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Railway applications — Train Modes functional interface specification

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Foreword

This document (CLC/TR 50610:2014) has been prepared by WG15 of the Technical Committee CENELEC TC 9X, "Electrical and electronic applications for railways".

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

The text was obtained as transposition of the functional interface specification FIS TrainmodesRpt_V32007 09 3 produced as output of the European research project MODTRAIN.

1 Scope

The scope of this Technical Report is to provide an overview of the Train Modes, their management and their functional interfaces.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

UIC 438, *Uniform numerical marking of railway rolling stock*

UIC 556, *Information transmission in the train (train bus) - General dispositions*

UIC 612-1, *Rolling Stock configurations and main activated functions for EMU/DMU, Locomotives and Driving Coaches – Operational configurations and driver procedures*

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms, definitions and abbreviations apply.

3.1 Terms

3.1.1
configuration
action which affects the system function

3.1.2
parameterisation
action which affects the system behaviour

3.2 Abbreviations

All the abbreviations used in this document are listed in Table 1, in alphabetic order referenced to their term.

Table 1 - Abbreviation table

Abbreviation	Term
ASC	Automatic Speed Control
DDU	Driver Display Unit
ETCS	European Train Control System
FBS	Functional Breakdown Structure
FI	Functional Interface
HV	High Voltage
HVAC	Heating Ventilation Air Conditioning
ID	Identity
LV	Low Voltage
PBS	Product Breakdown Structure
SL	Sleeping mode
STM	Specific Transmission Module (as part of ETCS)
SW	Software
TCMS	Train Control & Monitoring System
TCS	Traction Control System
TDD	Technical and Diagnostic Display
UML	Unified Modelling Language
WSP	Wheel Sliding Protection

4 TrainModes

4.1 General

The train modes describe the operational state of the train.

This report describes the train modes components and their management.

4.2 TrainModes_Components

4.2.1 General

With reference to Figure 1, the diagram shows the relation between the management of cabs and the relevant train modes.

The management of train-wide operational modes uses information from several other train-wide functions and issues commands to them.

