

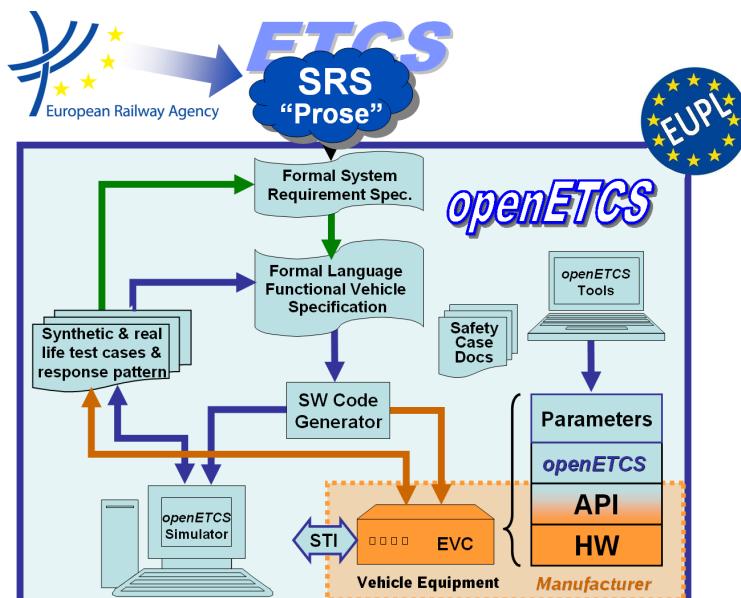
Work Package 3: "Modeling"

# openETCS Design Specification

## Software Component Design and Internal Interface Specification

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Work Package 3: "Modeling"

OETCS/WP3/D3.5.2

June 2015

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Document approbation

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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 |

# Table of Contents

|  |            |
|--|------------|
| <b>Modification History .....</b>  | <b>iv</b>  |
| <b>Figures and Tables.....</b>   | <b>vii</b> |
| <b>1 Functional Breakdown .....</b>  | <b>1</b>   |
| 1.1 openETCS API Runtime System and Input to the EVC .....                     | 1          |
| 1.1.1 Principles for Interfaces (openETCS API).....                            | 1          |
| 1.1.2 openETCS Model Runtime System.....                                       | 1          |
| 1.1.3 Input Interfaces of the openETCS API From other Units of the OBU.....    | 2          |
| 1.1.4 Message based interface (BTM, RTM) .....                                 | 3          |
| 1.1.5 Interfaces to the Time System .....                                      | 4          |
| 1.1.6 Interfaces to the Odometry System.....                                   | 4          |
| 1.1.7 Interfaces to the Train Interfaces (TIU).....                            | 5          |
| 1.1.8 Output Interfaces of the openETCS API TO other Units of the OBU .....    | 5          |
| <b>2 Design Description.....</b>   | <b>6</b>   |
| 2.1 Component Design Template .....  | 6          |
| 2.1.1 Component Requirements .....   | 6          |
| 2.1.2 Interface .....  | 6          |
| 2.1.2.1 Inputs .....   | 6          |
| 2.1.2.2 Outputs .....  | 6          |
| 2.2 F1: Receive information from Trackside.....                                | 7          |
| 2.3 F2: ETCS Kernel.....   | 7          |
| 2.3.1 Manage_TrackSideInformation_Integration .....                            | 7          |
| 2.3.1.1 Inputs .....   | 7          |
| 2.3.1.2 Outputs .....  | 10         |
| 2.3.1.3 Receive_TrackSide_Msg in Manage_TrackSideInformation_Integration ..... | 11         |
| 2.3.1.4 CheckBGConsistency in Manage_TrackSideInformation_Integration .....    | 13         |
| 2.3.1.5 CheckEuroradioMessage in Manage_TrackSideInformation_Integration ..... | 14         |
| 2.3.1.6 ValidateDataDirection in Manage_TrackSideInformation_Integration ..... | 15         |
| 2.3.1.7 InformationFilter .....  | 16         |
| 2.3.2 Train Supervision .....  | 18         |
| 2.3.2.1 Input .....  | 26         |
| 2.3.2.2 Output.....  | 27         |
| 2.3.2.3 SDM_InputWrapper in Train Supervision .....                            | 28         |
| 2.3.2.4 TargetManagement in Train Supervision .....                            | 28         |
| 2.3.2.5 CalcBrakingCurves_Integration in Train Supervision.....                | 29         |
| 2.3.2.6 SDMLimitLocations in Train Supervision .....                           | 31         |
| 2.3.2.7 CalcSpeeds in Train Supervision .....                                  | 32         |
| 2.3.2.8 ReleaseSpeed_Selection in Train Supervision .....                      | 32         |
| 2.3.2.9 SDM_Commands in Train Supervision .....                                | 33         |
| 2.3.2.10 SDM_OutputWrapper in Train Supervision .....                          | 33         |
| 2.3.3 Manage ETCS Procedures .....   | 34         |
| 2.3.3.1 Start of Mission - Awakness of Train .....                             | 34         |
| 2.3.3.2 Start of Mission in Level 2 or 3 Mode SR FS OS LS SH .....             | 36         |
| 2.3.4 Manage Track Data .....  | 37         |
| 2.3.4.1 F.2.2 Calculate Train Position.....                                    | 37         |

|              |   |           |
|--------------|---|-----------|
| 2.3.4.2      | Provide Position Report .....                   | 42        |
| 2.3.5        | Mode and Level.....                             | 44        |
| 2.3.5.1      | Function Level Management .....                 | 44        |
| 2.3.5.2      | Function Mode Management.....                   | 46        |
| 2.3.5.3      | Function Check and Provide Level and Mode ..... | 51        |
| 2.3.6        | Manage Radio Communication.....                 | 51        |
| 2.3.6.1      | Management of Radio Communication (MoRC).....   | 51        |
| 2.4          | F3: Measure Train Movement .....                | 55        |
| 2.5          | F4: Manage Radio Communication .....            | 56        |
| 2.6          | F5: Manage JRU.....                             | 56        |
| 2.7          | F6: DMI Controller.....                         | 56        |
| 2.7.1        | DMI Controller .....                            | 56        |
| <b>Index</b> | .....   | <b>60</b> |

# Figures and Tables

## Figures

|   |    |
|---|----|
| Figure 1. openETCS API Highlevel View.....  | 1  |
| Figure 2. Component SysML diagram .....   | 6  |
| Figure 3. Structure of the Manage_TrackSideInformation_Integration module with submodules. .... | 7  |
| Figure 4. High level overview of the InformationFilter components. ....                         | 17 |
| Figure 5. Lists of packages and their handling depending on train modes .....                   | 22 |
| Figure 6. Lists of packages and their handling depending on train modes .....                   | 24 |
| Figure 7. Structure of component ProvidePositionReport .....                                    | 25 |
| Figure 8. Calculation of Braking Curves.....  | 30 |
| Figure 9. Start of Mission - Awakness of Train.....   | 35 |
| Figure 10. Start of Mission - Start of Mission in Level 2 or 3 and Mode SR FS OS LS SH .....    | 36 |
| Figure 11. Calculating the balise group locations. ....   | 39 |
| Figure 12. Calculating the current train position and attributes. ....                          | 40 |
| Figure 13. Structure of component ProvidePositionReport .....                                   | 42 |
| Figure 14. High level Architecture.....   | 44 |
| Figure 15. Modes subfunction architecture. ....   | 50 |
| Figure 16. Main function of MoRC. ....  | 54 |
| Figure 17. Implementation of session states. ....   | 55 |
| Figure 18. DMI Interfaces .....   | 56 |
| Figure 19. Cabin State Machine. ....  | 58 |
| Figure 20. HandshakeSM and DynamicInfoSM State Machines. ....                                   | 59 |
| Figure 21. Windows state machine. ....  | 60 |
| Figure 22. Sequence Diagram of start of mission scenario .....                                  | 61 |
| Figure 23. Sequence diagram of Dynamic data. ....   | 61 |
| Figure 24. Sequence Diagram of DMI status.....  | 62 |

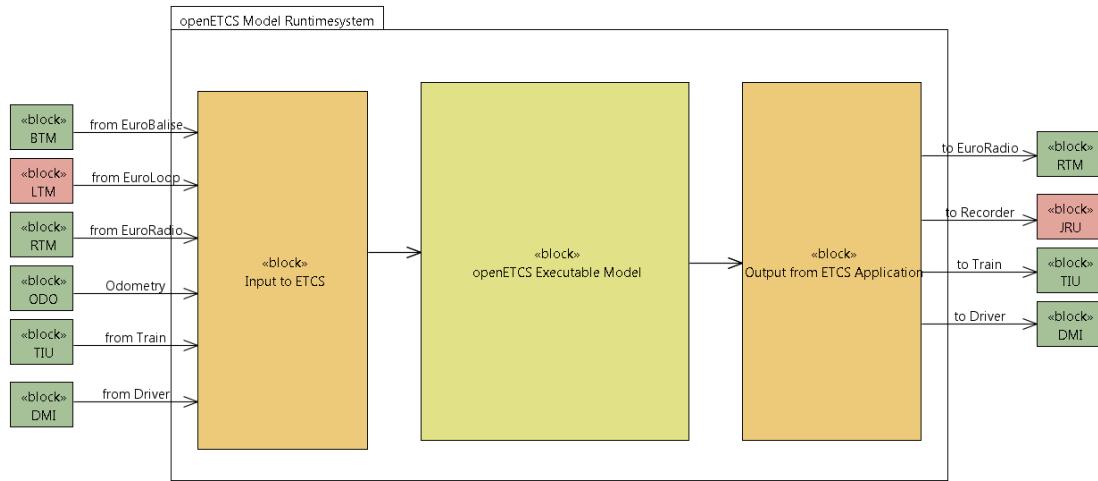
## Tables

|   |    |
|---|----|
| Table 4. Overview over input .....  | 8  |
| Table 5. Possible values for the input fullChecks .....                   | 8  |
| Table 6. Possible values for the input reset. ....                        | 8  |
| Table 7. Possible values for the input connectionStatus. ....             | 9  |
| Table 8. Dataflow at output .....   | 10 |
| Table 9. Structure of ReceivedMessage_T .....                             | 10 |
| Table 10. Possible values for the input errorLinkedBG.....                | 11 |
| Table 11. Possible values for the input errorUnlinkedBG .....             | 11 |
| Table 12. Possible values for the input radioSequenceError .....          | 11 |
| Table 13. Possible values for the input radioMessageConsistencyError..... | 11 |
| Table 14. Overview of the InformationFilter interface .....               | 16 |
| Table 15. Overview of inputs .....  | 26 |
| Table 16. Overview of outputs .....                                       | 27 |



# 1 Functional Breakdown

## 1.1 openETCS API Runtime System and Input to the EVC



**Figure 1. openETCS API Highlevel View**

Figure 1 shows the structure of API with respect to the software architecture. Note that red input and output modules were not yet implemented and thus are not part of the openETCS OBU 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.

### 1.1.1 Principles for Interfaces (openETCS API)

- 10 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 ??.

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.

### 1.1.2 openETCS Model Runtime System

The openETCS model runtime system also provides:

- 20 **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.

**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.

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, 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.

### 1.1.3 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).

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                |

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

<sup>50</sup> 1.1.4 Message based interface (BTM, RTM)

Balise Message (Track to Train)

| Message Name    | Optional Packets  | Restrictions in the current scope |
|-----------------|---|-----------------------------------|
| Balise Telegram | 3: National Values<br>41: Level Transition Order<br>42: Session Management<br>45: Radio Network registration<br>46: Conditional Level Transition Order<br>65: Temporary Speed Restriction<br>66: Revoke Temporary Speed Restriction<br>72: Packet for sending plain text messages<br>137: Stop if in Staff Responsible<br>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              |

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<br>27: International Static Speed Profile<br>49: List of balises for SH Area<br>80: Mode profile<br>plus common optional packets | a                                   |
| 9: Request To Shorten MA | 49: List of balises for SH Area<br>80: Mode profile   |                                     |
| 24: General Message      | From RBC:<br>21: Gradient Profile<br>27: International Static Speed Profile<br>plus common optional packets<br>From RIU:<br>44, 45, 143, 180, 254     | Messages from RIU are not supported |

|    |   |   |  |
|----|---|---|--|
| 55 | <p>28: SH authorised</p> <p>33: MA with Shifted Location Reference</p> <p>37: Infill MA</p> <p>List of common optional parameters</p> | <p>3, 44, 49</p> <p>21: Gradient Profile<br/>27: International Static Speed Profile<br/>49: List of balises for SH Area<br/>80: Mode profile<br/>plus common optional packets</p> <p>5, 21, 27, 39, 40, 41, 44, 49, 51, 52, 65, 66, 68, 69, 70, 71, 80, 88, 138, 139</p> <p>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</p> |  |
|----|---|---|--|

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

### 1.1.5 Interfaces to the Time System

60 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)

- 65
- 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.
- 70

### 1.1.6 Interfaces to the Odometry System

75 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.
- 80

- Coordinate (odometryLocation\_T)
  - \* nominal (L\_internal\_Type) [cm]
  - \* min (L\_internal\_Type) [cm]
  - \* max (L\_internal\_Type) [cm]

85

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 boundaries 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

- \* 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

- \* 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

100

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 boundaries are determined by the inaccuracy of the positioning system. All values are set to 0 when the train starts.

