroup/InformationFilter>

13.2 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 speed profile is calculated. Speed restrictions create target speeds (targets) that have to be followed. For each such target braking curves are generated to supervise at which location of the track the train must perform the brake. In case of no target restrictions the train may accelerate to the supervised maximum speed of the speed profile. These calculations lead to commands being sent to the driver and the brake system.

The functionality is modeled using eight operators, as shown in Figure 11, which are explained below.

The current status of the analysis of “Train Supervision” and a functional breakdown can be found in a separate document, *SpeedSupervision_analysis.pdf*.

13.2.1 Input

For providing the output, the module needs different input data flows. Table 72 gives an overview.

| 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 | 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 | | | | | |

| | | | | | | | |
|----------------------|---|-----|--------|-----------|--------|--------|--------|
| 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 | | | | | |
| Messenger 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 | Co-operative shortening of MA + (optional) Mode Profile + (optional) List of Balises for SH area | No | | | | | |
| Packet 80 | | Yes | R | R | R | A [3] [4] [5] | A [3] [4] [5] |
| Packet 49 | | No | | | | | |
| Message Radio 16 | Unconditional Emergency Stop | No | | | | | |
| | Conditional Emergency Stop | Yes | R [2] | R [2] | R [2] | A | A |
| Message Radio 15 | | No | | | | | |
| Message Radio 18 | Revocation of Emergency Stop (Conditional or Unconditional) | No | | | | | |
| Message Radio 27 | | Yes | R | R | R | A | A |
| | | No | | | | | |
| Message Radio 28 + (optional) Packet 49 | SH authorised + (optional) List of Balises for SH area | No | | | | | |
| | | Yes | R | R | R | A [3] | A [3] |
| ?? | | No | | | | | |
| Packet 2 | Trackside constituent System Version | No | A | A | A | A | A |
| | | Yes | A | A | A | A | A |
| Message Radio 34 | Track Ahead Free Request | No | | | | | |
| Packet 140 Track to train, Packet 40 Train to track | | Yes | R | R | R | A [3] | A [3] |
| Train Running Number | Initiation of session | No | | | | | |
| | | Yes | R | R | R | A | A |
| Message Radio 38 | Acknowledgement of session termination | No | A | A | A | A | A |
| Message 39 | | Yes | A | A | A | A | A |

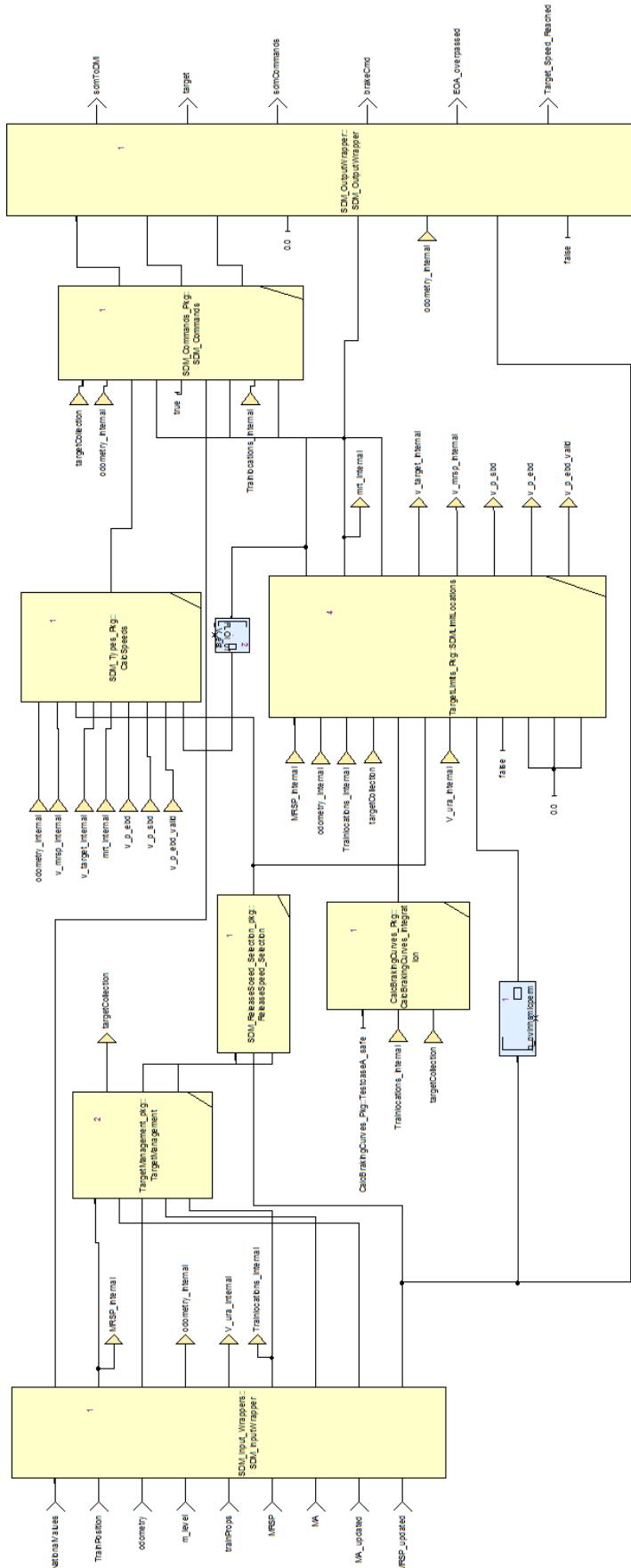
| | | | | | | | |
|------------------|--|-------------------------|-----------|-----------|-------|-------|-------|
| Message 40 | Train Rejected | No | | | | | |
| | | Yes | R | R | R | A | A |
| Message 41 | Train Accepted | No | | | | | |
| | | Yes | R | R | R | A | A |
| Message Radio 43 | SoM Position 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 |
| | | Onboard operating level | | | | | |
| | Information from National System X through STM interface | 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 9. Lists of packages and their handling depending on train modes

| | | | | | | | | | | | | | | | | | | | | | | |
|----|---|--|----|---------|---|---|---|---|---|---|---|---|---|------|----|----|----|----|----|----|----|---|
| 40 | Packet 39, 68 | Track conditions sound horn, non stopping areas, turn left, stopping areas | NR | A[2][4] | R | R | A | A | A | R | R | A | R | A[1] | NR | NR | NR | NR | NR | NR | A | R |
| 41 | Packet 67 | Track condition light masters | NR | A[2][4] | A | A | A | A | A | R | R | A | A | A | A | A | A | A | A | A | A | R |
| 42 | Header Update | Location identity (NID_C + NID_BG) | NR | A[2] | A | A | A | A | A | R | R | R | R | R | R | A | A | A | A | A | A | R |
| 43 | Message Radio 6 | Recognition of exit from TRIP mode | NR | R | R | R | R | R | R | R | R | R | R | R | R | A | A | A | A | A | A | R |
| 44 | Message Radio 8 | Acknowledgement of Train Data | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | A | A | A | A | A | A | A |
| 45 | Message 9 | Coo-operative shortening of WA + (optional) list of Balises for SH area | NR | R | R | R | A | A | R | R | R | R | R | R | R | A | A | A | A | A | A | R |
| 46 | Packet 80 | + (optional) Mode Profile | NR | R | R | R | A | A | R | R | R | R | R | R | R | NR | NR | NR | NR | NR | NR | R |
| 47 | Packet 49 | + (optional) list of Balises for SH area | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | NR | NR | NR | NR | NR | NR | R |
| 48 | Message Radio 16 | Unconditional Emergency Stop | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | A | R | R | R | R | R | R |
| 49 | Message Radio 15 | Conditional Emergency Stop | NR | R | R | R | A | A | R | R | R | R | R | R | R | A | R | R | R | NR | NR | A |
| 50 | Message Radio 18 | Revocation of Emergency Stop (Conditional or Unconditional) | NR | R | R | R | A | A | R | R | A | R | R | R | R | A | A | A | A | NR | NR | R |
| 51 | Message Radio 27 | ShuttleRelease | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | A | R | R | R | NR | NR | R |
| 52 | Message Radio 28, 1 (optional) | ShuttleReleased (Optional List of Balises in SH Area) | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | NR | NR | NR | NR | NR | NR | R |
| 53 | Packet 49 | TrainSafe Condition System | NR | A | A | A | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | R |
| 54 | 77 | System Version Order | NR | A | A | A | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | A |
| 55 | Packet 2 | TrackAhead Free Request | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | A |
| 56 | Message Radio 34 | TrackAhead Free Request | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | R |
| 57 | Packet 140 Track to Train, Packet 140 Train to Track | Train Running Number | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | A |
| 58 | Message Radio 38 | Initiation of session | NR | A | R | R | A | A | A | R | R | A | A | A | A | R | A | A | A | NR | NR | A |
| 59 | Message 39 | Acknowledgement of session termination | NR | A | A | A | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | A |
| 60 | Message 40 | Train Rejected | NR | A[2] | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | NR | NR | R |
| 61 | Message 41 | Train Accepted | NR | A[2] | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | NR | NR | R |
| 62 | Message Radio 43 | Solo Position Report Confirmed by REC | NR | A[2] | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | NR | NR | R |
| 63 | Packet 138 | Reversing Area Information | NR | A[2][4] | R | R | A | A | A | R | R | R | R | R | R | A | R | A | A | NR | NR | A |
| 64 | Packet 139 | Reversing Supervision Information | NR | A[2][4] | R | R | A | A | A | R | R | R | R | R | R | A | R | A | A | NR | NR | A |
| 65 | Packet 254 | Default BasedLocPDU Information | NR | A[2] | A | A | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | A |
| 66 | Packet 90 | TrackAhead Free up to level 2/3 | NR | A[2] | R | R | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | R |
| 67 | Packet 52 | Permit/Disallow instance | NR | A[2][4] | R | R | A | A | A | R | R | R | R | R | R | A | R | A | A | NR | NR | R |
| 68 | Packet 88 | Level Crossing Information | NR | A[2][4] | R | R | A | A | A | R | R | R | R | R | R | A | R | A | A | NR | NR | R |
| 69 | Packet 60 | Virtual Balise Cover order | NR | A | A | A | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | A |
| 70 | Packet 44 | Data to be used by applications outside ETHERNETS | NR | A | A | A | A | A | A | R | R | R | R | R | R | A | A | A | A | NR | NR | A |