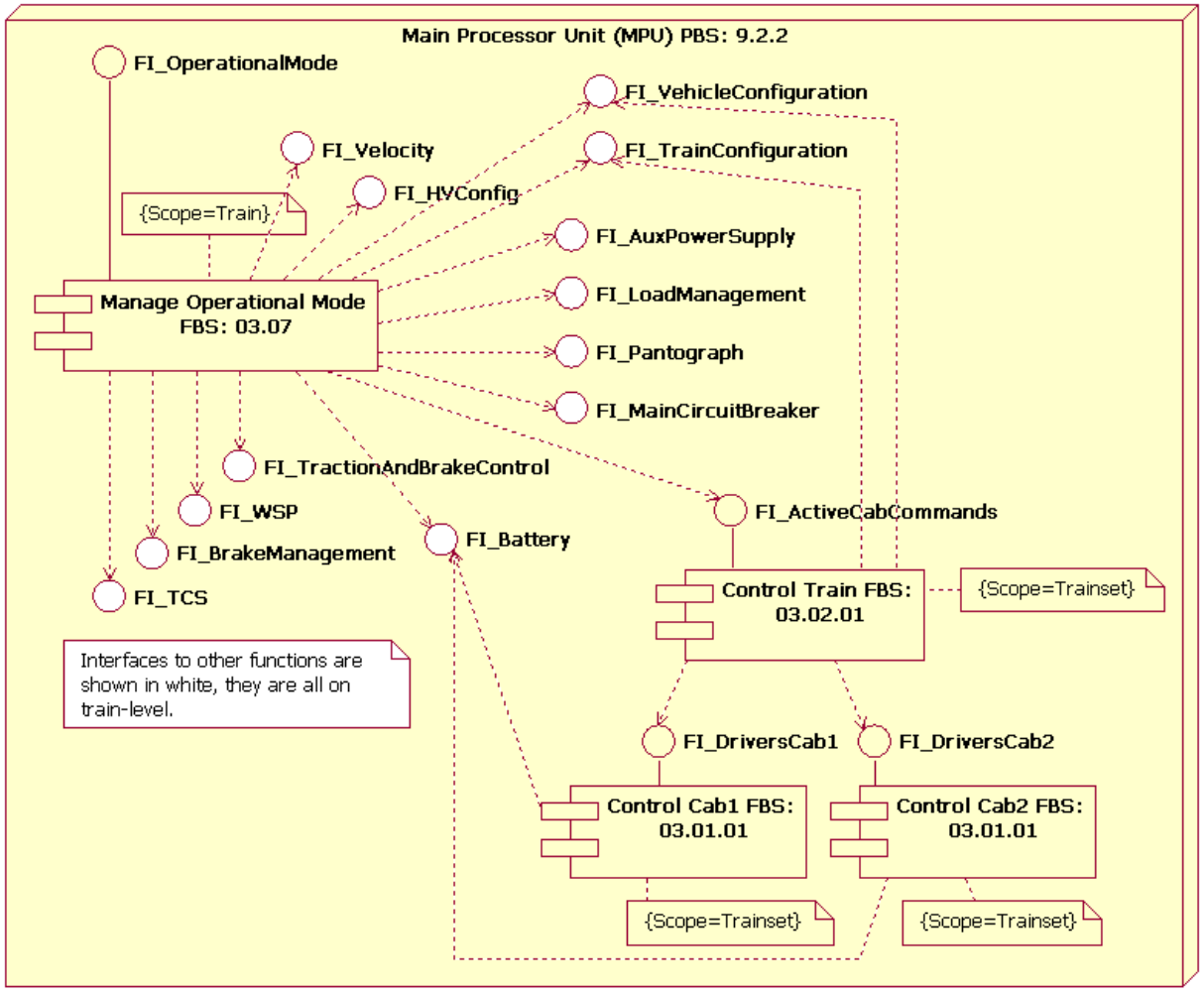

Figure 1 - Management of cabs and relevant Train Modes

4.2.2 Manage Operational Mode FBS: 03.07

This block represents the function to manage the train-wide operational modes.

4.2.3 Control Cab1 FBS: 03.01.01

This block represents the local function managing the modes of a single driver's cab. This function is local within a trainset.

4.2.4 Control Cab2 FBS: 03.01.01

This block represents the local function managing the modes of a single driver's cab. This function is local within a trainset.

4.2.5 Control Train FBS: 03.02.01

This block represents the function which is managing the modes of the driver's cabs in a trainset and the command issued from the cabs and information sent to the cabs.

4.3 TrainModes_Logical

4.3.1 General

This sub-clause describes the Interfaces, classes and behaviour of train modes.

Figure 2 shows the other functions and subsystems involved in the train modes management. Furthermore the figure shows the signals which cause the entering and leaving of train modes.