- acceleration (A\_internal\_Type)[0.01 m/s<sup>2</sup>],

Standardized acceleration type for all internal calculations : in

105

- motionState (Enumeration)

indicates whether the train is in motion or in no motion

- motionDirection (Enumeration)

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

### 1.1.7 Interfaces to the Train Interfaces (TIU)

110

The following information 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.

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

### 1.1.8 Output Interfaces of the openETCS API TO other Units of the OBU

| From Function | Name                     | To Unit   | Description |
|---------------|--------------------------|-----------|-------------|
|               | Radio Output Message     | EURORADIO |             |
| 115           | Communication Management | EURORADIO |             |
|               | Driver Information       | DMI       |             |
|               | Train Data               | TIU       |             |

Packets: to be completed

Radio Messages to be completed

## 2 Design Description

### 2.1 Component Design Template

#### 120 2.1.1 Component Requirements

|                        |   |
|------------------------|---|
| Component name         | [Component name]  |
| Version                | [GitHub hash tag]   |
| Link to SCADE model    | <a href="https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/Receive_TrackSide_Msg">https://github.com/openETCS/modeling/tree/master/model/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/Receive_TrackSide_Msg</a> |
| SCADE designer         | [Name, affiliation]   |
| Description            | [Brief description of the components functionality]   |
| Requirements realized  | [Reference to the requirement documents]  |
| Safety integrity level | 4   |
| Time constraints       |   |
| API requirements       | n/a   |

#### 2.1.2 Interface

##### 2.1.2.1 Inputs

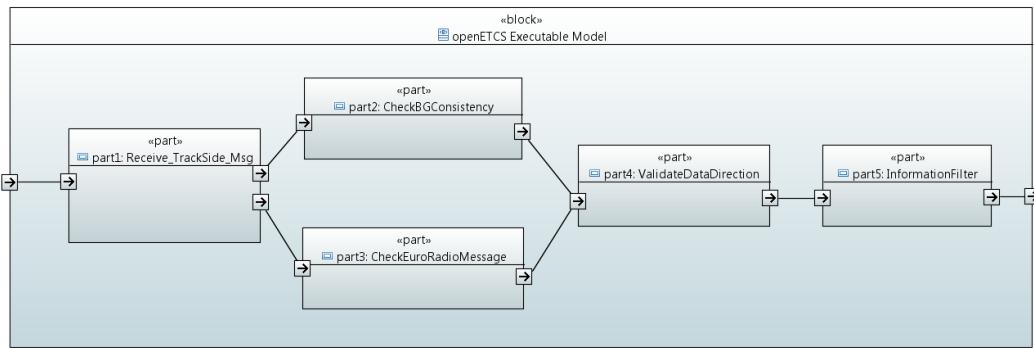
|   |                                  |
|---|----------------------------------|
| Input name                              | [Name of the input]              |
| Description                             | [Brief description of the input] |
| Source                                  | [Name of the source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

##### 2.1.2.2 Outputs

[Put SysML diagram of component here]

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Figure 2: Component SysML diagram



**Figure 3. Structure of the Manage\_TrackSideInformation\_Integration module with submodules.**

|                       |  |
|-----------------------|--|
| 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]        |

## 2.2 F1: Receive information from Trackside

### 2.3<sub>125</sub> F2: ETCS Kernel

#### 2.3.1 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.

- <sup>130</sup> 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.

##### 135 2.3.1.1 Inputs

For providing the output, the module needs different input data flows. An overview is provided in table 4

| 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::odometry_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                 | Q_NVLOCACC                               | Database                   |

**Table 4.** Overview over input**Input 0: fullChecks**

140 The boolean indicates, if all checks on the message should be performed. The possible values are given in table 5.

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

**Table 5.** Possible values for the input fullChecks**Input 1: API\_trackSide\_Message**

145 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.

**Input 2: ActualOdometry**

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

150 **Input 3: reset**

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

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

**Table 6.** Possible values for the input reset.

155 **Input 4: trainPosition**

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

#### **Input 5: modeAndLevel**

The input is generated by the “Mode and level management” module. It provides the current level and mode of the EVC.  
160

#### **Input 6: tNvContact**

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

#### **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`.  
165

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

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

#### **Input 8: connectionStatus**

The input `connectionStatus` will give information about the radio connection. This input is delivered by the session management module, not from the API. The information is needed to perform the timing check, which is depending on the connection state.  
175

| 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 7. Possible values for the input `connectionStatus`.

#### **Input 9: inSupervisingRbcId**

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.  
180

#### **Input 10: inAnnouncedBGs**

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.

185 **Input 11: q\_nvlocacc**

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

### 2.3.1.2 Outputs

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.

190

An overview over the output dataflows is provided in table 8.

| 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 8. Dataflow at output

#### Output 0: outputMessage

The element **outputMessage** consists of the type **ReceivedMessage\_T** combines both balise

195 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 9. Structure of ReceivedMessage\_T

The Eurobalise-common-header **BG\_Header\_T** consists of the fields visible in the SCADE-

declaration. The structure corresponds to the structure defined in the SRS chapter 8.4.2.1. Some

200 fields were removed since they are not needed anymore for further processing after building

messages from separate telegrams.

The Euroradio-common-header **Radio\_TrackTrain\_Header\_T** consists of the fields visible in

the SCADE declaration. The structure corresponds to the structure defined in the SRS chapter

8.4.4.6.1. The structure contains all variables required by possible **NID\_MESSAGE** values for the

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

#### 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.

#### **Output 2: BadBaliseMessageToDMI**

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

#### **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 10. Possible values for the input **errorLinkedBG**

#### **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 11. Possible values for the input **errorUnlinkedBG**

- 215 **Output 5: passedBG**

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

#### **Output 6: outPositionParams**

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

#### **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”.

#### **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 12. Possible values for the input **radioSequenceError**

#### **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 13. Possible values for the input **radioMessageConsistencyError**

### 2.3.1.3 Receive\_TrackSide\_Msg in Manage\_TrackSideInformation\_Integration

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

- 230 • [? , Chapt. 7 and 8]: Definition of the Balise Telegram
- [? , Chapt. 4.2.2, 4.2.4, 4.2.9]: Interface to the BTM
- [? , Chapt. 3.4.1 - 3.4.3, 3.16.2]: Handling of Balise Telegrams
- [? , Chapt. 3.16.2]: Check of the balise group
- [? , Chapt. 3.4.2]: Determining the orientation
- 235 • [? , Chapt. 4.5.2]: Active Functions Table
- [? , Chapt. 8.4.4]: Rules for Euroradio messages

#### Short description of the functionality

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.

#### Interface

#### Functional Design Description

##### Design Constraints and Choices

- 250 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.
- 255 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.
- 260 5. This function does not process information from the packets. The information is passed to the check without further processing of the values.

## Reference to the Scade Model

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/Receive\\_TrackSide\\_Msg](https://github.com/openETCS/modeling/tree/master/model1/Scade/System/ObuFunctions/ManageLocationRelatedInformation/BaliseGroup/Receive_TrackSide_Msg)

<sup>265</sup> **2.3.1.4 CheckBGConsistency in Manage\_TrackSideInformation\_Integration**

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

- [? , Chapt. 7 and 8]: Definition of the Balise Telegram
  - [? , Chapt. 3.4.1 - 3.4.3, 3.16.2]: Handling of Balise Telegrams
  - [? , Chapt. 3.16.2]: Check of the balise group
- <sup>270</sup> • [? , Chapt. 4.5.2]: Active Functions Table

### Short description of the functionality

This function has the task to verify 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.

- A message is still complete and correct, if a telegram is missing (or not decoded or incomplete decoded ), and this telegram is duplicated within the balise group and the duplicating one is correctly read.
- By more than one telegram, the order of the telegrams must be either ascending (nominal) or descending(reverse).
- A message is correct, if all message counters (M MCUNT) do not equal 254 (that means: The telegram never fits any message of the group). A message counter can be equal 255 (that means: The telegram fits with all telegrams of the same balise group) and all other values must be the same.

### Interface

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.

### Functional Design Description

The orientation of the BG will also be calculated in this block. The check, if the message has been received in due time and the right at the right expected location, will be performed in "Calculate Train Position". The checks on the validity of the data in the packets and the validity with respect to the direction of motion will be performed in other modules, e.g. "Validate Data Direction".

## Reference to the Scade Model

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>

### 2.3.1.5 CheckEuroradioMessage in Manage\_TrackSideInformation\_Integration

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

- [? , Chapt. 8.4.4]: Rules for Euroradio messages
- [? , Chapt. 3.16]: Data consistency

#### 300 Short description of the functionality

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.

#### Interface

- 305 The operator expects a radio message, information about the timestamp of the last relevant event, the national value for timeout (T\_NVCONTACT) and the status of the radio connection as input. The operator provides as output the radio message marked as valid or invalid in the message header and updated metadata in the message. Errors are indicated through boolean outputs.

#### Functional Design Description

- 310 The operator performs the following checks:

- Content checks
  - The whole message must be complete and contains all necessary fields. [? , 3.16.1.1]
  - The message must respect the ETCS language. [? , 3.16.1.1] The operator checks, if all necessary variables and packets for the corresponding message are part of the message and if no packets and variables are included in the message, which are not allowed.
- Timing checks
  - Check if the timestamp of a message is greater than the timestamp of the message received before. [? , 3.16.3.3.3]
  - If a message contains the timestamp “Unknown”, check if this message is part of the initiation of the communication session. [? , 3.16.3.3.4]
  - Perform the check with the current message  $n$ :  $T\_TRAIN_n \leq T\_TRAIN_{n-1} + T\_NVCONTACT$  [? , 3.16.1.1]. This ensures, that the message was received in due time.

For inconsistent messages, the following actions are performed by the operator:

- If a message is not consistent, it shall be rejected. [? , 3.16.3.1.1.1] For this purpose, the message is marked as invalid, so it can be rejected by the operators using the output of the CheckEuroradioMessage-operator.
- The RBC shall be informed, when a message was rejected. [? , 3.16.3.1.1.2] Therefore the necessary information for creating an error report is provided as boolean flags.
- This operator will not trigger the reaction for an interrupted radio connection to the RBC. The reaction specified by M\_NVCONTACT will be triggered by the RBC session management module.

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

The operator is not responsible for checking the integrity of the message in the bitstream format.

The bitwalker, which is converting the bitstream into the internally used datatypes, is performing the checks, which are only possible on the raw data. This includes a CRC check on the whole message and a value range check for each variable. If a consistency error is detected by the bitwalker, it is signalled to the model. If the bitwalker marks a packet as valid, all variables are expected to contain a valid value. The bitwalker is not part of the ETCS kernel.

- Safe connection supervision is not in the scope of this operator. This functionality will be implemented by the “Management of Radio communication” module.

## **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/CheckEuroRadioMessage>

### **2.3.1.6 ValidateDataDirection in Manage\_TrackSideInformation\_Integration**

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

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

#### **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.

#### **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.

#### **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.

## 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/ValidateDataDirection>

### 2.3.1.7 InformationFilter

#### Reference to the SRS and other requirements

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

#### Short description of the functionality

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 [? , 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.