| | Packet, Message | Information | Modes | | | | | | | | | | | | | | | | | |
|----|--------------------------------|--|-------|---------|------|------|----|------|----|----|----|----|----|----|------|---------|----|----|----|---|
| | | | NP | SB | FS | SH | FS | LS | SR | GS | 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 | A | A | A | A | |
| 2 | Packet 5 | Linking | NR | A[2][4] | R | R | A | A | A | A | A | R | A | A | R | NR | NR | NR | R | |
| 3 | V_Main in Packet 12 | Signalling Related Speed Restriction | NR | A[2][4] | R | R | A | A | A | A | A | R | R | A | A | NR | NR | NR | A | |
| 4 | Packet 12..15 | Movement Authority | NR | A[2][4] | R | R | A | A | A | A | R | R | A | R | A[1] | NR | NR | NR | R | |
| 5 | (optional) Packet 80 | + (optional) Mode Profile | NR | A[2][4] | R | R | A | A | A | A | R | R | A | R | A[1] | NR | NR | A | R | |
| 6 | (optional) Packet 49 | + (optional) List of Balises for SH area | | | | | | | | | | | | | | | | | | |
| 7 | Packet 16 | Reporting Information | NR | R | R | A | A | R | A | A | R | R | R | R | R | NR | NR | NR | R | |
| 8 | Packet 21 | Gradient Profile | NR | A[2][4] | R | R | A | A | A | A | R | R | A | R | A[1] | NR | NR | A | R | |
| 9 | Packet 27 | International SSP | NR | A[2][4] | R | R | A | A | A | A | R | R | A | R | A[1] | NR | NR | A | R | |
| 10 | Packet 51 | All load speed profile | NR | A[2][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 | Conditional Level Transition Order | NR | A[2] | A[7] | A[7] | A | A | A | A | A | A | A | A | A | A[1][6] | NR | NR | A | R |
| 14 | Packet 42 | Session Management | NR | A[2] | 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 | MRP 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 | R | A | R | A[1] | NR | NR | A | A | |
| 18 | Package Radio 63 * Message | SS Administration* | NR | A[2][4] | R | R | R | A | R | R | R | R | R | R | A[1] | NR | NR | R | R | |
| 19 | Radio 2 + (optional) Packet 49 | + (optional) List of Balises in SR mode | | | | | | | | | | | | | | | | | | |
| 20 | Packet 137 | Stop in SR mode | NR | R | R | R | R | R | R | R | R | R | R | R | R | NR | NR | R | R | |
| 21 | □_SR in Packet 13 | SR distance information form stop | NR | R | R | R | R | A[6] | R | R | R | R | R | R | R | NR | NR | R | R | |
| 22 | Packet 65 | Temporary Speed Restriction | NR | A[2][4] | R | R | A | A | A | A | R | R | A | A | A[1] | NR | NR | A | R | |
| 23 | Packet 66 | Temporary Speed Restriction Revocation | NR | A[2][4] | R | R | A | A | A | A | R | R | A | A | A[1] | NR | NR | A | R | |
| 24 | Package 64 | Inhibition of several TSUs from Balises in L3 | 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 | A[2][4] | R | R | A | A | A | A | R | R | A | A | A[1] | NR | NR | A | R | |
| 26 | Packet 70 | Route Suitability Data | NR | A[2][4] | R | R | A | A | A | A | R | R | A | R | A[1] | NR | NR | A | R | |
| 27 | Packet 71 | Adhesion Factor | NR | A[2][4] | R | R | A | A | A | A | R | R | A | R | A[1] | NR | NR | A | R | |
| 28 | Packet 72 | Plan Test Information | NR | A[2] | R | R | A | A | A | A | R | R | A | A | A[1] | NR | NR | A | A | |
| 29 | Packet 76 | Fixed Text Information | NR | A[2] | R | R | A | A | A | A | R | R | A | A | A | A[1] | NR | NR | A | A |
| 30 | Packet 79 | Geographical Position | NR | A[2] | R | R | A | A | A | A | R | R | A | A | A | A[1] | NR | NR | A | R |
| 31 | Packet 131 | RBC Transition Order | NR | A[2][4] | A[8] | A[8] | A | A | A | A | R | R | A | A | A[1] | NR | NR | R | R | |
| 32 | Packet 132 | Danger for SH information | NR | R | A | R | R | R | R | R | R | R | R | R | R | NR | NR | R | R | |
| 33 | Packet 135 | Stop Shunting on track opening | NR | R | A | R | R | R | R | R | R | R | R | R | R | NR | NR | R | R | |
| 34 | Packet 133 | Radio Infill Area information | NR | R | R | A | A | A | A | R | R | R | R | R | R | NR | NR | R | R | |
| 35 | Package 42 | Session Management with neighbouring RCU | NR | R | R | R | A | A | A | R | R | R | R | R | R | NR | NR | R | R | |
| 36 | Package 134 | ECU/M Information | NR | R | R | A | A | A | A | A | A | A | A | A | A | NR | NR | A | A | |
| 37 | Message Radio 45 | Assignment Co-ordinate system | NR | A[2] | R | R | A | R | R | R | R | R | 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 insulation areas and metal masses | NR | A[2][4] | R | R | A | A | A | A | R | R | A | A | A[1] | NR | NR | A | R | |

Figure 10. Lists of packages and their handling depending on train modes

**Figure 11. Structure of component ProvidePositionReport**

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

Table 72. Overview of inputs

13.2.1.1 Input 0: NationalValues

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

13.2.1.2 Input 1: TrainPosition

This input is the current train position.

500 13.2.1.3 Input 2: odometry

This input is the odometry data.

13.2.1.4 Input 3: m_level

This input is the current level of the train.

13.2.1.5 Input 4: trainProps

505 This input is a set of train related properties.

13.2.1.6 Input 5: MRSP

This input is the most restrictive speed profile.

13.2.1.7 Input 6: MA

This input is a movement authority.

510 13.2.1.8 Input 7: MA_updated

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

13.2.1.9 Input 8: MRSP_updated

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

515 **13.2.2 Output**

Based on the input the block produces the following output. Table 73 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 73. Overview of outputs

13.2.2.1 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.

520 **13.2.2.2 Output 1: target**

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

13.2.2.3 Output 2: sdmCommands

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

525 **13.2.2.4 Output 3: brakeCmd**

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

13.2.2.5 Output 4: EOA_overpassed

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

530 **13.2.2.6 Output 5: Target_Speed_Reached**

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

13.2.3 SDM_InputWrapper in Train Supervision

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

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

535 13.2.3.2 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 automatically the highest precision in the calculations by the meaning of floating point operations. In addition, to ease the modeling, inside block “Speed Supervision” only units meters ([m]), seconds([s]), meters per second([$\frac{m}{s}$]), and meters per square second([$\frac{m}{s^2}$]) are used.

540

13.2.3.3 Interface

13.2.3.4 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.

545 13.2.3.5 Reference to the Scade Model

13.2.4 TargetManagement in Train Supervision

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

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

13.2.4.2 Short description of the functionality

550 This operator calculates/updates the list of targets to be supervised by the block “Train Supervision”. Taking the current movement authority, the most restrictive speed profile and the current maximum safe front end position as an input, the operator outputs a single End of Authority target, a list of all MRSP-Targets and a list of all LoA-Targets.

13.2.4.3 Interface

555 13.2.4.4 Functional Design Description

13.2.4.4.1 Derivation of Targets from Movement Authority Sections

The sections of the *Movement Authority* could cause two types of targets:

End Of Authority(EoA) only one could exist and this is only in the *end section* of the *MA*

Limit of Authority (LoA) is possibly in every section of the *MA* except the end section

560 In every cycle in which the *MA* is updated, the operator iterates through the entire *MA* and puts all speed limitations by *LoAs* into a list of targets. The end section is used to derived the *EoA* target. All *LoA* targets are sorted by location.

13.2.4.4.2 Derivation of Targets from MRSP

According to [1, Chapt. 3.13.8.2], every speed decrease of the *MRSP* is used to derive a target.

565 Therefore in every cycle in which the *MRSP* is updated, the operator iterates through the entire

MRSP searching for all MRSP targets. For this purpose, every element of the MRSP is compared with its successor.

13.2.4.4.3 Update of Targets

In every cycle the operator monitors whether all targets are already passed. To this end, it iterates

570 over the list of targets comparing the current max safe front end position with the target position.

13.2.4.5 Reference to the Scade Model

13.2.5 CalcBrakingCurves_Integration in Train Supervision

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

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

575 • [1, Chapt. 3.13.8.4]: Service Brake Deceleration curves (SBD)

- [1, Chapt. 3.13.8.5]: Guidance curves (GUI)

13.2.5.2 Short description of the functionality

For each type of target a certain braking curve has to be calculated. This curve enables proactive

monitoring of the train's speed. A reverse lookup on this braking curve indicates, where the

580 train has to start braking given the current speed. The braking curve does not depend on the actual train status. As a consequence the braking curve stays constant over time. As a legitimate simplification the calculation of the braking curve is not extended after the estimated front end position of the train has been passed.