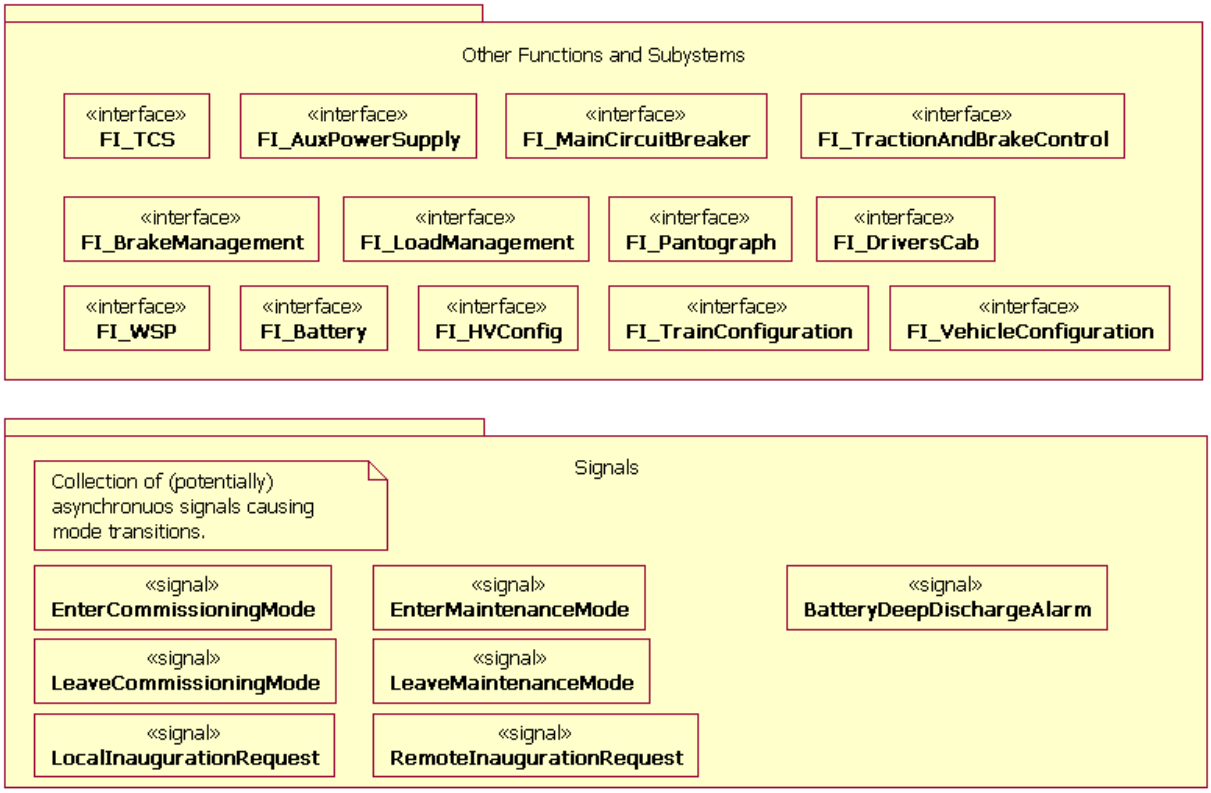

Figure 2 - Interfaces to other functions and subsystems and signals to enter/leave modes

Figure 3 shows the UML diagram of the common interface between the drivers cab and the relevant train modes.