#### 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 14.

| 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 14. Overview of the InformationFilter interface

#### 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

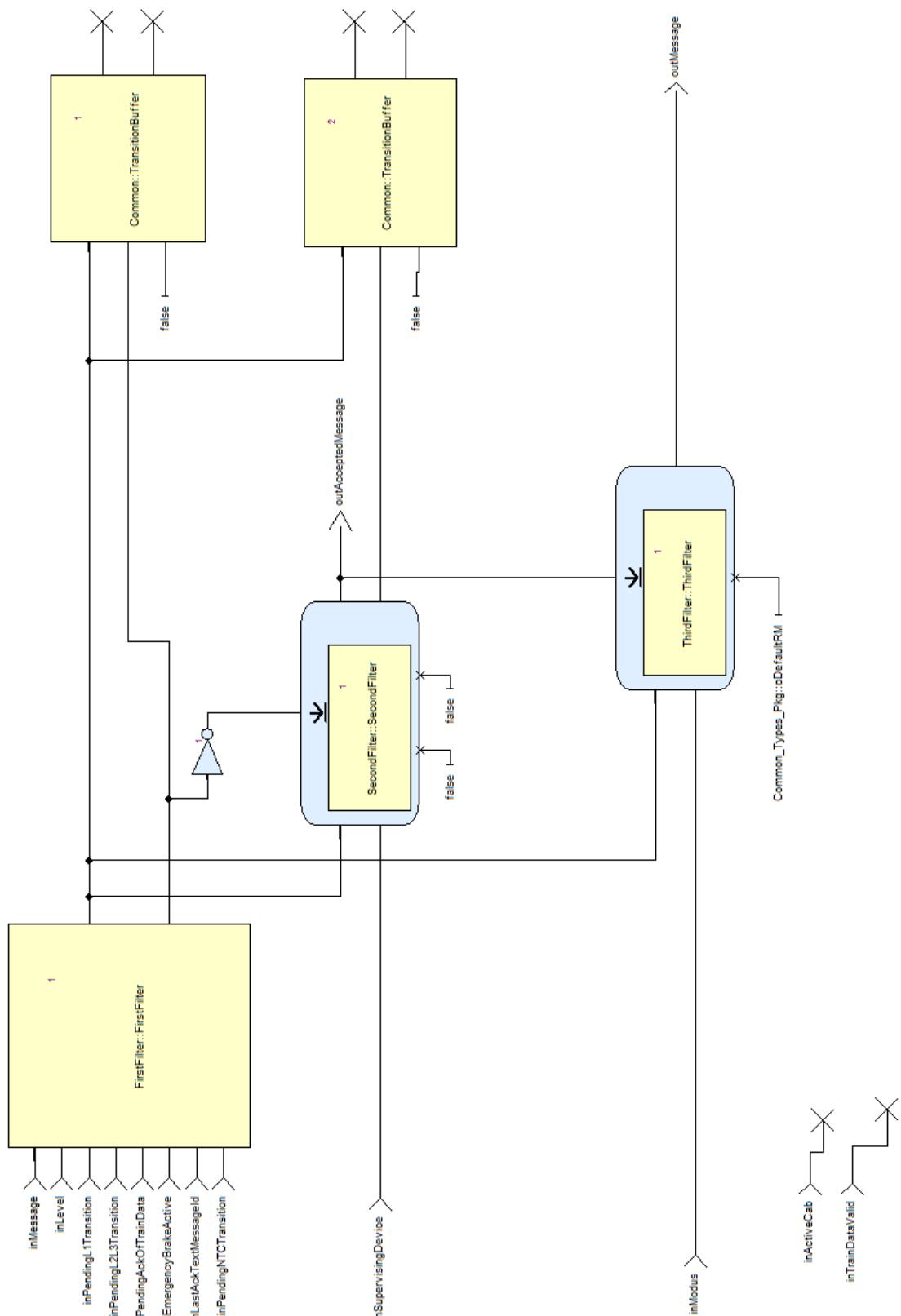


Figure 4. High level overview of the InformationFilter components.

385 by other ETCS subsystems. The figure 4 show the highlevel decomposition of the functionality. The filter functionality can be decomposed into a FirstFilter, SecondFilter, ThirdFilter and TransitionBuffer.

### **FirstFilter**

390 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.

395 **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.

400 **ThirdFilter**

The last filter is functionally very similiar to 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**

405 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 5 and 6.

### **Reference to the Scade Model**

410 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/InformationFilter>

### **2.3.2 Train Supervision**

415 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 [? , Chapt. 3.13].

420 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.

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

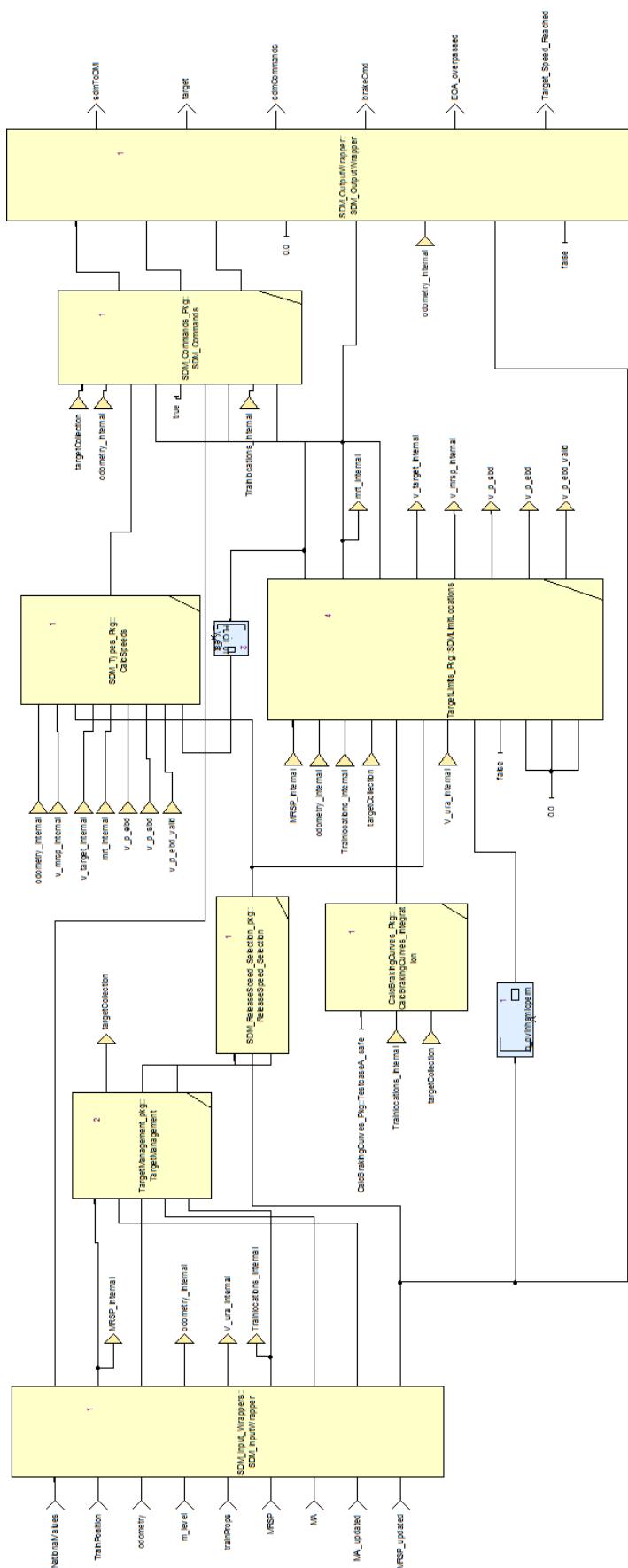
|                  |  |       |           |           |       |       |       |
|------------------|--|-------|-----------|-----------|-------|-------|-------|
| Message 40       | Train Rejected   | No    |           |           |       |       |       |
|                  |  | Yes   | R         | R         | R     | A     | A     |
| Message 41       | Train Accepted   | No    |           |           |       |       |       |
|                  |  | Yes   | R         | R         | R     | A     | A     |
| Message Radio 43 | SoM Position Report Confirmed by RBC                     | No    |           |           |       |       |       |
|                  |  | Yes   | R         | R         | R     | A     | A     |
| Packet 138       | Reversing Area Information                               | No    | R [1]     | R [1]     | A     | R [1] | R [1] |
|                  |  | Yes   | R [2]     | R [2]     | R [2] | A [3] | A [3] |
| Packet 139       | Reversing Supervision Information                        | No    | R [1]     | R [1]     | A     | R [1] | R [1] |
|                  |  | Yes   | R [2]     | R [2]     | R [2] | A [3] | A [3] |
| Packet 254       | Default Balise/Loop/RIU Information                      | No    | A         | A         | A     | A     | A     |
|                  |  | Yes   |           |           |       |       |       |
| Packet 90        | Track Ahead Free up to level 2/3 transition location     | No    | A [9]     | A [9]     | A [9] | R     | R     |
|                  |  | Yes   |           |           |       |       |       |
| Package 52       | Permitted Braking Distance Information                   | No    | R [1]     | R [1]     | A     | R [1] | R [1] |
|                  |  | Yes   | R [2]     | R [2]     | R [2] | A [3] | A [3] |
| Package 88       | Level Crossing information                               | No    | R [1] [2] | R [1] [2] | A     | A     | A     |
|                  |  | Yes   | R [2]     | R [2]     | R [2] | A [3] | A [3] |
| Package 6(0)     | Virtual Balise Cover order                               | No    | A         | A         | A     | A     | A     |
|                  |  | Yes   |           |           |       |       |       |
| Package 44       | Data to be used by applications outside ERTMS/ETCS       | No    | A         | A         | A     | A     | A     |
|                  |  | Yes   | A         | A         | A     | A     | A     |
|                  | 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 5. Lists of packages and their handling depending on train modes

|    |   |  |    |         |   |   |   |   |   |   |   |   |   |      |    |    |    |      |    |    |    |   |
|----|---|--|----|---------|---|---|---|---|---|---|---|---|---|------|----|----|----|------|----|----|----|---|
| 40 | <b>Packet 39, 68</b>  | Track conditions sound horn, non<br>stopping areas, turn left, stopping<br>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 | <b>Packet 67</b>  | Track condition long metal masses  | NR | A[2][4] | A | A | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | A  | A  | A  | R |
| 42 | <b>Header 68e</b>   | 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 | <b>Message Radio 6</b>  | Recognition of exit from TRIP mode   | NR | R       | R | R | R | R | R | R | R | R | R | R    | R  | R  | R  | R    | R  | R  | R  | R |
| 44 | <b>Message Radio 8</b>  | Acknowledgement of Train Data  | NR | A[2]    | R | R | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | A  | A  | A  | A |
| 45 | <b>Message 9</b>  | Coo-operative shortening of WA<br>+ (optional) Mode Profile                      | NR | R       | R | R | A | A | R | A | R | R | R | R    | R  | R  | R  | R    | R  | R  | R  | R |
| 46 | <b>Packet 80</b>  | + (optional) list of Balises for SH<br>area                                      |    |         |   |   |   |   |   |   |   |   |   |      |    |    |    |      |    |    |    |   |
| 47 | <b>Packet 49</b>  |  |    |         |   |   |   |   |   |   |   |   |   |      |    |    |    |      |    |    |    |   |
| 48 | <b>Message Radio 16</b>   | Unconditional Emergency Stop   | NR | A[2]    | R | R | A | A | A | A | A | A | A | A    | A  | R  | R  | R    | R  | R  | R  | R |
| 49 | <b>Message Radio 15</b>   | Conditional Emergency Stop   | NR | R       | R | R | A | A | R | A | R | R | R | R    | R  | A  | R  | R    | R  | R  | A  | R |
| 50 | <b>Message Radio 18</b>   | Reversion of Emergency Stop<br>(Conditional or Unconditional)                    | NR | R       | R | R | A | A | R | A | R | R | R | R    | R  | R  | R  | R    | R  | R  | R  | R |
| 51 |   |  |    |         |   |   |   |   |   |   |   |   |   |      |    |    |    |      |    |    |    |   |
| 52 | <b>Message Radio 27</b>   | Shuttle/Refresher  | NR | A[2]    | R | R | A | A | A | A | A | A | A | R    | R  | R  | R  | R    | R  | R  | R  | R |
| 53 | <b>Message Radio 28, 1 (optional)</b><br><b>Packet 49</b>       | Shuttle/Refresher (optional)<br>List of Balises in SH area                       | NR | A[2]    | R | R | A | A | A | A | A | A | A | R    | R  | R  | R  | A[1] | NR | NR | NR | R |
| 54 | <b>77</b>   | TrainSafe condition System   | NR | A       | A | A | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | A  | A  | A  | A |
| 55 | <b>Packet 2</b>   | System Version order   | NR | A       | A | A | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | A  | A  | A  | A |
| 56 | <b>Message Radio 34</b>   | Track-Ahead Free Request   | NR | A[2]    | R | R | A | A | A | A | A | A | A | R    | R  | R  | R  | A[1] | NR | NR | NR | R |
| 57 | <b>Packet 140 Track to Train,<br/>Packet 140 Train to Track</b> | Train Running Number   | NR | A[2]    | R | R | A | A | A | A | A | A | A | R    | A  | R  | A  | A    | A  | NR | NR | A |
| 58 | <b>Message Radio 38</b>   | Initiation of session  | NR | A       | R | R | A | A | A | A | A | A | A | R    | A  | A  | A  | A    | A  | NR | NR | A |
| 59 | <b>Message 39</b>   | Acknowledgement of session<br>termination  | NR | A       | A | A | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | A  | A  | A  | A |
| 60 | <b>Message 40</b>   | Train Rejected   | NR | A[2]    | R | R | R | R | R | R | R | R | R | R    | R  | R  | R  | R    | R  | R  | R  | R |
| 61 | <b>Message 41</b>   | Train Accepted   | NR | A[2]    | R | R | R | R | R | R | R | R | R | R    | R  | R  | R  | R    | R  | R  | R  | R |
| 62 | <b>Message Radio 43</b>   | Solo Position Report Confirmed by<br>REC   | NR | A[2]    | R | R | R | R | R | R | R | R | R | R    | R  | R  | R  | R    | R  | R  | R  | R |
| 63 | <b>Packet 138</b>   | Reversing Area information   | NR | A[2][4] | R | R | A | A | A | A | A | A | A | R    | R  | A  | R  | A[1] | NR | NR | A  | A |
| 64 | <b>Packet 139</b>   | Reversing Supervision Information  | NR | A[2][4] | R | R | A | A | A | A | A | A | A | R    | R  | A  | R  | A[1] | NR | NR | A  | A |
| 65 | <b>Packet 254</b>   | Default BasedOnRPLU Information  | NR | A[2]    | A | A | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | A  | NR | NR | A |
| 66 | <b>Packet 90</b>  | Track-Ahead Free up to level 2/3<br>transition location                          | NR | A[2]    | R | R | A | A | A | A | A | A | A | R    | R  | A  | A  | A    | A  | NR | NR | R |
| 67 | <b>Packet 52</b>  | Permit/Disallow instance   | NR | A[2][4] | R | R | A | A | A | A | A | A | A | R    | R  | A  | R  | A[1] | NR | NR | A  | R |
| 68 | <b>Packet 88</b>  | Level Crossing Information   | NR | A[2][4] | R | R | A | A | A | A | A | A | A | R    | R  | A  | R  | A[1] | NR | NR | A  | R |
| 69 | <b>Packet 60</b>  | Virtual Balise Cover order   | NR | A       | A | A | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | NR | NR | A  | A |
| 70 | <b>Packet 44</b>  | Data to be used by applications<br>outside ETHERNETS                             | NR | A       | A | A | A | A | A | A | A | A | A | A    | A  | A  | A  | A    | NR | NR | A  | 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       | NR | 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       | 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 TSRs 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  | A  | A  | A  | R  | 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  | A  | R  | R  | R  | R  | R    | NR      | NR | R  | R  |   |
| 35 | Package 42                     | Session Management with neighbouring RCU                           | NR    | R       | R    | R    | A  | A    | A  | A  | R  | R  | R  | R  | R    | NR      | NR | R  | R  |   |
| 36 | Package 134                    | ECU/M Information  | NR    | R       | R    | A    | A  | A    | A  | A  | R  | R  | 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 6. Lists of packages and their handling depending on train modes



**Figure 7. Structure of component ProvidePositionReport**

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 7, 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*.