13.2.5.3 Interface

585 13.2.5.4 Functional Design Description

The calculation of the braking curve takes the complex function A_{safe} as an input, which describes

the overall braking performance of the train in a speed and position dependent meaning. This

two-dimensional function needs to be simplified for every target to get a function of position to

speed. Each individual target has a position and a speed (a point in the distance speed plane) and

590 is the starting point of the braking curve. The first step is to get the deceleration of the train at the target point from the A_{safe} -function. Afterward the calculation iterates through the A_{safe} -function until the current estimated front end position is reached. Two cases can be distinguished:

- a new distance step of A_{safe} is reached
- a new speed step of A_{safe} is reached

595 Both cases are checked and the applicable one is used to calculate a new arc. Every arc of the braking curve consists of:

- the distance where the arc begins,

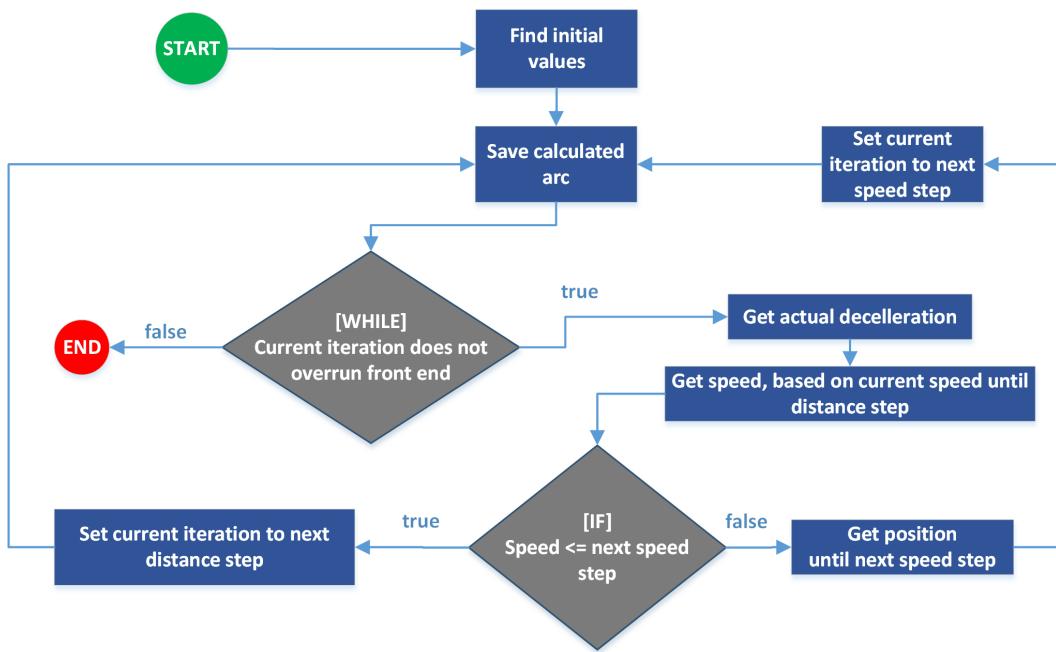


Figure 12. Calculation of Braking Curves

- the speed at the point where the arc begins,
- the deceleration for the whole arc.

600 An abstract overview of the calculation could be seen in Fig. 12.

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

605 13.2.5.5 Reference to the Scade Model

13.2.6 SDMLimitLocations in Train Supervision

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

- [1, Chapt. 3.13.9]: Supervision Limits
- [3, Chapt. 5.3.1.2]: f_{41} – accuracy of speed known on-board
- [1, Chapt. 3.13.10]: Monitoring Commands as reference for required outputs of this module

13.2.6.2 Short description of the functionality

This operator calculates the various locations needed to determine the speed and distance monitoring commands. The current implementation of functionality is stateless and requires a complete recalculation each cycle.

615 **13.2.6.3 Interface**

13.2.6.3.1 Input

1. **MRSPPProfile** Speed profile related to current track under train.
2. **odometry, trainLocations** External state of train provided by odometry.
3. **targetCollection** The different target (list) types wrapped in a structure.
- 620 4. **curveCollection** The related braking curves correlated to above targets.
5. $v_{release}$ Release speed as defined by external sources.
6. $v_{mathit{itura}}$ Speed under reading amount.
7. **inhibitUnderReadingCompensation** A flag defined by National Value, relating to above item.
- 625 8. $T_{bs}, T_{be}, T_{tractionCutOff}$ Time constants defined externally or in other modules.

13.2.6.3.2 Output

1. **locations** Internal type to wrap the locations calculated herein and pass it on directly to SDM-Commands-Operator.
2. **MostRestrictiveTarget** An internal structure to contain the information the target based locations are linked to.
- 630 3. **FLOIisSBI1** Flag is true if First Line of Intervention uses the service brake curve (SBI1) or false if it uses deceleration values based on the emergency brake curve (SBI2).
4. v_{target} The designated speed of the Most Restrictive Target. This is a convenience reference into the above data structure.
- 635 5. $v_{mathit{MRSP}}$ The current Most Restrictive Speed at the Max Safe Frontend of the train.

13.2.6.4 Functional Design Description

This operator gathers all necessary input values and computes some frequently used intermediate values in the operators **surplusTractionDeltas** and v_{bec} . The other input preparation operator is the **TargetSelector** whose main task is to dissect the list of targets to find the Most Restrictive Target. The accompanying braking curves are extracted and promoted to trailing location calculations. Also the special values of the EOA are exposed.

The operator creates the requested values for the commands package. These are in particular the preindication locations for EBD and SBD based targets, the release speed monitoring start locations, the locations for target speed monitoring of the I-, W-, P- and FLOI-curve, the related FLOI speed and the location of the permitted speed supervision limit. Included in the output are also certain flags for the validity of linked values.

13.2.7 CalcSpeeds in Train Supervision

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

- [1, Chapt. 3.13.9]: Supervision Limits

650 **13.2.7.2 Short description of the functionality**

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

13.2.7.3 Interface

13.2.7.4 Functional Design Description

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

only in special case or link to the Scade model

13.2.8 ReleaseSpeed_Selection in Train Supervision

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

- [1, Chapt. 3.8]: Movement authority

660 **13.2.8.2 Short description of the functionality**

This operator outputs the release speed which can be given either by the national values or the movement authority.

13.2.8.3 Interface

13.2.8.4 Functional Design Description

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

13.2.8.4.1 Reference to the Scade Model

13.2.9 SDM_Commands in Train Supervision

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

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

670 **13.2.9.2 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.

13.2.9.3 Interface

675 13.2.9.4 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 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.

13.2.9.5 Reference to the Scade Model

13.2.10 SDM_OutputWrapper in Train Supervision

685 13.2.10.1 Reference to the SRS or other Requirements (or other requirements)

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

13.2.10.2 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.

13.2.10.3 Interface

13.2.10.4 Functional Design Description

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

13.2.10.5 Reference to the Scade Model

13.3 Manage ETCS Procedures

13.3.1 Start of Mission - Awakness of Train

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

700 Chapter 5, § 5.4

13.3.1.1 Short descriptoion of the functionality

This functionality describes the Start of Mission procedure of the train until the status of the awakness. From this point of the awakness the train will be able to start different modes, levels and further procedure. See scope of the Start of Mission - Awakness of train in the figure below.

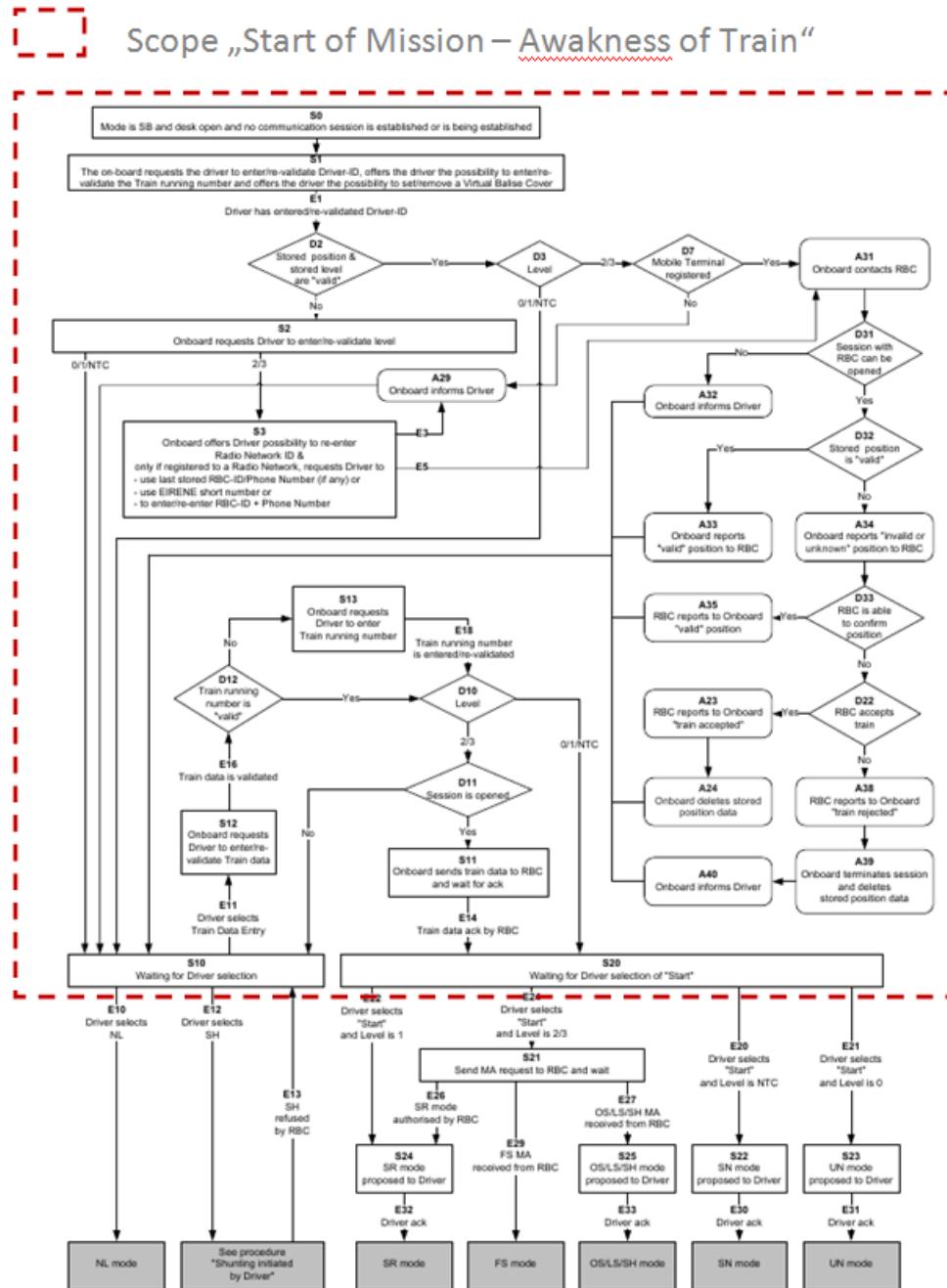


Figure 13. Start of Mission - Awkness of Train

705 **13.3.1.2 Interface**

13.3.1.2.1 Input Flow

- Information from TIU
 - Action from Driver (DMI)
 - Information from Position Calculation
- 710
- Information from Persistent Data
 - Information from Management of Radio Communication
 - Information from Mode and Level Management (Level and Mode Status)
 - Information from Radio Block Control

13.3.1.2.2 Output Flow

- 715
- Information to Management of Radio Communication
 - Request to Management of Radio Communication
 - Request to Driver (DMI)
 - Request to Mode and Level Management (Request Mode Change)
 - Request to Radio Block Control (Validation of Train Data)

720 **13.3.1.3 Functional Design Description**

For the third iteration just a part of the Scope has been design. To complete the scenario in the third iteration the ideal path to the awakness of train until the state "waiting for Driver selection of "Start"" have been realized. Furthermore the initial data from the persistend database such as Level, Driver ID, Train Number, Train Data, Radio Number, RBC ID hase been consider as constants.