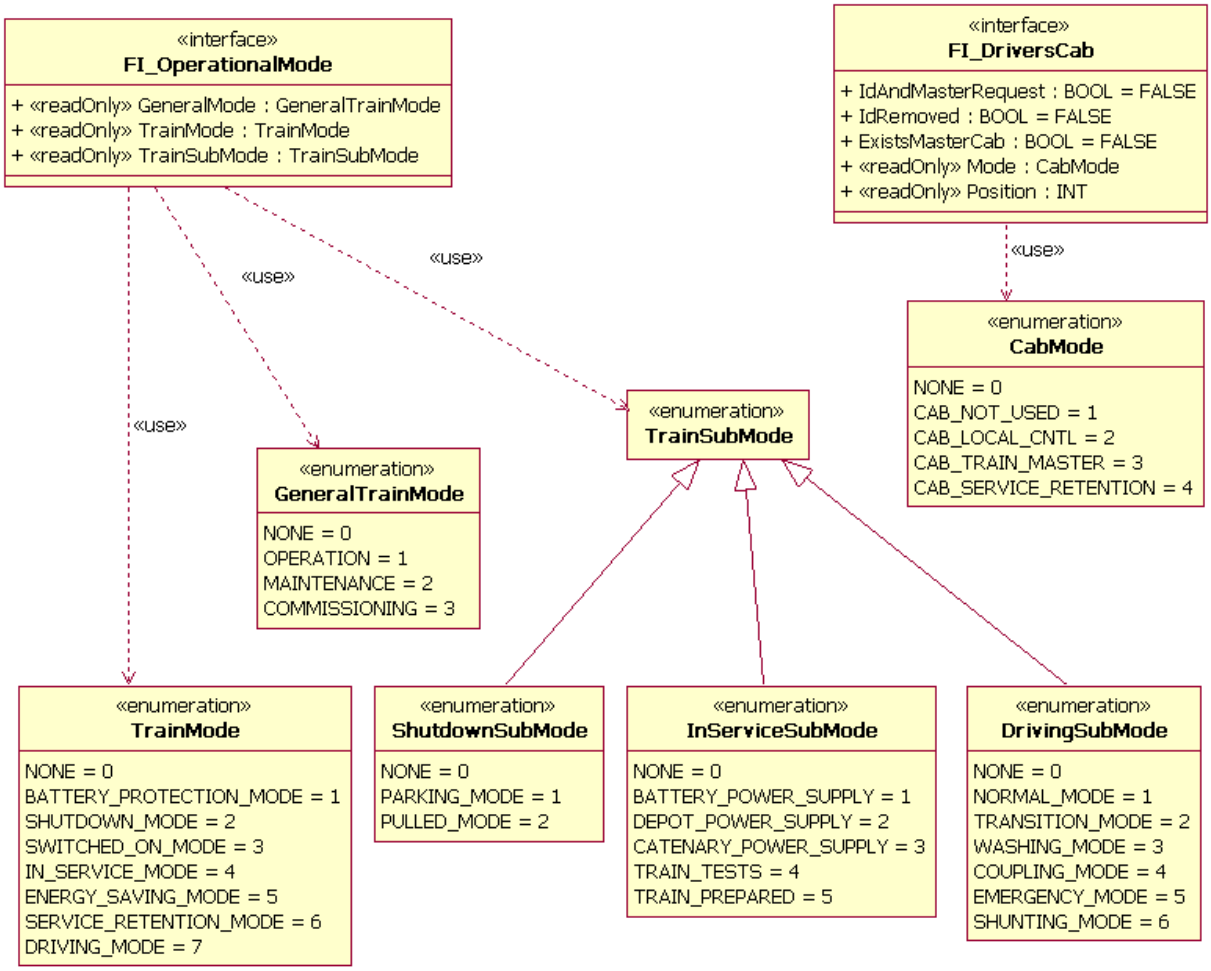

Figure 3 - Common interface between the drivers cab and the relevant train modes

4.3.2 <Interface> FI_DriversCab

The interface FI_DriversCab is specified by a collection of variables showing the current mode of a single driver's cab and commands issued from that cab. Table 2 lists such variables.

Table 2 - FI_DriversCab interface variable

Attribute	Visibility	Type	Description
IdAndMasterRequest	0 - PUBLIC	BOOL	Indicates the insertion of the id card, thus requesting train-wide master role for the cab; this is input from the HW.
IdRemoved	0 - PUBLIC	BOOL	Indicates the removal of the Id card; this is input from the HW.
ExistsMasterCab	0 - PUBLIC	BOOL	The status of ExistsMasterCab is usually set/reset by the insertion/removal of the driver's id card in exactly one cab on the train; this is input from the train- and trainsetwide HW-trainlines.
Mode	0 - PUBLIC	CabMode	Current mode of the cab.
Position	0 - PUBLIC	INT	Fixed position of the cab (end 1 or

Attribute	Visibility	Type	Description
			end 2 of the vehicle).

4.3.3 <Interface> FI_ActiveCabCommands

This interface routes the commands from the active driver's desk.

4.3.4 <Interface> FI_CabCommands

This interface routes the commands from a single driver's cab.
Table 3 lists the driver's cab commands.

Table 3 - Driver's cab commands

Attribute	Visibility	Type	Description
RequestCoupling	0 - PUBLIC	BOOL	Indicates the request for a transition into coupling mode.
RequestShunting	0 - PUBLIC	BOOL	Indicates the request for a transition into shunting mode.
RequestWashing	0 - PUBLIC	BOOL	Indicates the request for a transition into washing mode.
RequestTransition	0 - PUBLIC	BOOL	Indicates the request for a transition into transition mode.
RequestEmergency	0 - PUBLIC	BOOL	Indicates the request for a transition into emergency mode.
EnergySavingRequest	0 - PUBLIC	BOOL	Indicates the request for a transition into energy saving mode.

4.3.5 Other Functions and Subystems

4.3.5.1 <Interface> FI_VehicleConfiguration

This interface provides the access to the configuration data of the vehicle in term of UIC-556 vehicle attributes.

Table 4 provides a definition of the configuration data.

Table 4 - Configuration data over the interface FI_VehicleConfiguration

Attribute	Visibility	Type	Description
VehicleConfiguration	0 - PUBLIC	VehicleProperties	Attributes specifying the current configuration and properties of the vehicle (such as UIC 556 static and dynamic attributes).

4.3.5.2 <Enumeration> VoltageType

The definition of the voltage types is provided by Table 5.

Table 5 - List of VoltageType

Literal	Value	Description
Default	0	Voltage system type not specified / not needed.
DC	1	Voltage system type is DC.
AC	2	Voltage system type is AC.

4.3.5.3 <Enumeration> EnergySource

The definition of the energy sources is provided by Table 6.

Table 6 - List of EnergySource

Literal	Value	Description
None	0	Source not specified / not needed.
Battery	1	Energy source is battery or battery network.
DepotPowerSupply	2	Energy source is (external) power supply from the depot.
Catenary	3	Energy source is catenary.
DepotPowerSupply2	4	Energy source is another (external) power supply from the depot. To be used if there are additional depot power supply systems (e.g. wire and trolley).
Catenary2	5	Energy source is another catenary. To be used, if there are two catenary systems.

4.3.5.4 <Enumeration> CountryOpCode

The definition of the country codes is provided in Table 7.

The list is according to the UIC 438 leaflet and is provided for giving examples.

Not all codes from the leaflet are listed herein after.