#### 430 **2.3.2.1 Input**

For providing the output, the module needs different input data flows. Table 15 gives an overview.

| <b>Index</b> | <b>Input name</b> | <b>Input type</b>   | <b>Source</b>     |
|--------------|-------------------|---------------------|-------------------|
| 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 15. Overview of inputs

#### **Input 0: NationalValues**

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

#### **Input 1: TrainPosition**

435 This input is the current train position.

#### **Input 2: odometry**

This input is the odometry data.

#### **Input 3: m\_level**

This input is the current level of the train.

440 **Input 4: trainProps**

This input is a set of train related properties.

**Input 5: MRSP**

This input is the most restrictive speed profile.

**Input 6: MA**

<sup>445</sup> This input is a movement authority.

**Input 7: MA\_updated**

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

**Input 8: MRSP\_updated**

<sup>450</sup> This flag is true if the most restrictive speed profile has been updated in this clock cycle and false otherwise.

**2.3.2.2 Output**

Based on the input the block produces the following output. Table 16 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     | E0A_overpassed       | bool                     |
| 5     | Target_Speed_Reached | bool                     |

Table 16. Overview of outputs

**Output 0: sdmToDMI**

<sup>455</sup> This output contains information about different speeds and positions, on the one hand and the current supervision status, on the other hand. This information shall be displayed to the driver.

**Output 1: target**

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

**Output 2: sdmCommands**

<sup>460</sup> This output gives some intermediate results of operator SDM\_Commands. It is currently used for test purposes only.

**Output 3: brakeCmd**

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

#### **Output 4: EOA\_overpassed**

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

#### **Output 5: Target\_Speed\_Reached**

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

### **2.3.2.3 SDM\_InputWrapper in Train Supervision**

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

470 • [? , Chapt. 3.13]: Speed and distance monitoring

#### **Short description of the functionality**

The motivation for this operator is to convert all inputs of block “Speed Supervision” that contain information about length, speed, distance, and acceleration defined as integer into **real** to allow automatically the highest precision in the calculations by the meaning of floating point operations. 475 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.

#### **Interface**

#### **Functional Design Description**

This operator forwards input messages, takes data from complex data types or transforms inputs 480 messages into an internal type thereby converting int to real.

#### **Reference to the Scade Model**

### **2.3.2.4 TargetManagement in Train Supervision**

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

• [? , Chapt. 3.13.8.2]: Determination of the supervised targets

485 **Short description of the functionality**

This operator calculates/updates the list of targets to be supervised by the block “Train Supervision”. Taking the current movement authority, 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.

490 **Interface**

#### **Functional Design Description**

**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*

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

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.

**Derivation of Targets from MRSP** According to [? , Chapt. 3.13.8.2], every speed decrease

500 of the *MRSP* is used to derive a target. 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.

**Update of Targets** In every cycle the operator monitors whether all targets are already passed.

To this end, it iterates over the list of targets comparing the current max safe front end position

505 with the target position.

### Reference to the Scade Model

#### 2.3.2.5 CalcBrakingCurves\_Integration in Train Supervision

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

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

510 • [? , Chapt. 3.13.8.4]: Service Brake Deceleration curves (SBD)

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

#### Short description of the functionality

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

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

515 train has to start braking given the current speed. The braking curve does not depend on the

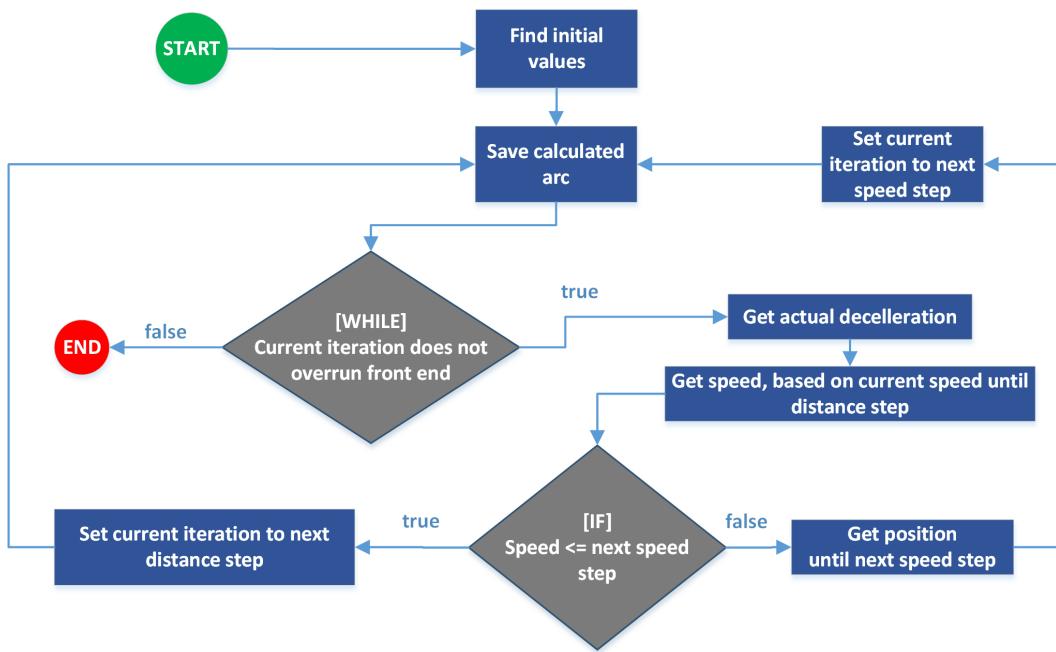
actual train status. As a consequence the braking curve stays constant over time. As a legitimate

simplification the calculation of the braking curve is not extended after the estimated front end position of the train has been passed.

#### Interface

#### 520 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



**Figure 8. Calculation of Braking Curves**

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 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

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

An abstract overview of the calculation could be seen in Fig. 8.

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

#### 540 Reference to the Scade Model

### 2.3.2.6 SDMLimitLocations in Train Supervision

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

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

#### 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.

550 **Interface**

#### 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.
- 555 4. **curveCollection** The related braking curves correlated to above targets.
5.  $v_{release}$  Release speed as defined by external sources.
6.  $v_{mathit{ura}}$  Speed under reading amount.
7. **inhibitUnderReadingCompensation** A flag defined by National Value, relating to above item.
- 560 8.  $T_{bs}$ ,  $T_{be}$ ,  $T_{tractionCutOff}$  Time constants defined externally or in other modules.

#### 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.
- 565 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.
- 570 5.  $v_{mathit{MRSP}}$  The current Most Restrictive Speed at the Max Safe Frontend of the train.

## 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.

### 2.3.2.7 CalcSpeeds in Train Supervision

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

- [? , Chapt. 3.13.9]: Supervision Limits

**585 Short description of the functionality**

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

#### Interface

#### Functional Design Description

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

**only in special case or link to the Scade model**

### 2.3.2.8 ReleaseSpeed\_Selection in Train Supervision

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

- [? , Chapt. 3.8]: Movement authority

**595 Short description of the functionality**

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

#### Interface

#### Functional Design Description

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

## Reference to the Scade Model

### 2.3.2.9 SDM\_Commands in Train Supervision

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

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

#### <sup>605</sup> Short description of the functionality

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

#### Interface

#### <sup>610</sup> 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.

## Reference to the Scade Model

### 2.3.2.10 SDM\_OutputWrapper in Train Supervision

#### <sup>620</sup> Reference to the SRS or other Requirements (or other requirements)

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

#### Short description of the functionality

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

#### Interface

#### Functional Design Description

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

## Reference to the Scade Model

### 2.3.3 Manage ETCS Procedures

#### 2.3.3.1 Start of Mission - Awakness of Train

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

635 Chapter 5, § 5.4

##### 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.

640 **Interface**

##### Input Flow

- Information from TIU
- Action from Driver (DMI)
- Information from Position Calculation
- 645 • 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

##### Output Flow

- 650
- 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)

655 **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.