725

13.3.1.4 Refernce to the Scade Model

https://github.com/openETCS/modeling/blob/master/model/Scade/System/ObuFunctions/Procedures/ManageProcedure_Pkg.xscade

13.3.2 Start of Mission in Level 2 or 3 Mode SR FS OS LS SH

730 **13.3.2.1 Reference to the SRS or other Requirements (or other requirements)**

Chapter 5, § 5.4

13.3.2.2 Short description of the functionality

This functionality describes the Start of Mission procedure of the train in Level 2 or 3 and the Modes SR FS OS LS SH where the train under the defined Mode Level supervision starts running.

735 See scope of the Start of Mission - Level 2 or 3 and Modes SR FS OS LS SH in the figure below.

Scope „Start of Mission – Level 2 or 3 in Mode SR FS OS LS SH

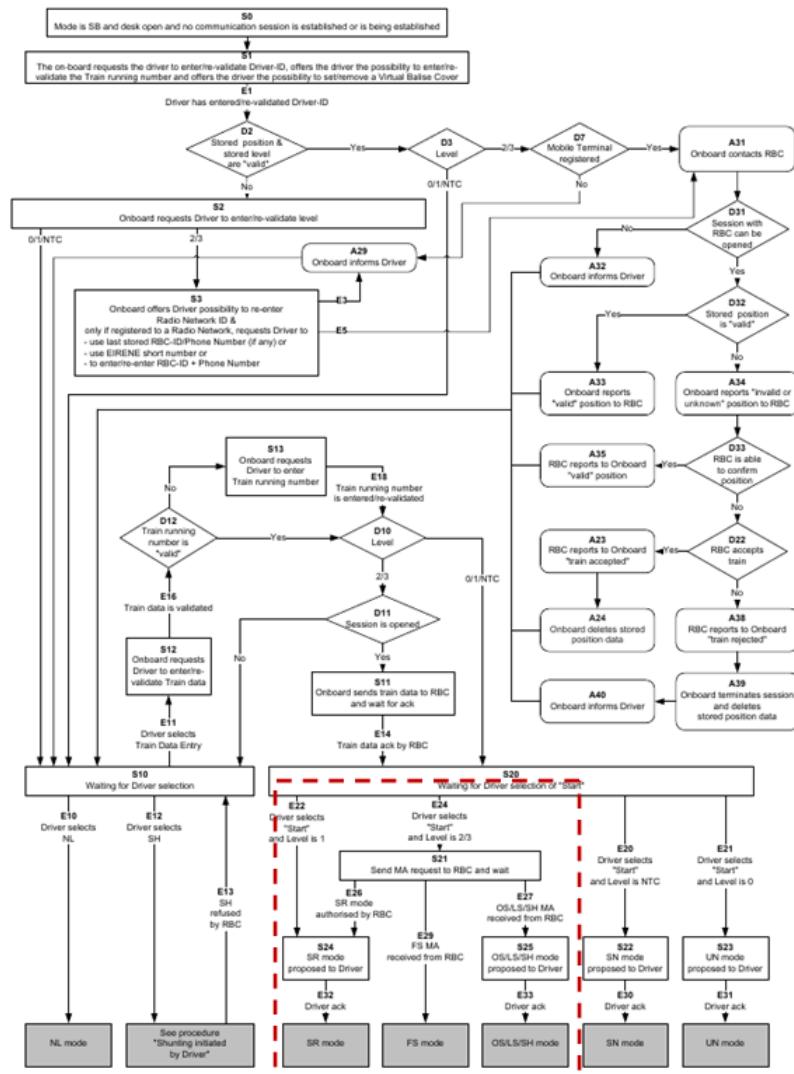


Figure 14. Start of Mission - Start of Mission in Level 2 or 3 and Mode SR FS OS LS SH

13.3.2.3 Interface

13.3.2.3.1 Input Flow

- Action from Driver (DMI)
- Information from Mode and Level Management (Level and Mode Status)
- 740 • Information from Movement Authority Management (Receiving of Movement Authority)

13.3.2.3.2 Output Flow

- Request to Driver (DMI)
- Request to Movement Authority Management (Request Movement Authority)
- Request to Mode and Level Management (Request Mode Change)

745 13.3.2.4 Functional Design Description

For the third iteration just a part of the Scope has been design. To complete the scenario in the third iteration the path "Full Supervision Movement Authority received from RBC" has been realized. The state will end after the train receives the Change Authority to FS and will be ready to run.

750 13.3.2.5 Reference to the Scade Model

https://github.com/openETCS/modeling/blob/master/model/Scade/System/ObuFunctions/Procedures/SoM_SR_FS_OS_LS_SH_SN_UN.xscade

13.4 Manage Track Data

13.4.1 F.2.2 Calculate Train Position

755 13.4.1.1 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

- 760 • 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

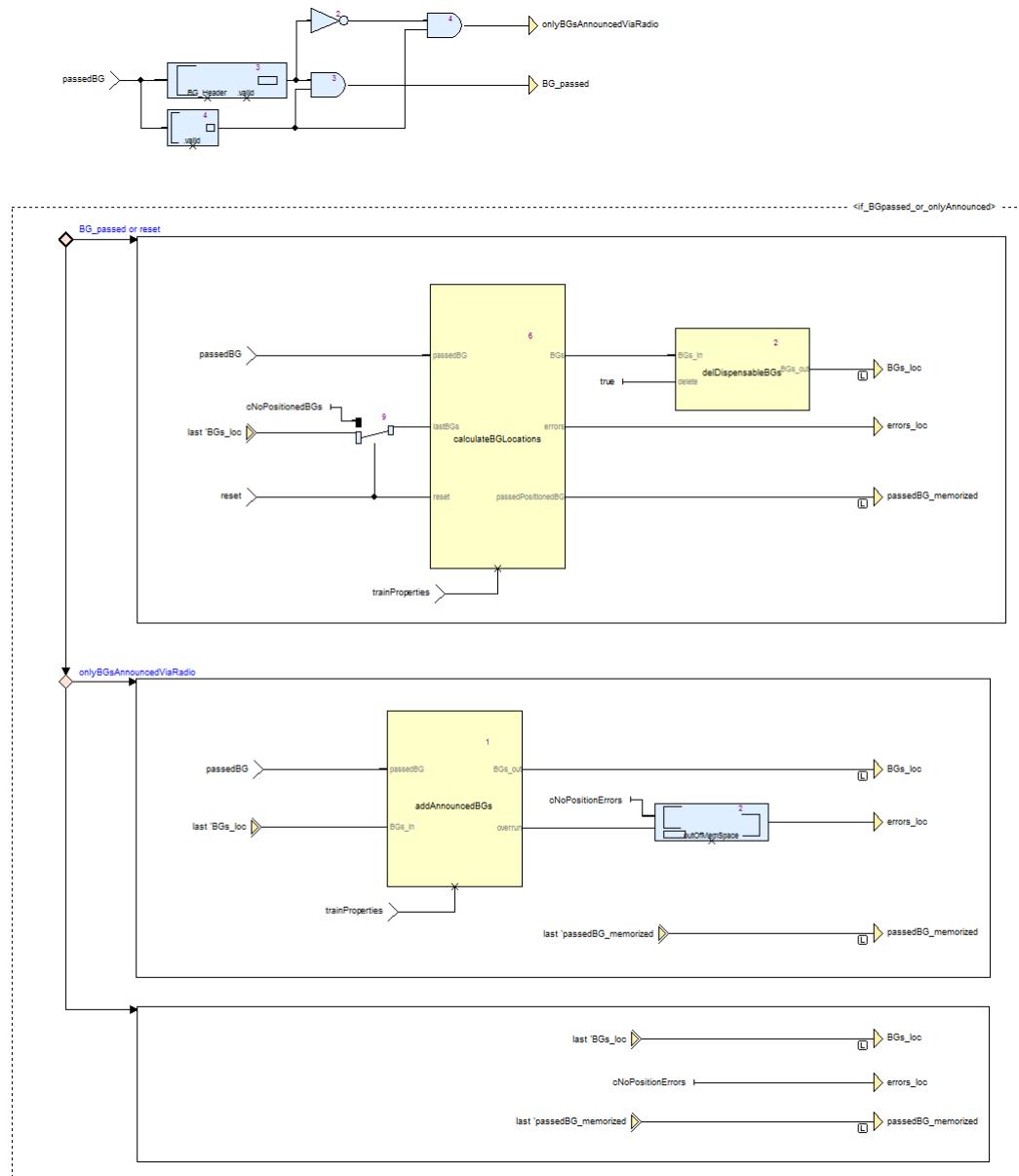


Figure 15. Calculating the balise group locations.

- 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
- 770 • 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.