Table 7 - List of CountryOpCodes according to UIC438 leaflet

Literal	Value	Description
None	0	Code is not specified / not needed.
RENFE	71	Red Nacional de los Ferrocarriles Españoles
DB	80	Deutsche Bahn
ÖBB	81	Österreichische Bundesbahnen
FS	83	Trenitalia (formerly Ferrovie dello Stato)
SBB	85	Schweizerische Bundesbahnen
SNCF	87	Société Nationale des Chemins de fer Français
SNCB	88	Société nationale des chemins de fer belges

4.3.5.5 <Enumeration> VoltageSystem

The definition of the voltage system is provided in Table 8.

Table 8 - List of VoltageSystem

Literal	Value	Description
None	0	Voltage system is not specified / not needed.
15KV_16_7Hz	1	15 KV AC; 16,7Hz
25KV_50Hz	2	25 KV AC; 50Hz
750V_DC	3	750 V DC
1_5KV_DC	4	1,5 KV DC
3KV_DC	5	3 KV DC

4.3.5.6 <Interface> FI_HVConfig

This is a train-wide interface used for the configuration of the high voltage power equipment.

The parameters used for the configuration are listed in Table 9.

The command to invoke the configuration is described in Table 10.

Table 9 - List of parameters relevant to the interface FI_HVConfig

Attribute	Visibility	Type	Description
CurrentSystem	0 - PUBLIC	VoltageSystem	The voltage system, which is currently configured.
CurrentPowerSource	0 - PUBLIC	PowerSource	The power source, which is currently configured.
CurrentCountry	0 - PUBLIC	CountryOpCode	The country, which is currently configured.

Table 10 - SetSystem command

Operation	Visibility	Parameter	Description / Parameter
SetSystem	0 - PUBLIC	(0 - IN) system: VoltageSystem (0 - IN) net: CountryOpCode (0 - IN) source: EnergySource	Command to configure the HV equipment for the specified voltage system, network / energy source.

4.3.5.7 <Enumeration> LoadManagementMode

The mode “Load management” switches classes of electrical consumers off or on according to the mode, which has been selected and the current velocity.

Table 11 lists the cases of the LoadManagementMode.

Table 11 - List of LoadManagementMode cases

Literal	Value	Description
Off	0	Load management shall switch off all electrical consumers.
FullOperation	1	Load management shall switch on all electrical consumers (for full operation).
EnergySaving	2	Load management shall switch on all electrical consumers, which have to be active in the EnergySavingMode and switch off others (typically HVAC).
Emergency	3	Load management shall switch on all electrical consumers, which have to be active in the EmergencyMode and switch off others.

4.3.5.8 <Enumeration> Direction

The definition of the travel directions is provided in Table 12.

Table 12 - List of travel directions

Literal	Value	Description
Neutral	0	No direction specified, direction switch is in neutral position.
Forward	1	Direction is set to forward.
Backward	2	Direction is set to backward.

4.3.5.9 <Interface> FI_Velocity

The interface FI_Velocity provides a train-wide information about velocity.

The values are listed in Table 13.

Table 13 - List of values of the interface FI_Velocity

Attribute	Visibility	Type	Description
Standstill	0 - PUBLIC	BOOL	Train-wide "v=0" information.
Velocity	0 - PUBLIC	REAL	Train-wide velocity information.
Valid	0 - PUBLIC	BOOL	Indicates the validity of the speed-information.

4.3.5.10 <Interface> FI_TrainConfiguration

FI_TrainConfiguration is the interface for retrieving the train configuration (combines info from functions 'train-wide communication', 'checking train integrity' and 'coupling') according to UIC 556 leaflet.

Though this interface it is also possible to retrieve the vehicle status.

Table 14 lists the parameters of the FI_TrainConfiguration interface.

The command to retrieve the configuration is described in Table 15.

Table 14 - List of parameters of the FI_TrainConfiguration interface

Attribute	Visibility	Type	Description
ExistsMasterCab	0 - PUBLIC	BOOL	The status of ExistsMasterCab is usually set/reset by the insertion/removal of the driver's id card in exactly one cab on the train of the cad
TrainsetIsLeading	0 - PUBLIC		This variable indicates to the trainset (from its train bus node) that it is leading.

Table 15 - RequestLeading command

Operation	Visibility	Parameter	Description / Parameter
RequestLeading	0 - PUBLIC		Requests a train inauguration and set this trainset as leading.

4.3.5.11 <Interface> FI_Battery

Table 16 lists the parameters of the Interface to the battery equipment.

The commands to switch on and off the battery equipment are listed in Table 17.