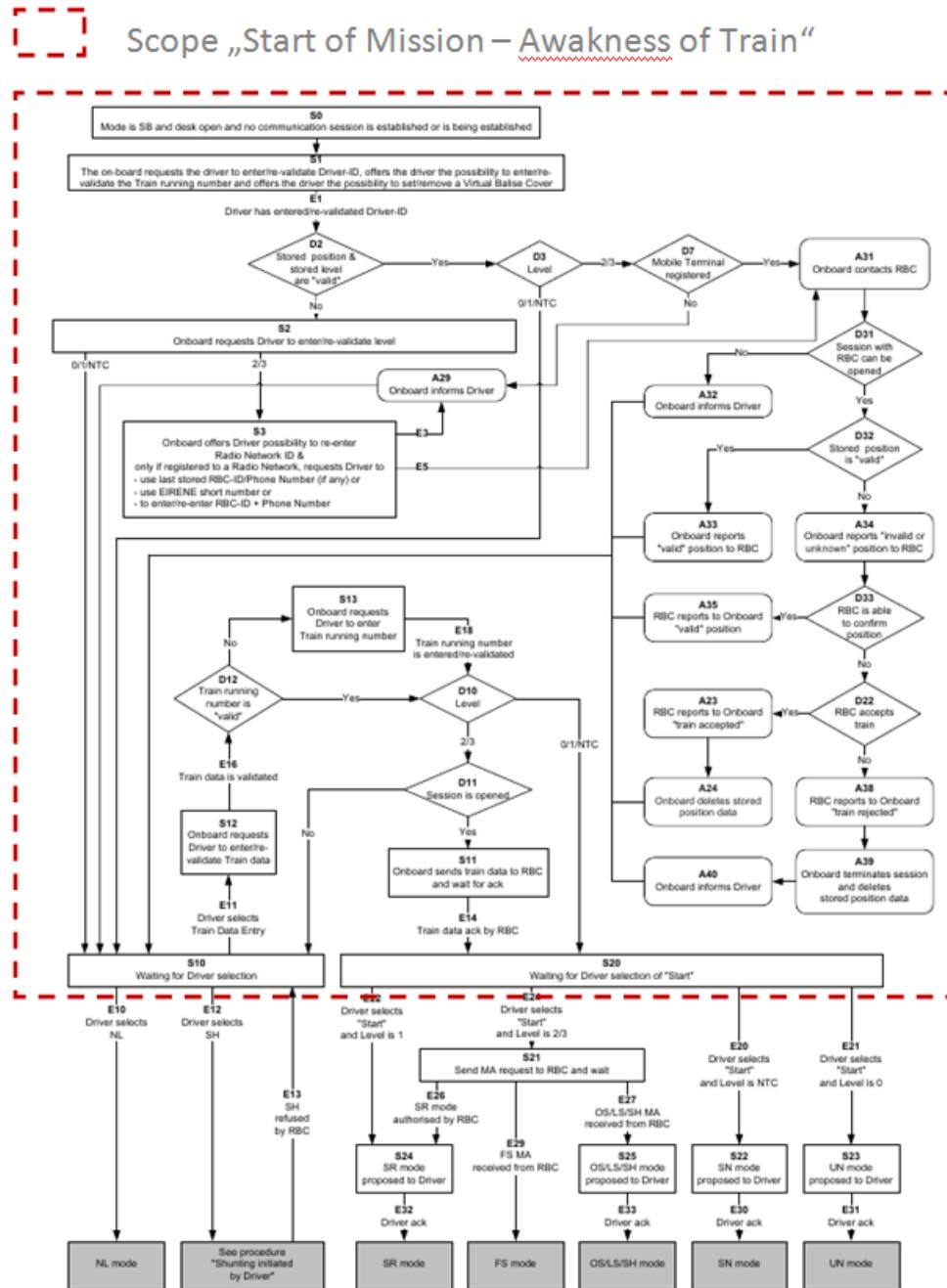


Figure 9. Start of Mission - Awkness of Train

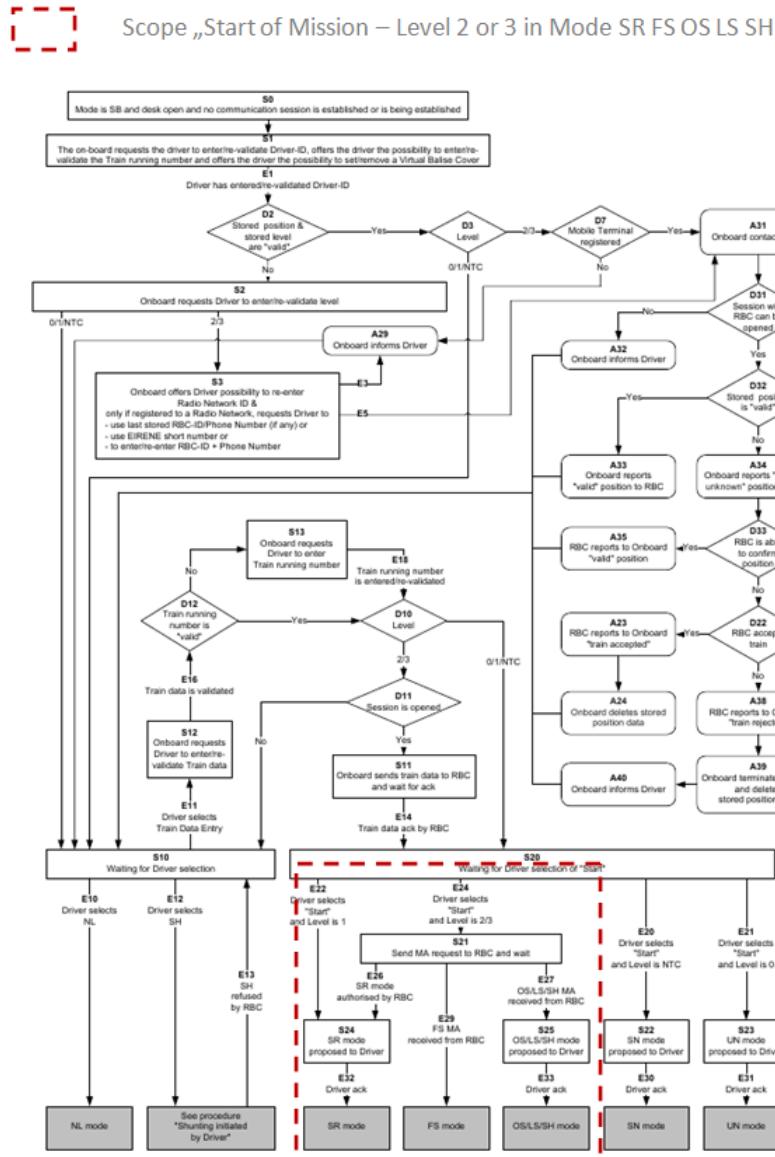


Figure 10. Start of Mission - Start of Mission in Level 2 or 3 and Mode SR FS OS LS SH

## Reference to the Scade Model

[https://github.com/openETCS/modeling/blob/master/model/Scade/System/ObuFunctions/Procedures/ManageProcedure\\_Pkg.xscade](https://github.com/openETCS/modeling/blob/master/model/Scade/System/ObuFunctions/Procedures/ManageProcedure_Pkg.xscade)

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

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

Chapter 5, § 5.4

#### 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.

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

## Interface

### Input Flow

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

### Output Flow

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

## 680 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.

## 685 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](https://github.com/openETCS/modeling/blob/master/model/Scade/System/ObuFunctions/Procedures/SoM_SR_FS_OS_LS_SH_SN_UN.xscade)

### 2.3.4 Manage Track Data

#### 2.3.4.1 F.2.2 Calculate Train Position

## 690 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

- 695 • 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,  
700 based on odometry and linking information
- permanently calculating the current train position based on odometry and passed balise group  
information
- providing the last recently passed linked balise group as the LRBG
- providing additional position attribute information
- 705 ● 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](https://github.com/openETCS/SRS-Analysis/blob/master/System%20Analysis/WorkingRepository/Group4/SUBSET_26_3-6/DetermineTrainLocationProcedures.pdf).

### 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.

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

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

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

The following stages "`calculateTrainPositionInfo`" and "`calculateTrainpositionAttributes`" all the time calculate the current train position by using the list of known balise groups (including the  
725 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:

730 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

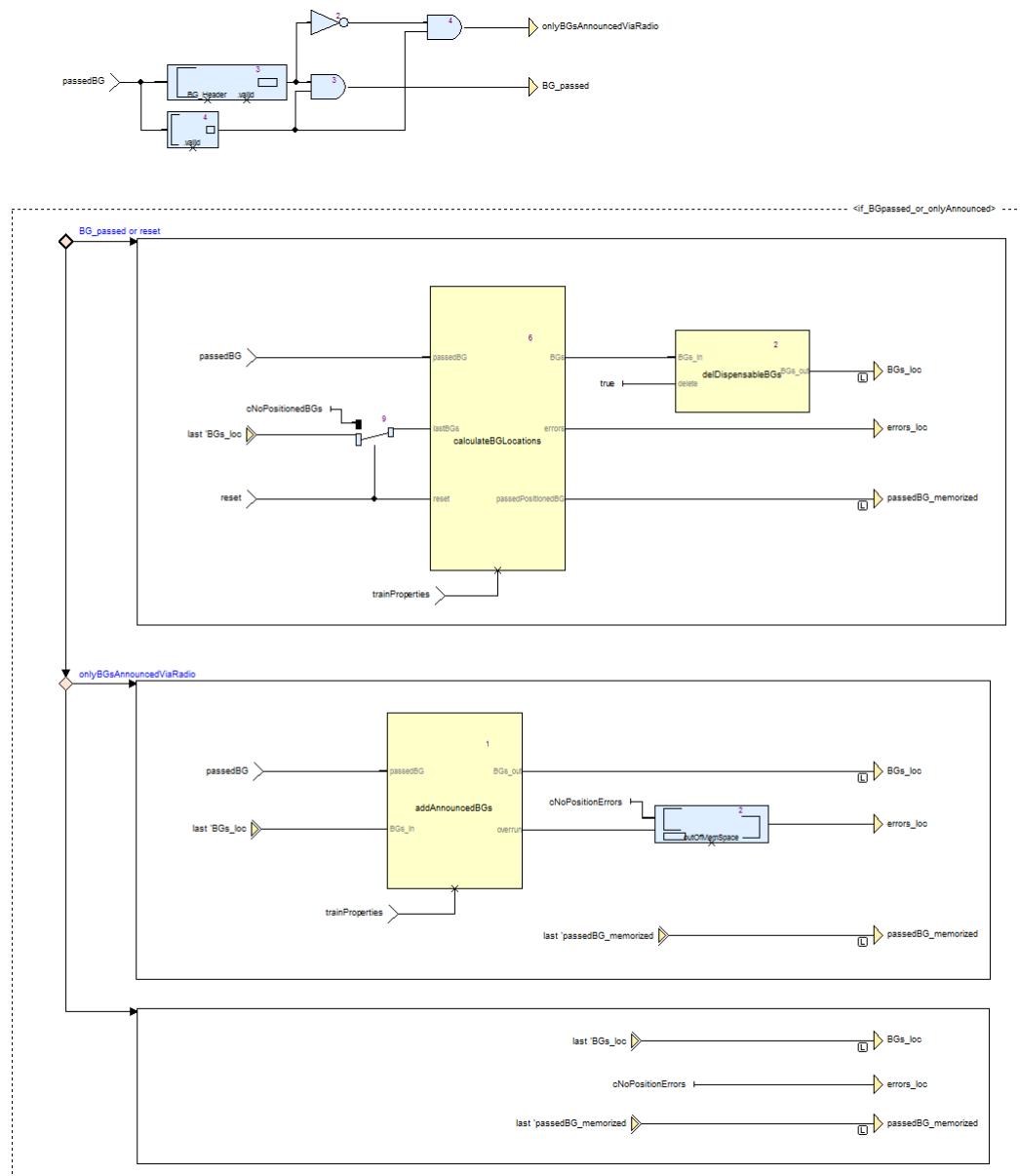
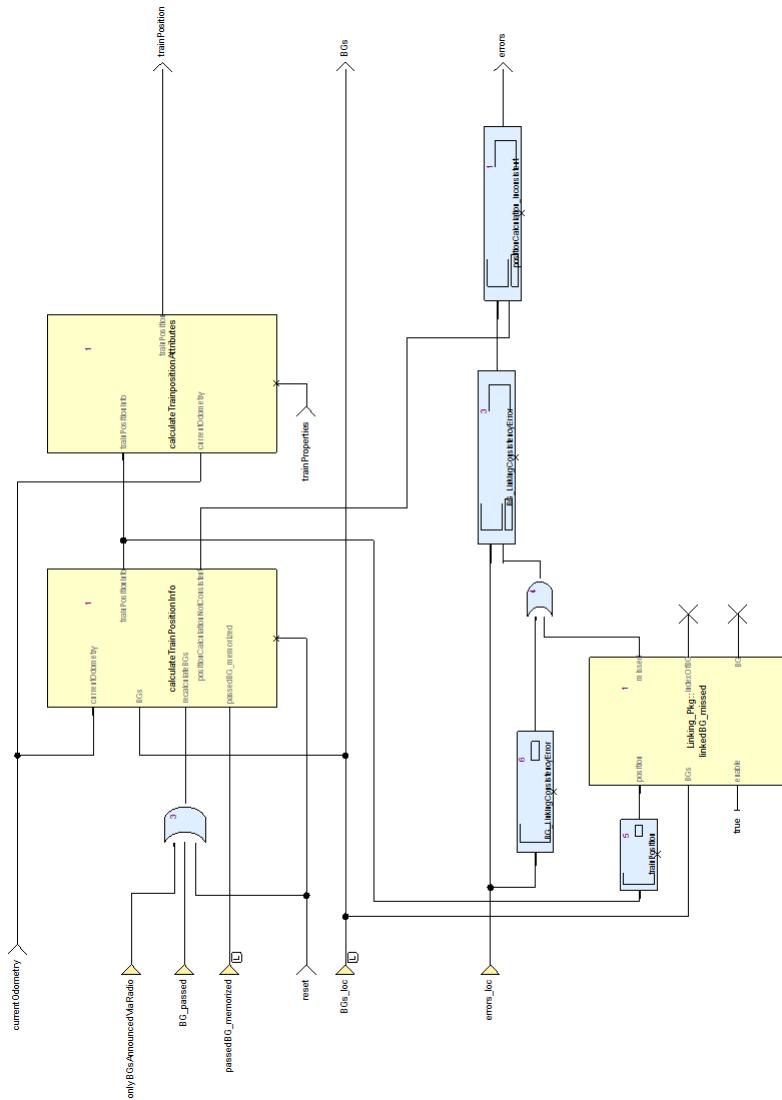


Figure 11. Calculating the balise group locations.



**Figure 12.** Calculating the current train position and attributes.

735 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.

740 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.

745 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. *delDispensableBGs*: Delete dispensable balise groups

The function removes balise groups supposed not to be needed any longer from the list of *BGs*. If the number of stored passed linked BGs exceeds the maximum number as specified in [? , 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. The locations of the announced *BGs* are calculated with reference to the LRBG reported by the RBC.