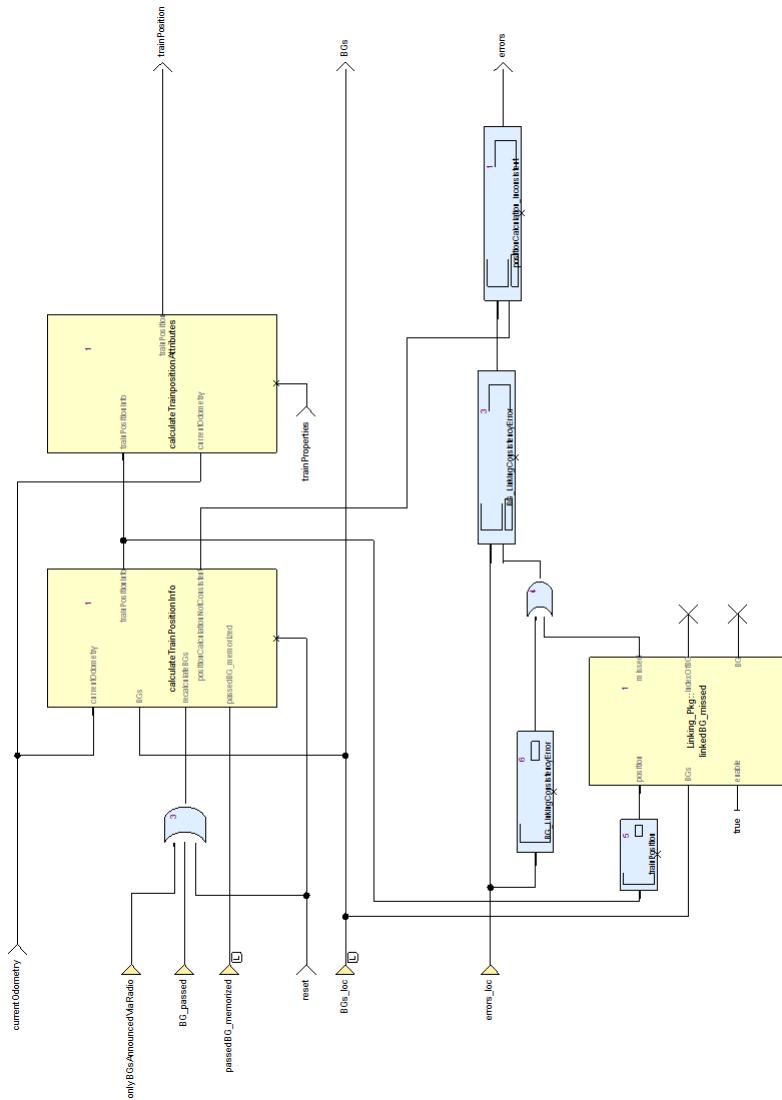


Figure 16. Calculating the current train position and attributes.

13.4.1.2 Functional Structure in Stages

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

780 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.

785 If the passedBG input event originates 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").

790 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:

795 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.

805 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.

810 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 inaccuracies around the current train position (= location of the passed BG).

2. ***delDisposableBGs***: Delete dispensable balise groups

815 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 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.

820 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.

13.4.1.3 Reference to the SRS (or other requirements)

835 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].

13.4.1.4 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.

840 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.

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

5. calculateTrainPosition does not yet consider repositioning information.

850 13.4.2 Provide Position Report

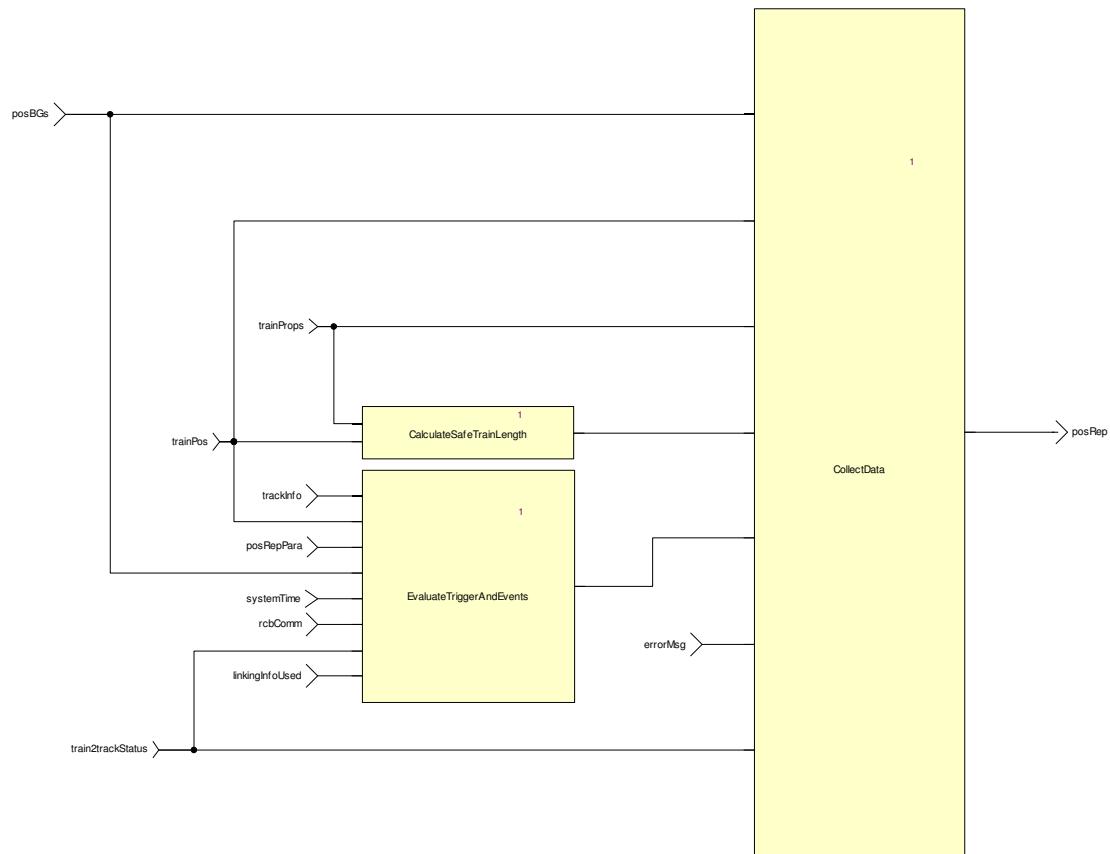


Figure 17. Structure of component ProvidePositionReport

13.4.2.1 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, 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 17, which are explained below.

CalculateSafeTrainLength Calculates the the safeTrainLength and the MinSafeRearEnd according to [1, Chapter 3.6.5.2.4/5].

$\text{safeTrainLength} = \text{absolute}(\text{EstimatedFrontEndPosition} - \text{MinSafeRearEnd})$,
where $\text{MinSafeRearEnd} = \text{minSafeFrontEndPosition} - L_{TRAIN}$.

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.

13.4.2.2 Reference to the SRS (or other requirements)

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

870 13.4.2.3 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.
- 875 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.
- 880 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.
- 885 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.

13.4.2.4 Open Issues

- 890 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.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].
- 895 3. 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.

13.5 Mode and Level

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

13.5.1 Function Level Management

13.5.1.1 Reference to the SRS or other Requirements

See [1] section 5.10

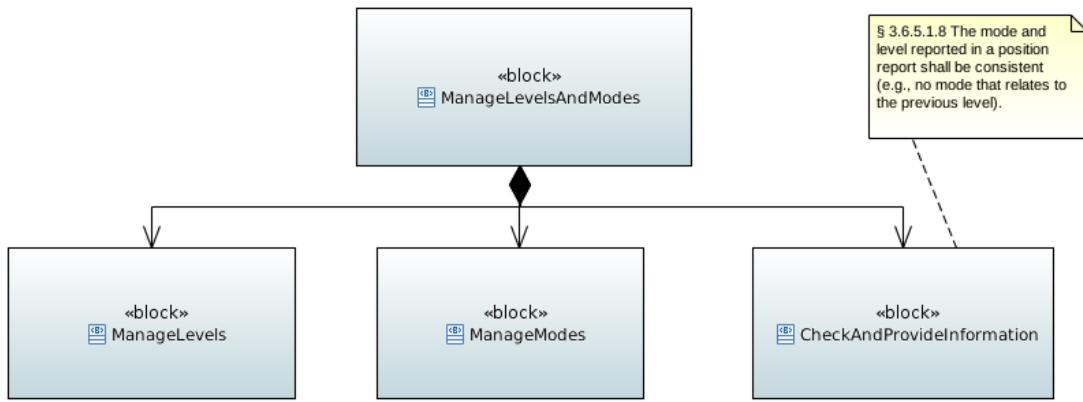


Figure 18. High level Architecture

905 13.5.1.2 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.

13.5.1.3 Interface

The interface consists of the following inputs:

- *conditional transitions*: a priority table containing the conditional level transition orders (from paquet 46)
- 915 ● *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
- 920 ● *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)
- 925 ● *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)

- 930
- *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:

- 935
- *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

13.5.1.4 Functional Design Description

940 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.

945 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.

13.5.1.5 Reference to the Scade Model

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

13.5.2 Function Mode Management

13.5.2.0.1 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

13.5.2.1 Short description of the functionality

955 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.

13.5.2.2 Interface

The inputs are the following:

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

- 960 • *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 acknowledges LS mode
 - *Ack_OS : bool*
 - *Ack_RV : bool*
 - *Ack_SH : bool*
 - *Ack_SN : bool*
 - *Ack_SR : bool*
 - 970 - *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
 - 975 - *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_Localisation*: set of data received from the function in charge of localisation of the train, indeed:
- 980 - *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) *Localisation function ?*
 - *Train_Position*: output provided by function in charge of computation of train position (type TrainPosition_Types_Pck::trainPosition_T)
 - *Train_Speed : Obu_BasicTypes_Pkg::Speed_T* provided by odometry function
 - 990 - *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)
 - 995 - *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_Override_Limit* : *bool* supervision when override function is active (to SR mode condition 37)
- 1005 • *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_Gradient_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_Revoked* : *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
- 1010 • *Failure_Occured*: boolean to indicate safety failure occurence
- 1015 • *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
- 1020 • *OnBoard_Powered*: boolean to indicate the poxering state of the system
- *Stop_Shunting_Stored*: boolean to store the information in regards of shunting function
- 1025 • *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_Request* 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 :
 - 1040 – *Ack_LS* : *bool* Driver acknowledges LS mode
 - *Ack_OS* : *bool*
 - *Ack_RV* : *bool*
 - *Ack_SH* : *bool*
 - *Ack_SN* : *bool*
 - 1045 – *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
 - 1050 – *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 :
 - 1055 – *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
 - 1060 – *MA_Req* : *bool* for message 132
 - *Req_for_SH_from_driver* : *bool* for message 130

13.5.2.3 Functional Design Description

Three subfunctions are defined:

Inputs proceeds to inputs check and preparation.

- 1065 **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]
- 1070 **Outputs** prepares packet of outputs.