Table 16 - List of parameters of the FI_Battery interface

Attribute	Visibility	Type	Description
MainSwitchOn	0 - PUBLIC	BOOL	Current status of the battery main switch.
Charging	0 - PUBLIC	BOOL	Indicates that the battery is being charged.
DeepDischarge	0 - PUBLIC	BOOL	Indicates deep discharge alarm for the battery.

Table 17 - List of commands for the FI_Battery interface

Operation	Visibility	Parameter	Description / Parameter
On	0 - PUBLIC		Command to switch the battery power on.
Off	0 - PUBLIC		Command to switch the battery power off.

4.3.5.12 <Interface> FI_LoadManagement

FI_LoadManagement is the interface to the train-wide load management.

The parameters of this interface are listed in Table 18.

Table 19 describes the command OperationMode which can be invoked through this interface.

Table 18 - List of parameters for the FI_LoadManagement interface

Operation	Visibility	Parameter	Description / Parameter
SetMode	0 - PUBLIC	(0 - IN) mode: LoadManagementMode	Command to set the mode for the LoadManagement.
SwitchOn	0 - PUBLIC		Command to switch the load management on.
SwitchOff	0 - PUBLIC		Command to switch the load management off.

Table 19 - OperationMode command

Attribute	Visibility	Type	Description
OperationMode	0 - PUBLIC	LoadManagementMode	Current operation mode set for the load management.

4.3.5.13 <Interface> FI_WSP

FI_WSP is the local interface to the wheel slip protection.

The parameters of this interface are listed in Table 20.

Table 21 describes the command OperationMode which can be invoked through this interface.

Table 20 - List of parameters of the FI_WSP interface

Attribute	Visibility	Type	Description
StandstillLocal	0 - PUBLIC	BOOL	Local "v=0" information.
isActivated	0 - PUBLIC	BOOL	Status of the WSP (active/not active).
BrakePipePressure	0 - PUBLIC	REAL	Status of the brake pipe pressure in bar.

Table 21 - List of commands for the FI_WSP interface

Operation	Visibility	Parameter	Description / Parameter
Activate	0 - PUBLIC		Command to activate the WSP.
Deactivate	0 - PUBLIC		Command to deactivate the WSP.

4.3.5.14 <Interface> FI_AuxPowerSupply

FI_AuxPowerSupply is the train-wide interface to the auxiliary power supply sub-system.

The parameters of this interface are listed in Table 22.

Table 23 describes the commands which can be invoked through this interface.

Table 22 - List of parameters for the FI_AuxPowerSupply interface

Attribute	Visibility	Type	Description
isOn	0 - PUBLIC	BOOL	Status of the auxiliary power supply.

Table 23 - List of commands for the FI_AuxPowerSupply interface

Operation	Visibility	Parameter	Description / Parameter
SwitchOn	0 - PUBLIC		Command to switch the consumers of auxiliary power supply on.
SwitchOff	0 - PUBLIC		Command to switch the consumers of the auxiliary power supply off.

4.3.5.15 <Interface> FI_TCS

FI_TCS is the interface to train control systems.

The parameters of this interface are listed in Table 24.

Table 25 describes the commands which can be invoked through this interface.

Table 24 - List of parameters for the FI_TCS interface

Attribute	Visibility	Type	Description
isActive	0 - PUBLIC	BOOL	Status of the train control system (active/not active).

Table 25 - List of commands for the FI_TCS interface

Operation	Visibility	Parameter	Description / Parameter
Activate	0 - PUBLIC		Command to activate the train control system.
Deactivate	0 - PUBLIC		Command to deactivate the train control system.

4.3.5.16 <Interface> FI_MainCircuitBreaker

FI_MainCircuitBreaker is the train-wide interface to the main circuit breaker.

The parameters of this interface are listed in Table 26.

Table 27 describes the commands which can be invoked through this interface.

Table 26 - List of parameters for the FI_MainCircuitBreaker interface

Attribute	Visibility	Type	Description
isOn	0 - PUBLIC	BOOL	On-Status for the default main circuit breaker, choosen by the system.
isOff	0 - PUBLIC	BOOL	Off-Status for the default main circuit breaker, choosen by the system.
StatusOn	0 - PUBLIC	BOOL[8*2]	On-Status for all main circuit breakers.
StatusOff	0 - PUBLIC	BOOL[8*2]	Off-Status for all main circuit breakers.

Table 27 - List of commands for the FI_MainCircuitBreaker interface

Operation	Visibility	Parameter	Description / Parameter
On	0 - PUBLIC	(0 - IN) breakerNo: int (0 - IN) type: VoltageType	Command for switching on the specified main circuit breaker.
Off	0 - PUBLIC	(0 - IN) breakerNo: int (0 - IN) type: VoltageType	Command for switching off the specified main circuit breaker.