## 4. *calculateTrainPositionInfo*: Calculate train position information.

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

## 5. *calculateTrainpositionAttributes*: Calculate train position attribute information.

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

## 6. *linkedBG\_missed*:

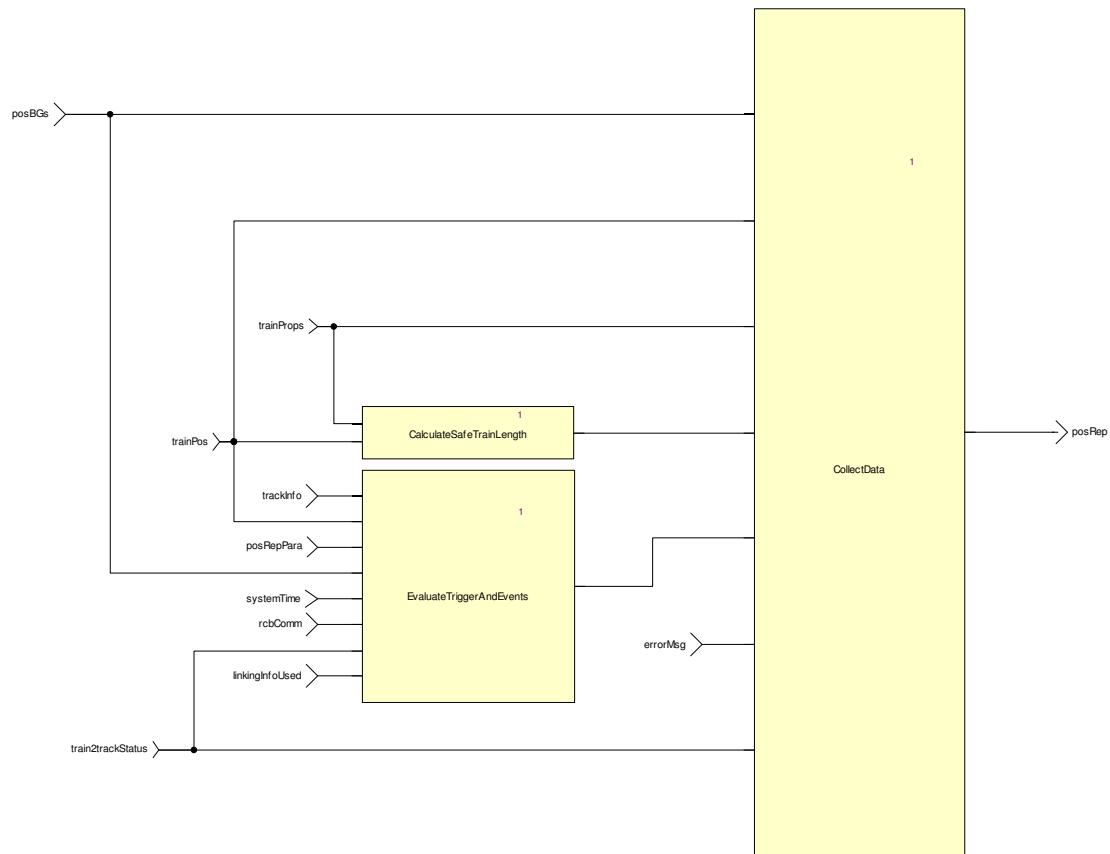
This function observes the list of *BGs* and the current train position. If an announced balise group is not found within its expectation window, an error flag will be raised.

## Reference to the SRS (or other requirements)

770 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 [? , Chapter 3.6].

## Design Constraints and Choices

The following constraints and prerequisites apply:



**Figure 13. Structure of component ProvidePositionReport**

1. The input data received from the balises groups or via radio must have been checked and filtered for validity, consistency and the appropriate train orientation before delivering them to calculateTrainPosition.
2. The storage capacity for balise groups is finite. calculateTrainPosition will raise an error flag when a balise group cannot be stored due to capacity limitations.
3. calculateTrainPosition will raise an error flag if a just passed balise group is not found where announced by linking information or if an announced balise group is missed when the end of its expectation window is reached. It does not yet implement all conditions of linking consistency.
4. calculateTrainPosition is not yet prepared for train movement direction changes.
5. calculateTrainPosition does not yet consider repositioning information.

#### 785 2.3.4.2 Provide Position Report

##### Short Description of Functionality

This function takes the current train position and generates a position report which is sent to the RBC. The point in time when such a report is sent is determined by events, on the one hand, 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 13, which are explained below.

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

795         $\text{safeTrainLength} = \text{absolute}(\text{EstimatedFrontEndPosition} - \text{MinSafeRearEnd})$ ,  
             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 [? , Chapter 3.6.5.1.4]).

800        **ErrorManager** Takes a boolean flag for each possible error that has been occurred and outputs the respective error using type M\_ERROR

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

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

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

805        **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.

810        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.

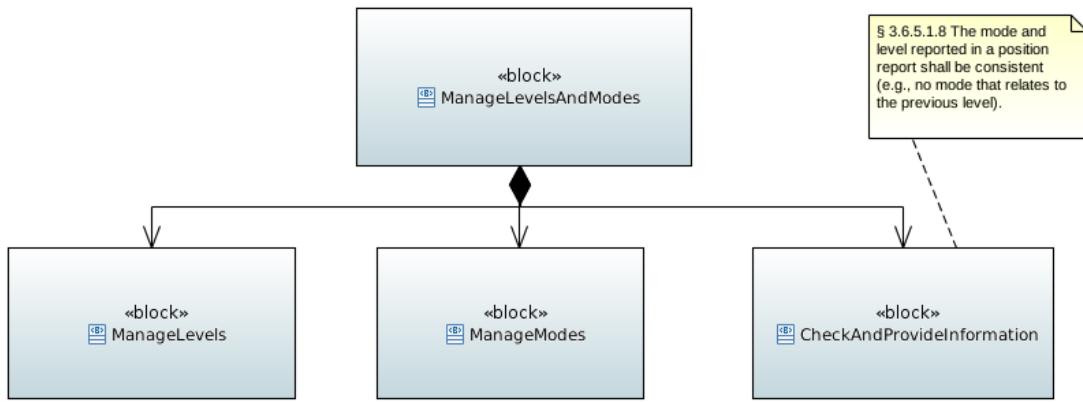
815        5. *Packet 44*: This packet is currently not contained in a position report as it is not part of the kernel functions.

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.

820        7. The *ErrorHandler* is currently restricted to deal with a single error. As a consequence, as for each error reported a report has to be sent to the RBC, the number of reports is limited to one.

### Open Issues

825        1. The specification requires to store the last eight balise groups for which a position report has been sent (see [? , Chapter 3.6.2.2.c]).

**Figure 14. High level Architecture**

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 [?, Chapter 3.4.2.3.3.6].  
 830 Moreover, such a coordination system can be invalid and then has to be rejected (see [?, 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.

### 2.3.5 Mode and Level

The "Management of Modes and Levels" function is mainly described in chapter 4 and 5 of [? ].

835 Modes and levels define the status of the ETCS regarding on-board functional status and track infrastructure.

#### 2.3.5.1 Function Level Management

##### Reference to the SRS or other Requirements

See [?] section 5.10

840 **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.  
 845

##### Interface

The interface consists of the following inputs:

- *conditional transitions*: a priority table containing the conditional level transition orders (from paquet 46)
- *level transition priority table*: a priority table containing the (non-conditional) level transition orders (from paquet 41)

- *train standstill*: a Boolean value indicating whether the train is at standstill (from odometry)
  - *driver level transition*: a level transition order selected by the driver (from DMI)
  - *ERTMS capabilities*: the ERTMS capabilities of the track
- 855 ● *getAck*: Boolean input that signals the acknowledgment of the driver (from DMI)
- *resetIdle*: Boolean input to reset without acknowledge
  - *currentDistance*: the current position of the train given with the same reference as the position of the level transition order (train position , from localisation)
  - *ackDistance*: the maximal distance for driver acknowledge after the level transition (from paquet 41)
- 860 ● *immediateAck*: a Boolean that signals that an immediate acknowledge is required
- *received L2 L3 MA*: a Boolean that indicates that a level 2 or level 3 movement authority for the track behind the level transition has been received (from paquet 15)
  - *received L1 MA*: a Boolean that indicates that a level 1 movement authority for the track behind the level transition has been received (from paquet 12)
  - *received target speed*: a Boolean indicating that a target speed for the track behind the level transition has been received (from paquet 27) ?

and the following outputs:

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

## Functional Design Description

- 875 On the most abstract level the design consists of the *manage\_priorities* function which takes the level transition order priority tables as inputs and computes the highest priority transition.

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

## Reference to the Scade Model

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

### 2.3.5.2 Function Mode Management

#### Reference to the SRS or other Requirements

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

#### Short description of the functionality

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

#### Interface

The inputs are the following:

- *Cab* identification of the current cabin (A or B)
  - 895 • *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
    - 900 – *Ack\_OS* : *bool*
    - *Ack\_RV* : *bool*
    - *Ack\_SH* : *bool*
    - *Ack\_SN* : *bool*
    - *Ack\_SR* : *bool*
    - 905 – *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
    - 910 – *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:
    - 915 – *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)
- 920 *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
- 925 - *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)
  - 930 - *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)
- 940 • *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
  - 945 - *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
  - 955 - *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
- 960 • *Failure\_Occured*: boolean to indicate safety failure occurrence
- *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
- 965 ● *OnBoard\_Powered*: boolean to indicate the power state of the system
- *Stop\_Shunting\_Stored*: boolean to store the information in regards of shunting function
- *Valid\_Train\_Data\_Stored*: boolean to indicate train data are available and valid.

The outputs are the following:

- *currentMode* the new computed mode (type is Level\_And\_Mode\_Types\_Pkg::T\_Mode, default value is Level\_And\_Mode\_Types\_Pkg::SB )
- 970 ● *EB\_Requested* boolean to request triggering of emergency brake
- *Service\_Brake\_Command* boolean to request command of service brake
- *Data\_To\_DMI*: set of data provided to the DMI Level\_And\_Mode\_Types\_Pkg::T\_Data\_To\_DMI :

  - 975 – *Ack\_LS* : *bool* Driver acknowledges LS mode
  - *Ack\_OS* : *bool*
  - *Ack\_RV* : *bool*
  - *Ack\_SH* : *bool*
  - *Ack\_SN* : *bool*
  - 980 – *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
  - 985 – *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 data to trackside Level\_And\_Mode\_Types\_Pkg::T\_Data\_To\_BG\_Management :

  - 990 – *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
  - 995 – *MA\_Req* : *bool* for message 132
  - *Req\_for\_SH\_from\_driver* : *bool* for message 130

## Functional Design Description

Three subfunctions are defined:

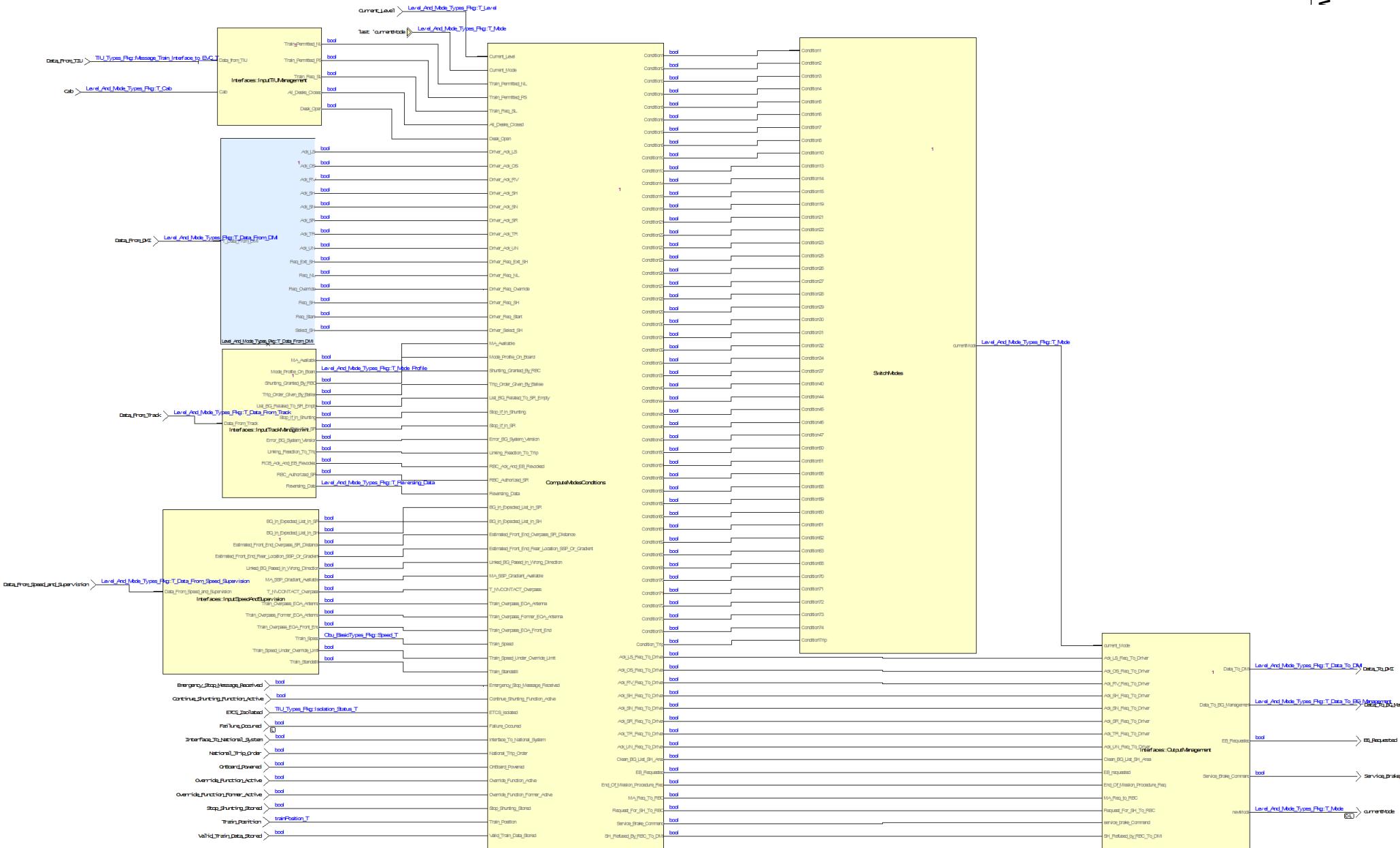
**Inputs** proceeds to inputs check and preparation.