13.5.2.4 Reference to the Scade Model

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

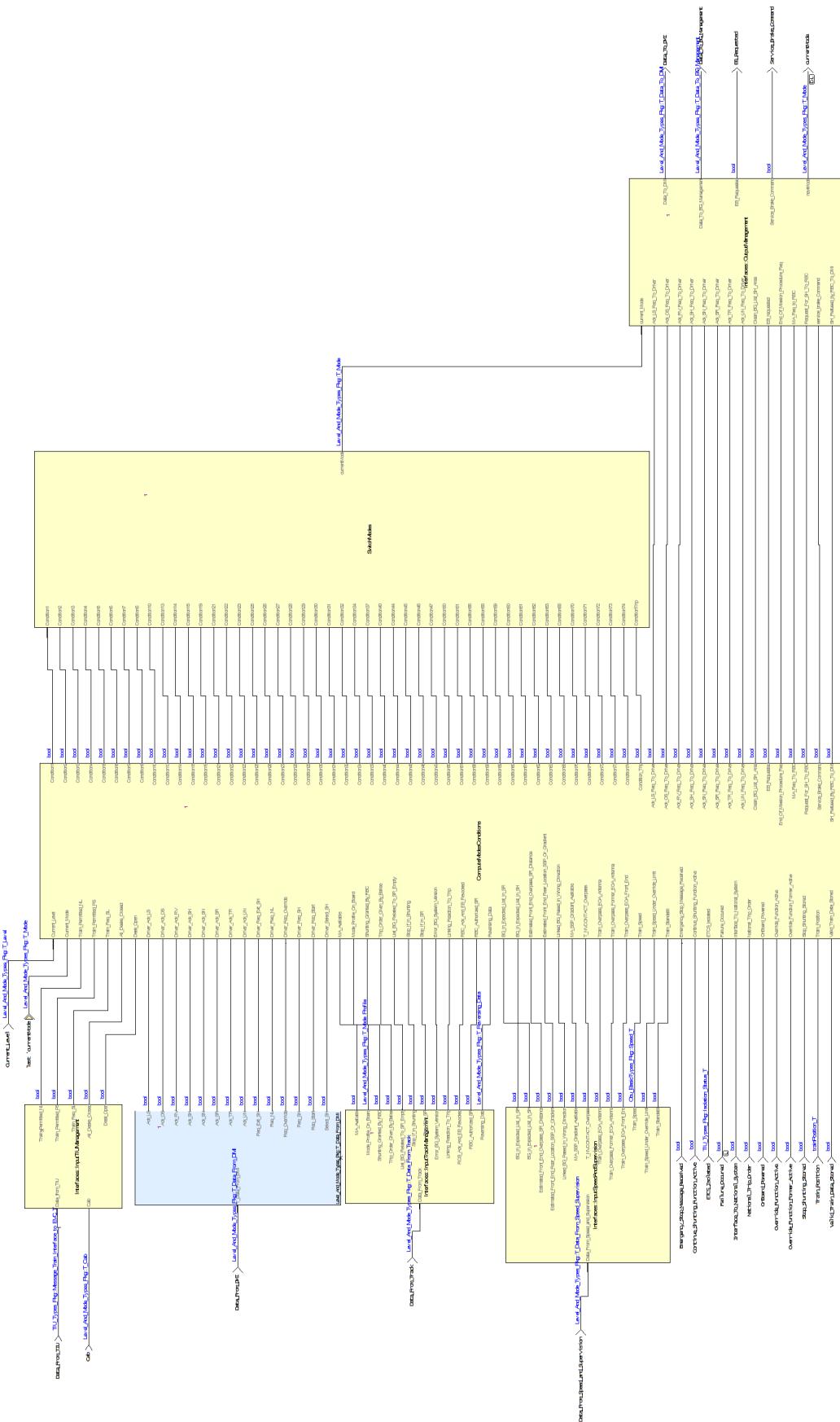


Figure 19. Modes subfunction architecture.

13.5.3 Function Check and Provide Level and Mode

¹⁰⁷⁵ **13.5.3.1 Reference to the SRS or other Requirements**

see [1] section 3.6.5

13.5.3.2 Short description of the functionality

checks compatibility between mode and level and provides outputs

13.5.3.3 Interface

¹⁰⁸⁰ *To design*

13.5.3.4 Functional Design Description

To design

13.5.3.5 Reference to the Scade Model

To design

13.6 Manage Radio Communication

13.6.1 Management of Radio Communication (*MoRC*)

13.6.1.1 Reference to the SRS

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

13.6.1.2 Short description of the functionality

¹⁰⁹⁰ 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.

¹⁰⁹⁵ **13.6.1.3 Interface**

13.6.1.3.1 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*):

¹¹⁰⁰

- 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*
 - *OBUs_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

¹¹⁴⁰ **13.6.1.3.2 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

13.6.1.4 Functional Design Description

¹¹⁶⁵ 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.

¹¹⁷⁰ 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

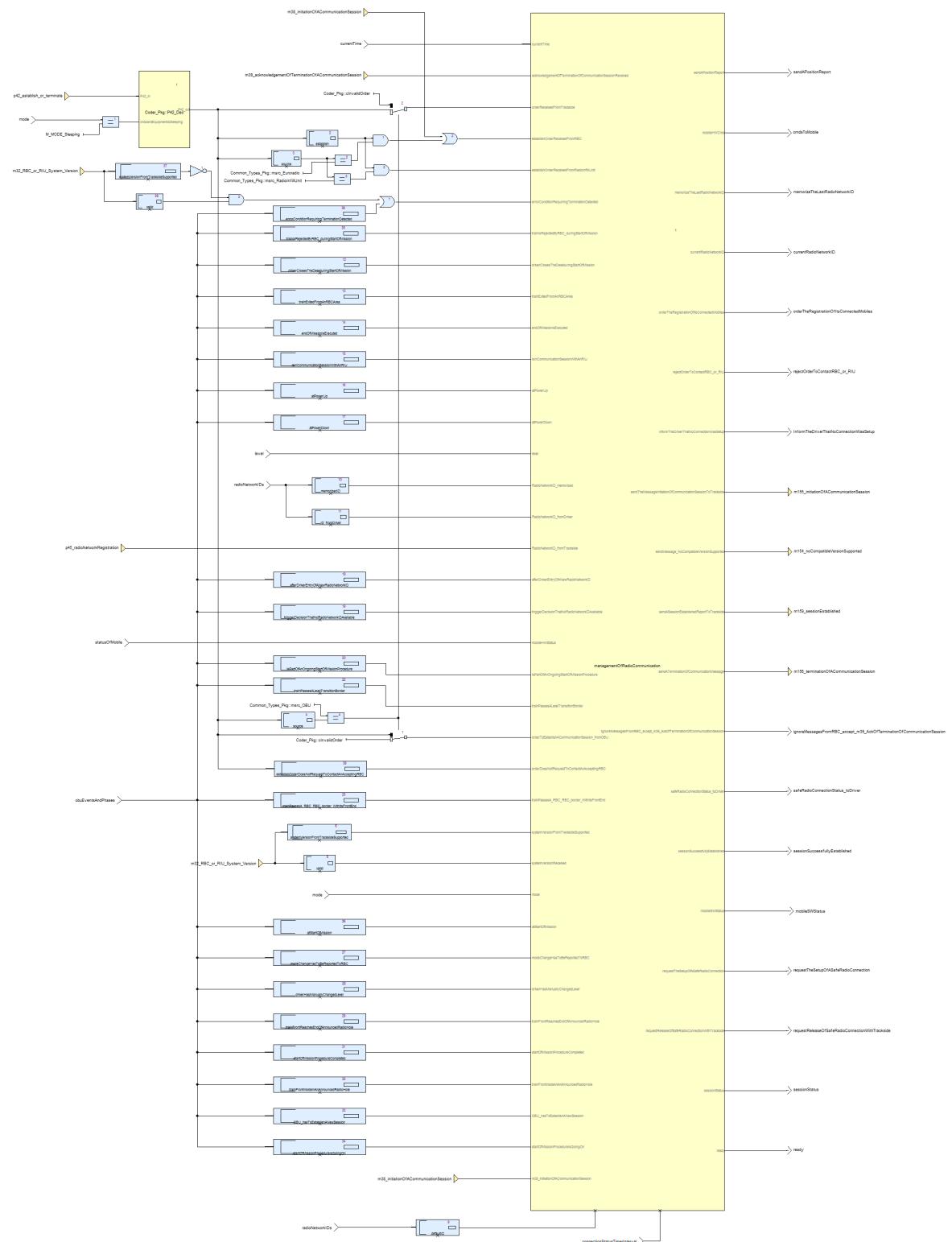


Figure 20. Main function of *MoRC*.

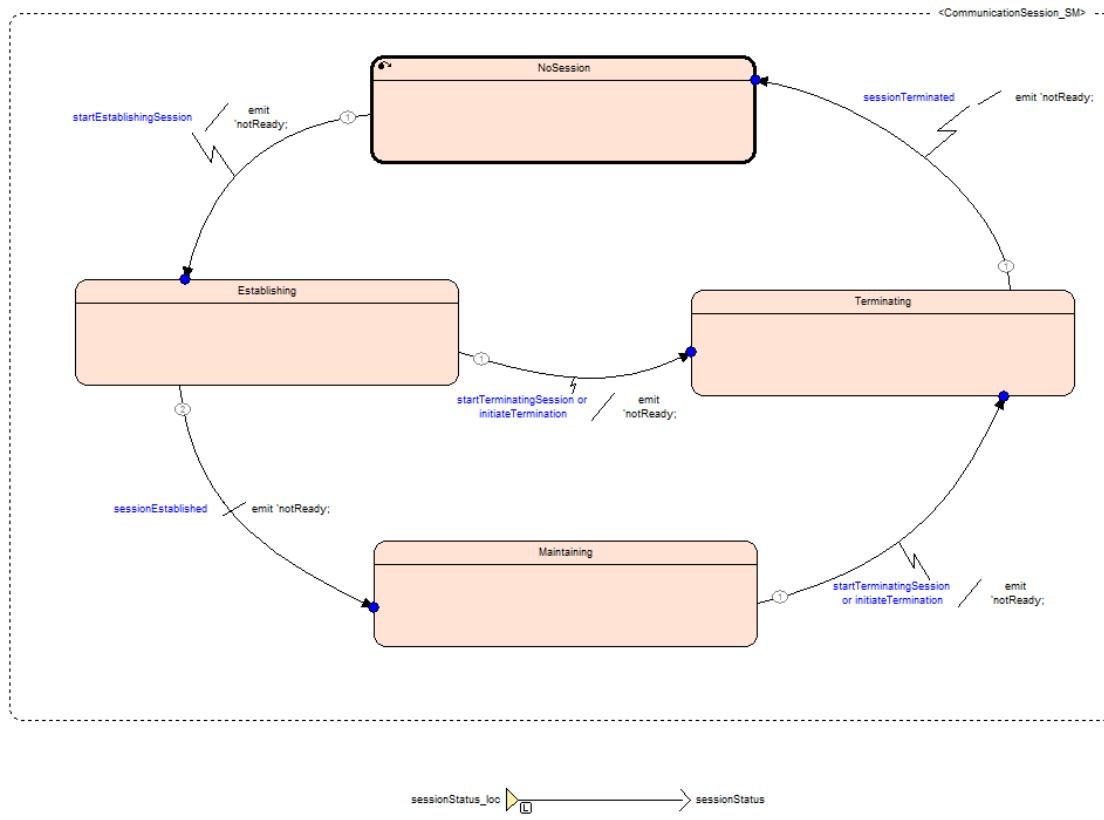


Figure 21. Implementation of session states.