4.3.5.17 <Interface> FI_TractionAndBrakeControl

FI_TractionAndBrakeControl is the train-wide interface to the control system of traction and brake.

The parameters of this interface are listed in Table 28.

Table 29 describes the commands which can be invoked through this interface.

Table 28 - List of parameters for the FI_TractionAndBrakeControl interface

Attribute	Visibility	Type	Description
isLocked	0 - PUBLIC	BOOL	Status for the (safe) traction lock, is TRUE, if a safe traction lock is active.
Direction	0 - PUBLIC	Direction	Status of the travel direction.

Table 29 - List of commands for the FI_TractionAndBrakeControl interface

Operation	Visibility	Parameter	Description / Parameter
Lock	0 - PUBLIC		Command to apply a safe traction-lock.
Unlock	0 - PUBLIC		Command to remove the safe traction-lock.

4.3.5.18 <Interface> FI_BrakeManagement

FI_BrakeManagement is the train-wide interface to the brake control system.

The parameters of this interface are listed in Table 30.

Table 31 describes the commands which can be invoked through this interface.

Table 30 - List of parameters for the FI_BrakeManagement interface

Attribute	Visibility	Type	Description
BrakePipePressure	0 - PUBLIC	REAL	Status of the brake pipe pressure in bar.
ParkingBrakeApplied	0 - PUBLIC	BOOL	Status of the parking brake.

Table 31 - List of commands for the FI_BrakeManagement interface

Operation	Visibility	Parameter	Description / Parameter
ApplyParkingBrake	0 - PUBLIC		Command to apply the parking brake.
ReleaseParkingBrake	0 - PUBLIC		Command to release the parking brake.
AutomaticBrakeTest	0 - PUBLIC		Execution of automatic brake tests during train preparation.

4.3.5.19 <Interface> FI_Pantograph

FI_Pantograph is the train-wide interface to the pantograph sub-system.

The parameters of this interface are listed in Table 32.

Table 33 describes the commands which can be invoked through this interface.

Table 32 - List of parameters for the FI_Pantograph interface

Attribute	Visibility	Type	Description
isDown	0 - PUBLIC	BOOL	Down-Status for the default panthograph, choosen by the system. "Down" means inactive position, no connection to catenary.
isRaised	0 - PUBLIC	BOOL	Down-Status for the default panthograph, choosen by the system. "Down" means in-active position. "Raised" means active position, connection to catenary.
StatusDown	0 - PUBLIC	BOOL[8*2]	Down-Status for all panthographs. "Down" means inactive position, no connection to catenary.
StatusRaised	0 - PUBLIC	BOOL[8*2]	Raised-Status for all panthographs. "Raised" means active position, connection to catenary.

Table 33 - List of commands for the FI_Pantograph interface

Operation	Visibility	Parameter	Description / Parameter
Down	0 - PUBLIC	(0 - IN) pantographNo: int (0 - IN) system: VoltageSystem (0 - IN) code: CountryOpCode	"Down" means inactive position, no connection to catenary.
Raise	0 - PUBLIC	(0 - IN) pantographNo: int (0 - IN) system: VoltageSystem (0 - IN) code: CountryOpCode	"Raised" means active position, connection to catenary.

4.3.6 <Interface> FI_OperationalMode

Though this interface, it is possible to collect variables showing the current train-wide operational mode and its transitions.

Table 34 lists the variable available through the FI_OperationalMode interface.

Table 34 - Variables available through the FI_OperationalMode interface

Attribute	Visibility	Type	Description
GeneralMode	0 - PUBLIC	GeneralTrainMode	Current general mode for train operation (normal, maintenance, etc.).
TrainMode	0 - PUBLIC	TrainMode	Current train mode.
TrainSubMode	0 - PUBLIC	TrainSubMode	Current sub mode of the current train mode; is NONE if no submode exists.

4.3.7 <<Control>> <Class> OperationalModeMgt

4.3.7.1 General

OperationalModeMgt is the control class managing all train-wide modes and transitions.

The parameters of this interface are listed in Table 35.

Table 36 describes the commands which can be invoked through this interface.