1000 **ComputeModesCondition** performs all specific procedure linked to mode management and defined in [? ] 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 [? ]

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

1005 **Outputs** prepares paquet of outputs.

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**Figure 15. Modes subfunction architecture.**

## Reference to the Scade Model

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

### 2.3.5.3 Function Check and Provide Level and Mode

#### <sup>1010</sup> Reference to the SRS or other Requirements

see [? ] section 3.6.5

#### Short description of the functionality

checks compatibility between mode and level and provides outputs

#### Interface

#### <sup>1015</sup> To design

#### Functional Design Description

To design

#### Reference to the Scade Model

To design

### <sup>1020</sup> 2.3.6 Manage Radio Communication

#### 2.3.6.1 Management of Radio Communication (*MoRC*)

#### Reference to the SRS

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

#### Short description of the functionality

<sup>1025</sup> 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.

#### <sup>1030</sup> Interface

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

- Datagrams received from track (*inMessage*):

- Packet 42 (session management) received from balise group or RBC
  - 1035 – 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)
- 1040 • *obuEventsAndPhases*: information about OBU internal events and OBU internal phases:
- *atPowerDown*
  - *atPowerUp*
  - *atStartOfMission*
  - *startOfMissionProcedureIsGoingOn*
  - 1045 – *startOfMissionProcedureCompleted*
  - *trainIsRejectedByRBC\_duringStartOfMission*
  - *endOfMissionIsExecuted*
  - *driverClosesTheDeskduringStartOfMission*
  - *driverHasManuallyChangedLevel*
  - 1050 – *afterDriverEntryOfANewRadioNetworkID*
  - *triggerDecisionThatNoRadioNetworkIDAvailable*
  - *isPartOfAnOngoingStartOfMissionProcedure*
  - *trainPassesALevelTransitionBorder*
  - *trainPassesA\_RBC\_RBC\_border\_WithItsFrontEnd*
  - 1055 – *trainExitedFromAnRBCArea*
  - *modeChangeHasToBeReportedToRBC*
  - *trainFrontInsideInAnAnnouncedRadioHole*
  - *trainFrontReachesEndOfAnnouncedRadioHole*
  - *OBUs\_hasToEstablishANewSession*
  - 1060 – *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
  - 1065 – *mode*: current OBU mode
  - *level*: current OBU level
- *statusOfMobile*: status of the associated mobile device
- configuration parameters:
- *onboardPhoneNumbers* (NID\_RADIO)
  - 1070 – *radioNetworkIDs*: Identities of radio networks (NID\_MN): default, memorized or from driver
  - *nid\_engine*: Onboard ETCS identity (NID\_ENGINE)
  - *connectionStatusTimerInterval*: Connection status timer period

**Outputs** MoRC generates a couple of outputs:

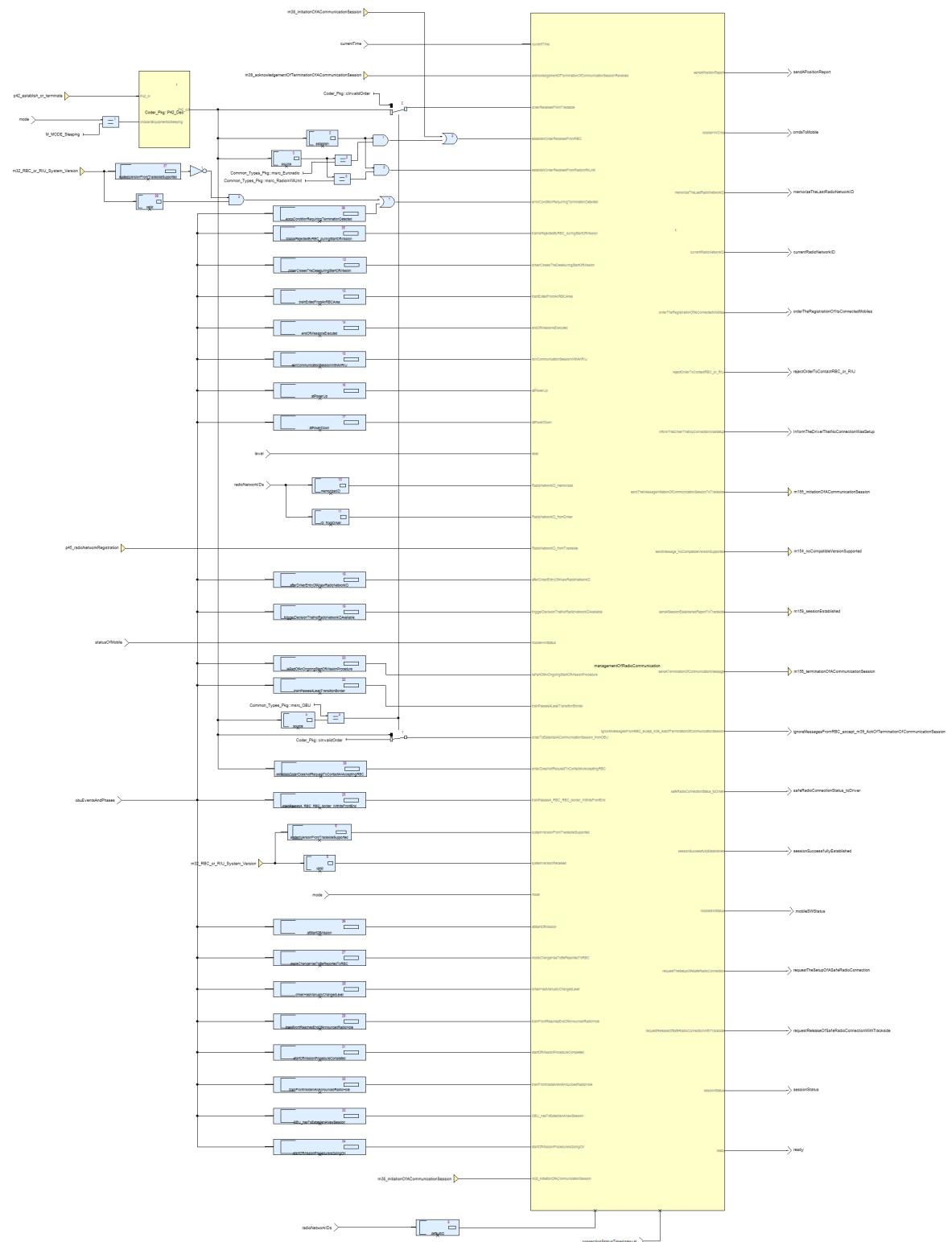
- 1075 • *MessageToRBC*: messages to be sent to the RBC:
  - Message 155 (initiation of a communication session)
  - Message 156 (termination of a communication session)
  - Message 159 (session established)
  - Message 154 (no compatible version supported)
- 1080 • Action triggers:
  - *sendAPositionReport*: 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
  - 1085 – *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

## Functional Design Description

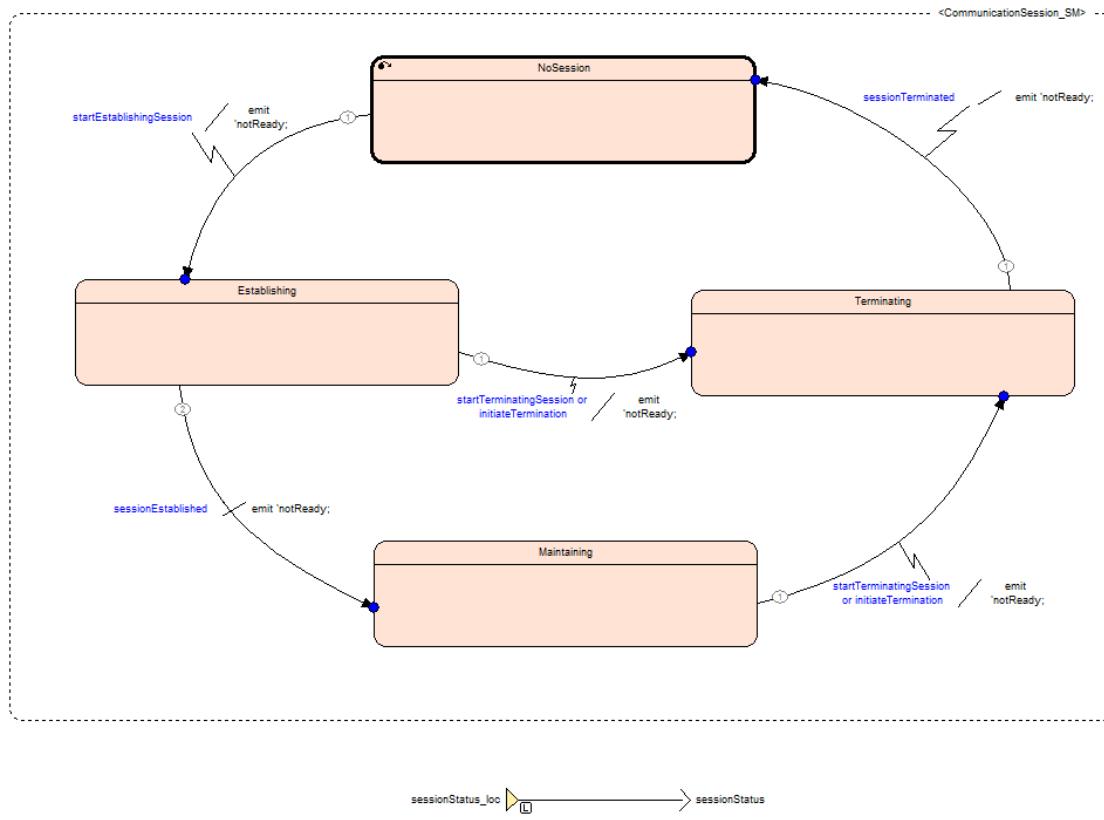
The kernel function of the *MoRC* component is *managementOfRadioCommunication* (figure ???). The implementation is kept close to the prose of Subset-026, chap. 3.5. Since chap. 3.5 rarely refers to terms, variable types, packets and messages of the ETCS language as specified in Subset-026, chap. 7 and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

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

1105 The function *managementOfRadioCommunication* implements the session states establishing, maintaining and termination as described in Subset-026, chap. 3.5. A SCADE state machine reflects this state model (figure ???) accurately. Within each of the states, the activities needed as long as the state is active, are performed. When there is no communication session (state *NoSession*) currently, the state machine waits for events that initiate a session (subfunction



**Figure 16.** Main function of *MoRC*.



**Figure 17. Implementation of session states.**

1110 *initiate\_a\_Session*). When the appropriate conditions are fulfilled, the state machine moves to the *Establishing* state. Here in, it runs through the sequence required fore establishing a session (subfunction *establish\_a\_Session*. Dependent on the results, the state machine changes over to the *Maintaining* or *Terminating* state. While in *Maintaining*, the communication connection is monitored. When an event triggering the session termination occurs, the state machine switches to the state *Terminating* with the subfunction *terminating\_a\_CommunicationSession* and performs the session termination sequence.  
1115

In parallel to the main state machine, *managementOfRadioCommunication* monitors all the time whether the session has to be terminated (subfunction *initiateTerminatingASession*) or if the session has the be terminated and subsequently established (subfunction *terminateAndEstablishSession*). *registeringToTheRadioNetwork* is responsible for connection to the radio network. *safeRadioConnectionIndication* controls the radio connection indication for the driver.  
1120

## Reference to the Scade Model

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

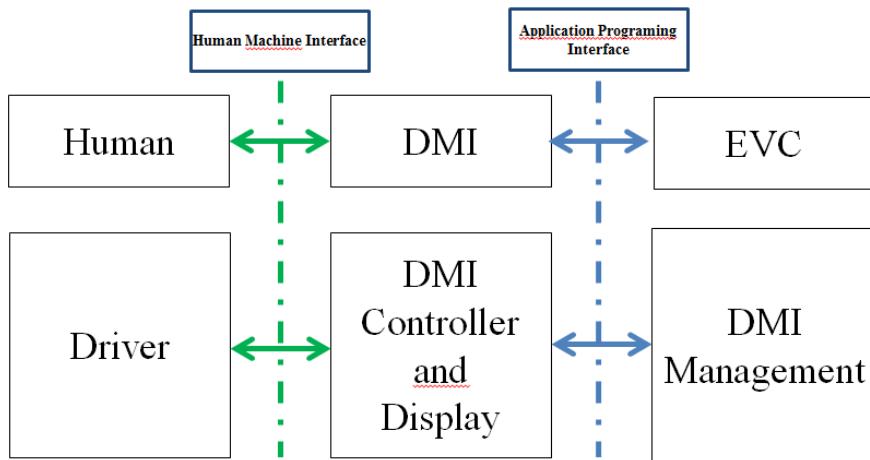


Figure 18. DMI Interfaces

## **2.4<sub>125</sub> F3: Measure Train Movement**

### **2.5 F4: Manage Radio Communication**

### **2.6 F5: Manage JRU**

### **2.7 F6: DMI Controller**

#### **2.7.1 DMI Controller**

##### **1130 Reference to the SRS or other Requirements (or other requirements)**

ERA\_ERTMS\_015560

##### **Short description of the functionality**

The DMI controller interact with the DMI display and is responsible for alls procedures between the DMI display and Driver. Furthermore, the DMI controller will interact with the DMI Management to compute the 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.