1175 as long as the state is active, are performed. When there is no communication session (state
 1176 *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
 1177 the *Establishing* state. Here in, it runs through the sequence required fore establishing a session
 1178 (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
 1185 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.

13.6.1.5 Reference to the Scade Model

1190 The MoRC SCADE model resides at <https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/Radio/MoRC>.

14 F3: Measure Train Movement

15 F4: Manage Radio Communication

16 F5: Manage JRU

17₁₉₅ F6: DMI Controller

17.1 DMI Controller

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

ERA_ERTMS_015560

17.1.0.7 Short description of the functionality

- ₁₂₀₀ 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 received information (e.g. driver number request, ...) and send, if necessary, data or reports to the DMI Management (acknowledge, text messages...). The DMI Controller is a passive module, this means that all the processing are performed EVC-side, therefore the DMI Controller simply responds to the requests of the EVC or Driver and performs some checks according with the information received from EVC.

17.1.0.8 Interface

The DMI Controller has two interfaces. One between DMI Controller and DMI Display and one between DMI Controller and DMI Management. The structure of the interface between DMI

- ₁₂₁₀ Controller and DMI Display is driven by the logic of SCADE Display therefore It doesn't follow any standard or constraints (It will not be described in this chapter). DMI Controller and DMI Management exchange packets. Each packet is a structured type with a valid flag (a boolean variable), the DMI controller takes into account the data inside the packet only when the valid flag is true.

- ₁₂₁₅ The interface between DMI Controller and DMI Management consist of three parts according with the direction of the information:

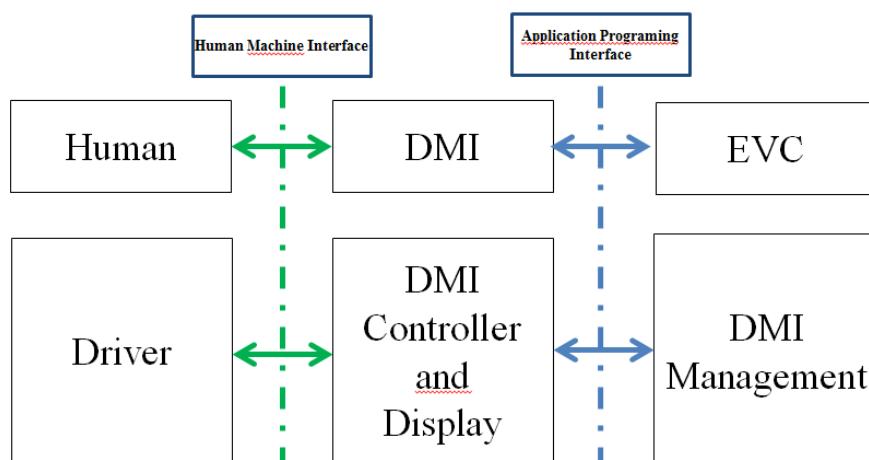


Figure 22. DMI Interfaces

- From DMI Management to DMI Controller
- From DMI Controller to DMI Management
- Both ways directions (You will find the same type both as input than as output)

¹²²⁰ **17.1.0.8.1 From DMI Management to DMI Controller**

In the following table are listed the inputs coming from DMI Management with a brief description:

| NAME | DESCRIPTION |
|------------------------|---|
| DMI_entry_request | Request to input data (e.g. driver id, Train running number etc.) |
| DMI_identifier_request | Request of the DMI informations |
| DMI_menu_request | Request to enable or disable buttons |
| DMI_dynamic | Contains informations about current speed, current mode etc. |
| DMI_text_message | Contains predefined or plain text messages |
| DMI_icons | Request to display one or more icons in any area |

Please note: TIU_trainStatus input is missing in the above table. This is the only input coming directly from TIU and contains the open/close Desk signal.

17.1.0.8.2 From DMI Controller to DMI Management

In the following table are listed the outputs directed to DMI Management with a brief description:

| NAME | DESCRIPTION |
|----------------------|---|
| DMI_identifier | Information about DMI (e.g. version, cabin identifier etc.) |
| DMI_driver_request | Driver request or acknowledgement |
| DMI_train_data_ack | Train data acknowledgement |
| DMI_status_report | The actual status of DMI (keep alive) |
| DMI_text_message_ack | Text message acknowledgement |
| DMI_icons_ack | Icon acknowledgement |

17.1.0.8.3 Both ways direction

¹²³⁰ In the following table are listed the outputs/inputs to/from DMI Management with a brief description:

| NAME | DESCRIPTION |
|--------------------------|--|
| DMI_driver_identifier | Contains the default or entered driver identifier |
| DMI_train_running_number | Contains the default or entered train running number |
| DMI_train_data | Contains the default or entered train data |

17.1.0.9 Functional Design Description

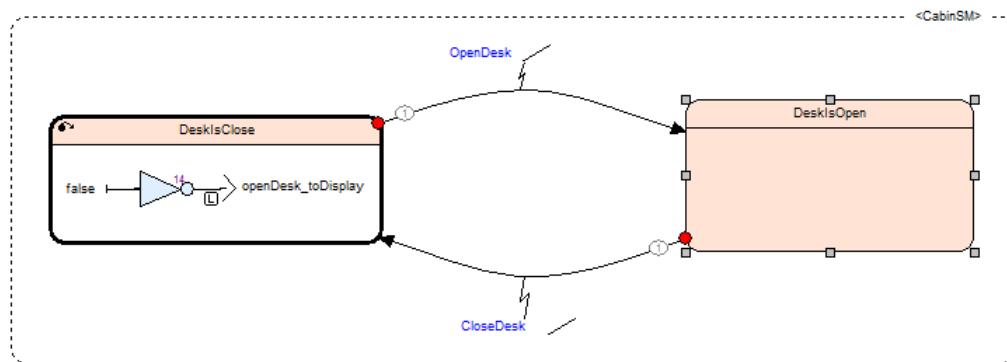


Figure 23. Cabin State Machine.

1235 **Please note:** DMI Controller is a project under construction, a lot of features and functionalities
are missing, therefore the structure described below is a draft version and will be changing in
the future.

1240 The informations (received and sent) could be divided in two groups: Sporadic and Periodic.
The first one are received/sent aperiodically in any time instead the second one are received/sent
periodically, with a fixed deadline. Are part of Periodic group the output DM_status_report
and the input DMI_dynamic all other are Sporadic. Therefore, the structure of DMI Controller
module consists of a first main state machine *CabinSM* (Fig. 23) triggered by a *OpenDesk* signal
(from TIU). Inside the *DeskIsOpen* state there are other two state machines :*HandshakeSM* and
DynamicInfoSM (Fig. 24).

1245 HandshakeSM performs an initial handshake between DMI Controller and DMI Management.
Before that, no data has to be sent or received to/from DMI Management. When the transition is
fired a DMI_identifier packet is sent to DMI Management with informations about the DMI (e.g.
DMI identifier, DMI name etc.). At this point the DMI Controller is ready to manage the sporadic
information (e.g. Enter or revalidate DriverID, Enter or revalidate Train running number etc.).

1250 The DynamicInfoSM state machine is triggered after the handshake, exactly when HandshakeSM
reaches the DynInfo_Activated state. At the time when the transition is fired a signal is emitted
(startDMI_status) and begins a periodic sending of DMI status information (keep alive) to DMI
Management. Once reached DynamicInfo_Active, the DMI Controller is ready to receive and
manage the dynamic informations.

1255 With the aim to improve the readability and for a better management of complexity, all the
functions (modules, state machines etc.) implemented in each state are divided several diagrams.

The *SporadicInfo* consist of:

- **diagram_SporadicInfo_Main:** Contains all the modules to manage the sporadic data like
“Enter revalidate Driver ID”, “Enter or revalidate train running number”, enable buttons in
1260 menus. The WindowSM state machine manages the windows that should appear on the
DMI(Fig. 25).
- **diagram_SporadicInfo_TrainData:** Contains all the logic to store and adapt the incoming
train data to a correct visualization on DMI Display.
- **diagram_SporadicInfo_Icon_Management:** Contains the logic to show/hide one or several
1265 icons in area and manage the acknowledgement mechanism if It's required.

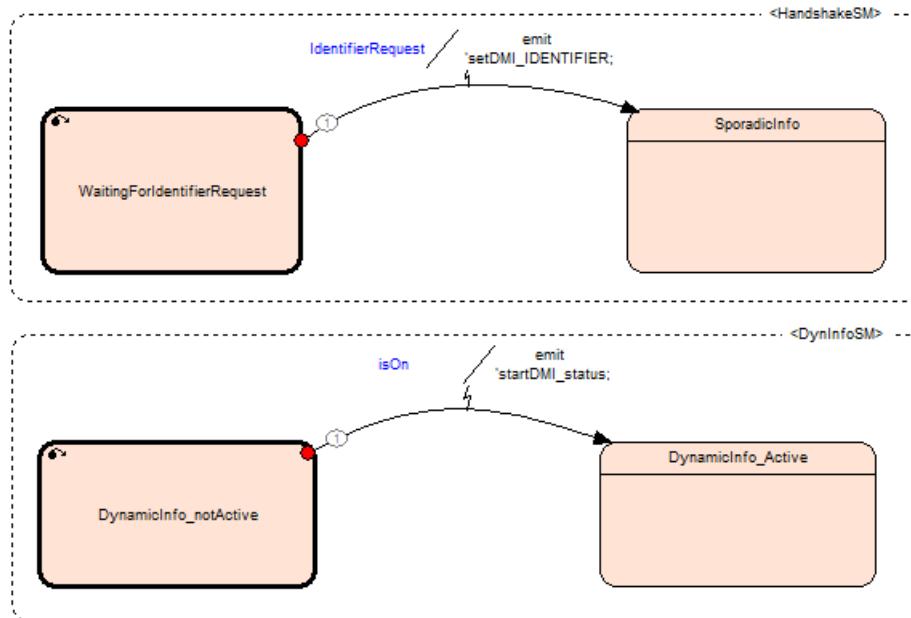


Figure 24. HandshakeSM and DynamicInfoSM State Machines.