##### **1140 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 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.

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

- 1150 • 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)

**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                                   |
| 1155 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.

**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  |

**Both ways direction** In the following table are listed the outputs/inputs to/from DMI Management with a brief description:

| NAME                       | DESCRIPTION  |
|----------------------------|--|
| 1165 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           |

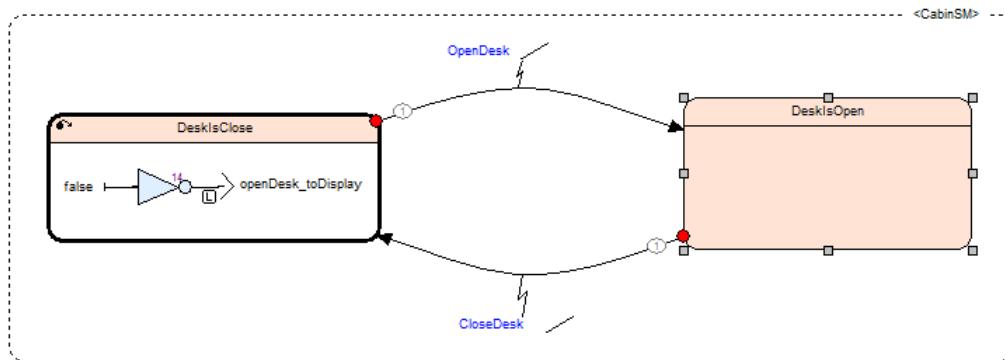


Figure 19. Cabin State Machine.

## Functional Design Description

**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.

1170 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. 19) triggered by a *OpenDesk* signal (from TIU). Inside the *DeskIsOpen* state there are other two state machines :*HandshakeSM* and *DynamicInfoSM* (Fig. 20).

1180 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.).

1185 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.

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:

- 1190 • **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 menus. The WindowSM state machine manages the windows that should appear on the DMI(Fig. 21).
- **diagram\_SporadicInfo\_TrainData:** Contains all the logic to store and adapt the incoming train data to a correct visualization on DMI Display.

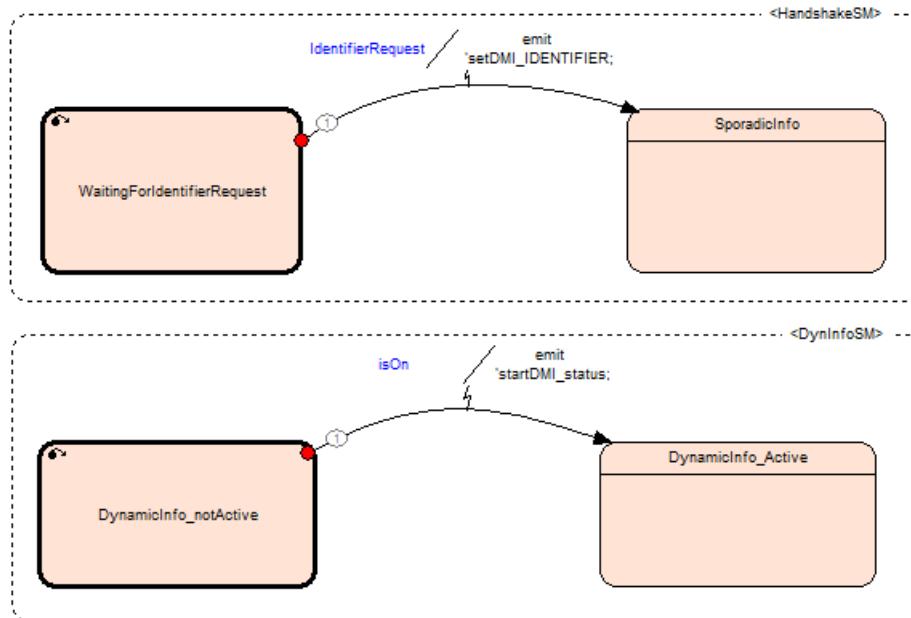


Figure 20. HandshakeSM and DynamicInfoSM State Machines.

- **diagram\_SporadicInfo\_Icon\_Management:** Contains the logic to show/hide one or several icons in area and manage the acknowledgement mechanism if It's required.
- **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.

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).

## 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.

**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

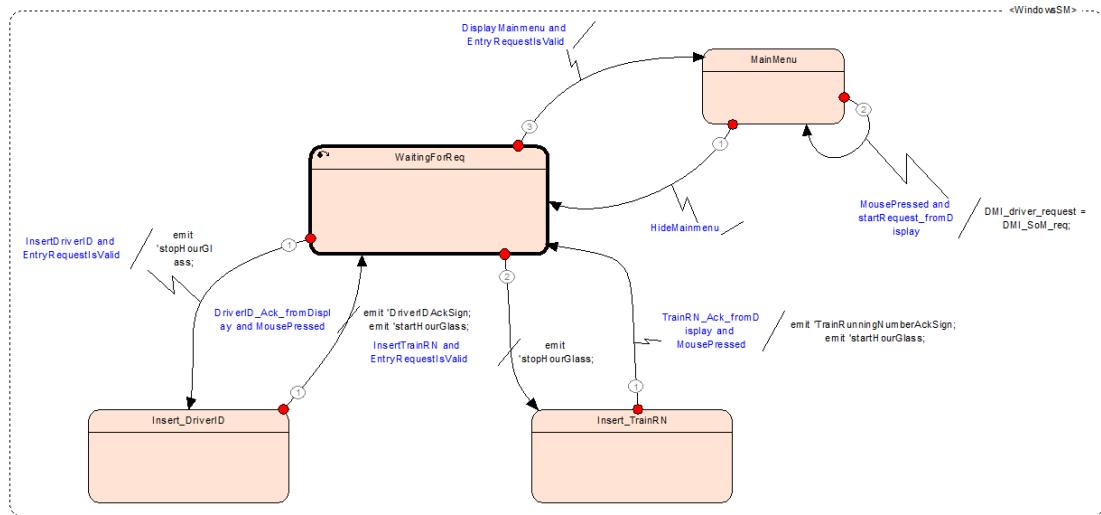


Figure 21. Windows state machine.

of mission procedure). It's assumed that a OpenDesk signal is received and the system starts in Stand By mode (Fig. 22).

**Cyclic Exchange of messages** 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.

### 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](https://github.com/openETCS/modeling/tree/master/model/Scade/System/DMI_Control)

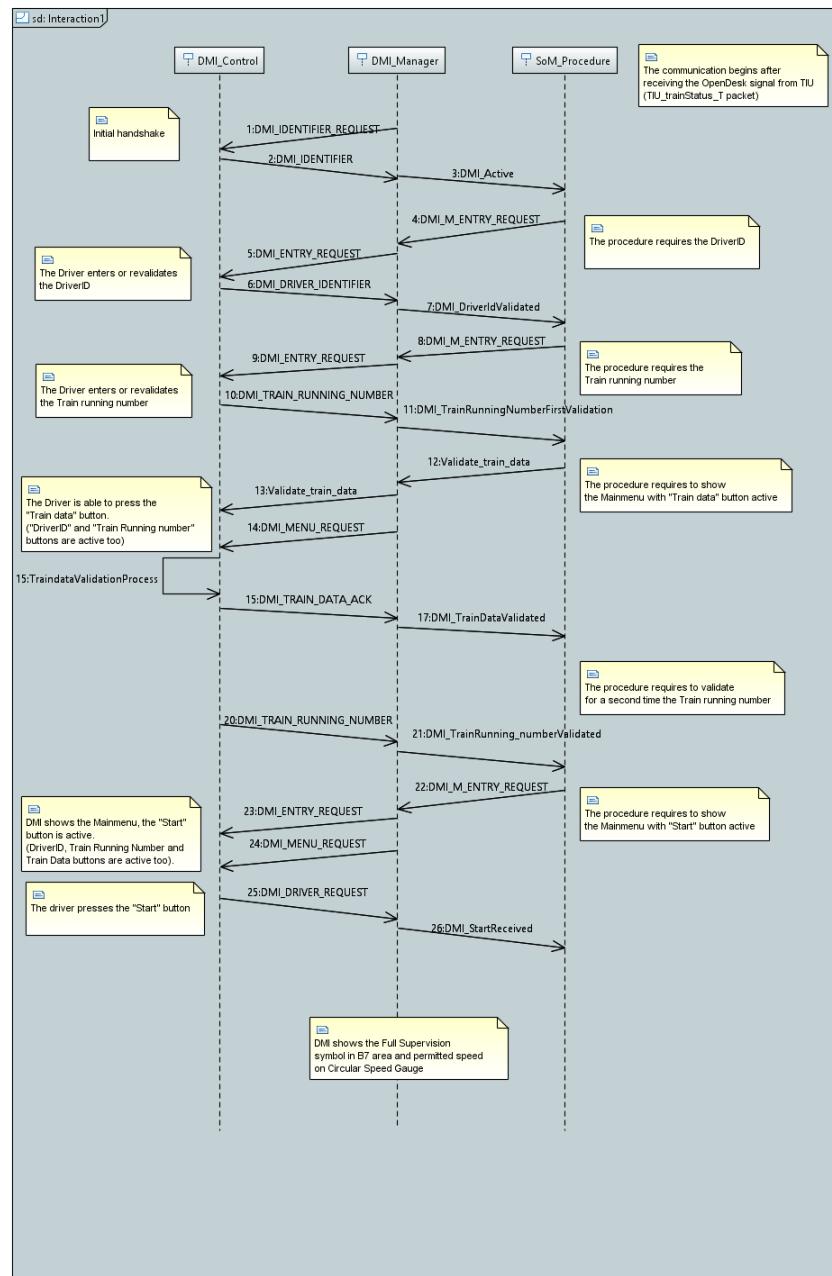


Figure 22. Sequence Diagram of start of mission scenario

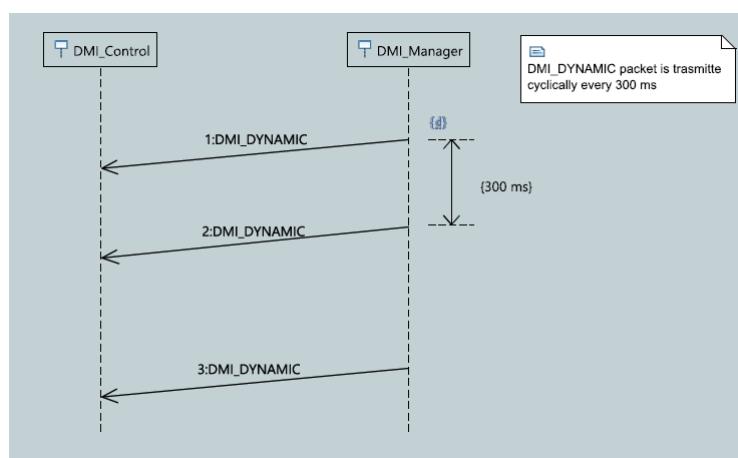


Figure 23. Sequence diagram of Dynamic data.

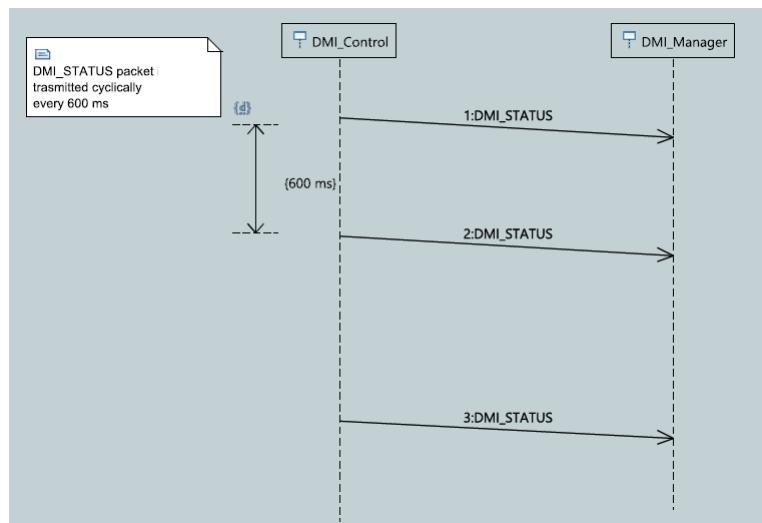


Figure 24. Sequence Diagram of DMI status.