- **diagram_SporadicInfo_DriverID_TRN:** Contains the logic to store and sent the Train running number and the Driver ID.
- **diagram_SporadicInfo_Text_Messages:** Contains the modules, state machines and all the logic to manage and display predefined and customized text messages.

1270 The *DynamicInfo_Active* state consists of:

- **diagram_DynamicInfo_Main:** Contains modules to store and display the informations like the current mode, ETCS level, RBC connection status and location brake target.
- **diagram_SpeedSupervision:** Contains the module where are implemented the behaviour of the speed pointer and the circular speed gauge (informations about speed target, speed permitted and speed release).

17.1.0.10 Communication Protocol

This section explains which messages are exchanged among DMI Controller, DMI Management and Start of mission procedure. As mentioned previously the DMI Controller is a passive component, It simply responds to requests, therefore is able to cover different scenarios. Below are some examples.

17.1.0.10.1 Start Of Mission scenario

Are detailed, through a sequence diagram, all the activities (exchanged messages) that should be done to start. In this scenario we have three actors: DMI Controller, DMI Management and SoM procedure (the module where is implemented the start of mission procedure). It's assumed that a OpenDesk signal is received and the system starts in Stand By mode (Fig. 26).

17.1.0.10.2 Cyclic Exchange of messages

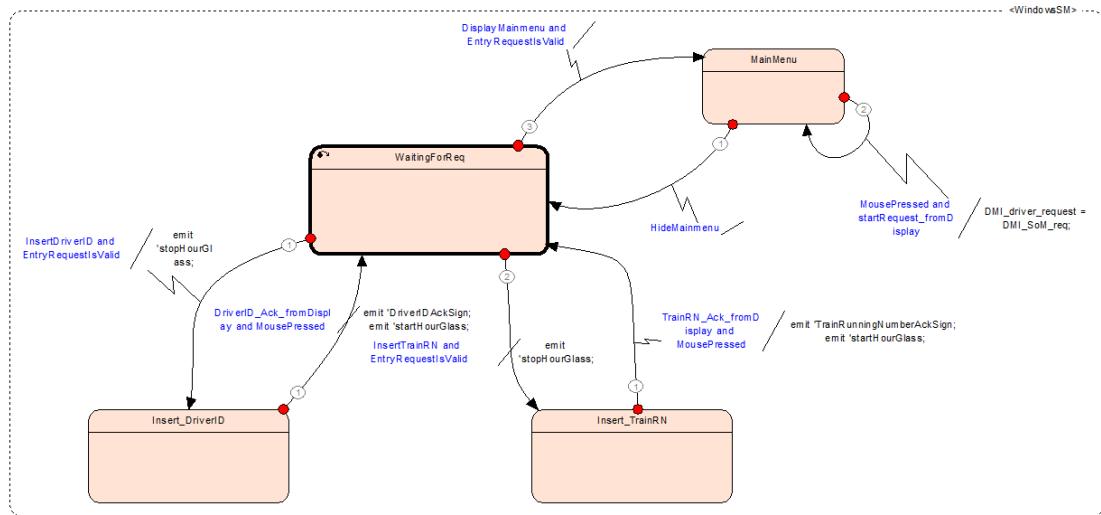


Figure 25. Windows state machine.

The time between two messages has not yet been definitively established. It might change in the future. The DMI status packet implements a keep alive mechanism, this means, if the EVC does not receive any DMI status signal during the lapse time, It shall consider a failure in DMI. This check is not yet implemented.

17.1.0.11 Reference to the Scade Model

The SCADE model can be found on github under the following path: https://github.com/openETCS/modeling/tree/master/model/Scade/System/DMI_Control

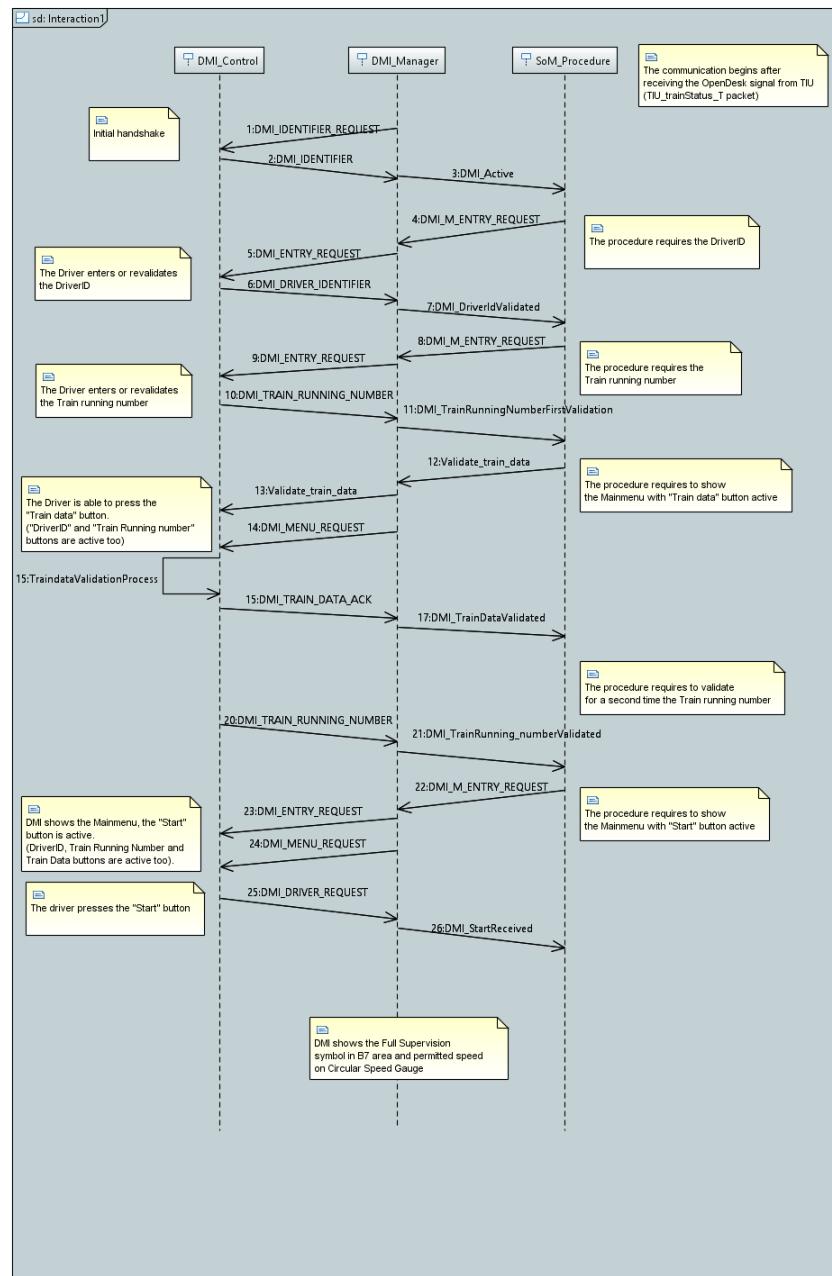


Figure 26. Sequence Diagram of start of mission scenario

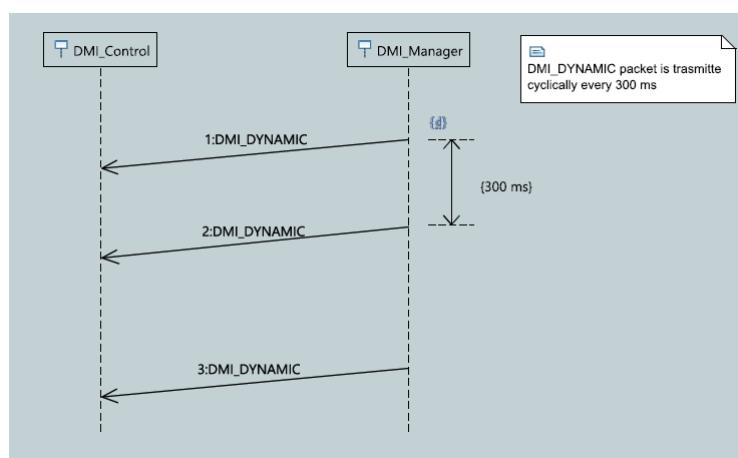


Figure 27. Sequence diagram of Dynamic data.

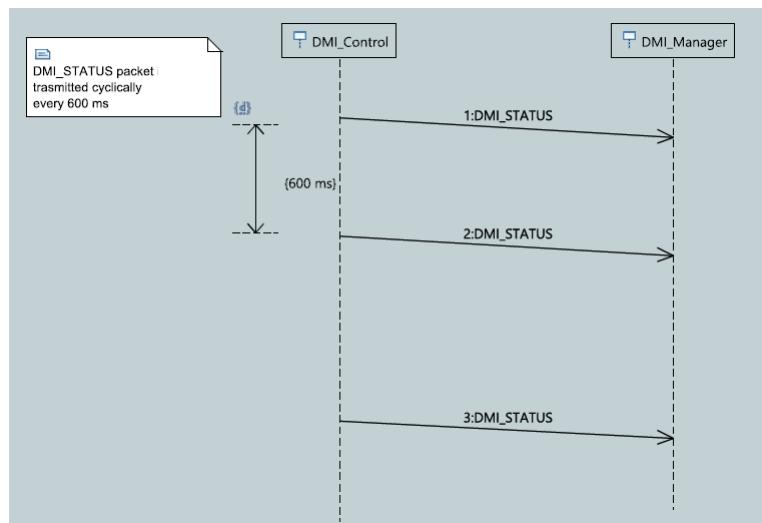


Figure 28. Sequence Diagram of DMI status.

References

- 1295 [1] ERA. *System Requirements Specification, SUBSET-026*, v3.3.0 edition, March 2012.
- [2] ERA. *FFFIS for Eurobalise, SUBSET-036*, v3.0.0 edition, February 2012.
- [3] ERA. *Performance Requirements for Interoperability, SUBSET-041*, v3.1.0 edition, March 2012.