Table 35 - List of parameters for OperationalModeMgt

Attribute	Visibility	Type	Description
SuccessfullyPrepared	0 - PUBLIC	BOOL	Status-variable showing, if train has been successfully prepared to enter driving mode. This variable is used instead of having an own state for this, because it should not appear as a single operational mode.
EnterDrivingMode	0 - PUBLIC	BOOL	Status variable indicating, that the train should enter driving mode. It is usually derived from the position of the direction switch, but also depends on other conditions, like TCS, if the driving mode will be entered or not.

Table 36 - List of commands for OperationalModeMgt

Operation	Visibility	Parameter	Description / Parameter
ExecuteSelfTests	0 - PUBLIC		Execution of initial self-tests for the TCMS.
ConfigureVoltageSystems	0 - PUBLIC		Configuration of the HV power supply.
ConnectToCatenary	0 - PUBLIC		Establish a connection to the catenary (also: connect to depot power supply, if choosen).

Operation	Visibility	Parameter	Description / Parameter
TestsForOperation	0 - PUBLIC		Placeholder for additional tests necessary for opertaion.

4.3.7.2 OperationModes

4.3.7.2.1 General

Figure 4 shows the diagram of the transition between the main train modes.

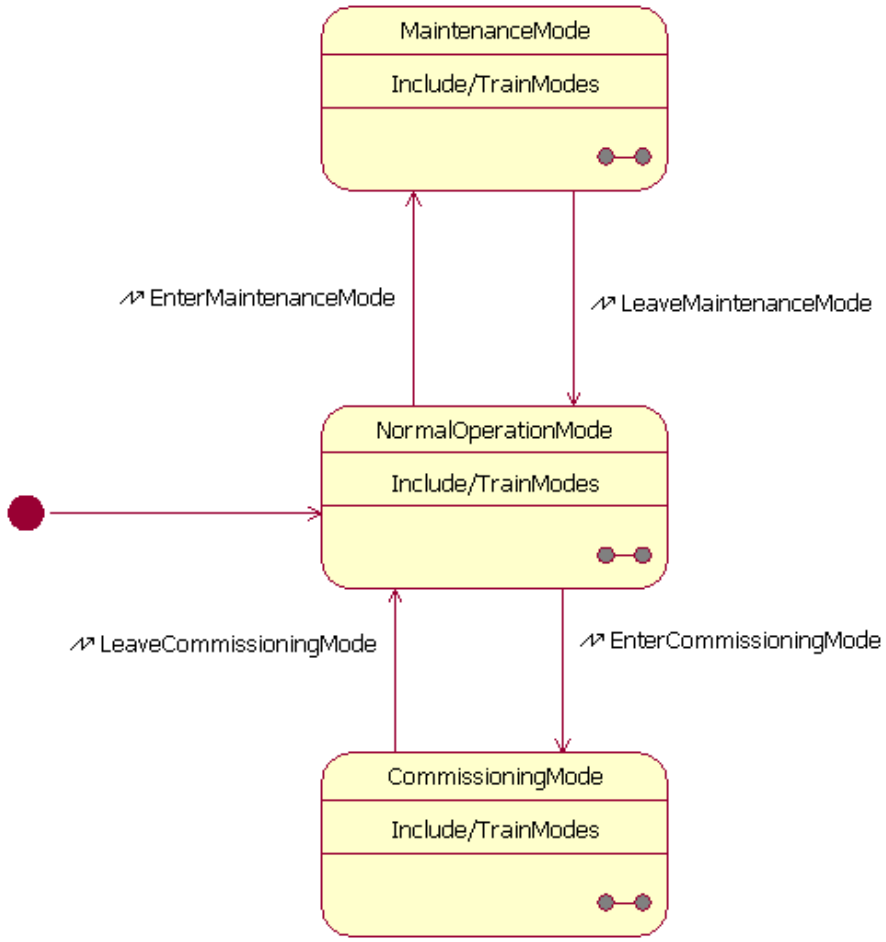

Figure 4 - Train mode transition main diagram

4.3.7.2.2 NormalOperationMode

This mode applies to the operation of train or locomotive in normal conditions.

4.3.7.2.3 MaintenanceMode

This mode applies when the train is in maintenance and under test in the depot in standstill or running.

In this mode the download of approved configurations of SW and parameters is allowed.

Incoming diagnostics events are marked.

Maintenance information and extended diagnostics information are available on DDU.

4.3.7.2.4 CommissioningMode

This mode applies when the train is in commissioning and under test in the depot/test-facility in standstill or running.

All functionalities from the maintenance mode are available.

Download of non-approved configurations of SW and parameters is also allowed.

To force signals for commissioning purposes additional protection (e.g. by password or another ID card has to be foreseen) are requested.

No further restrictions.

4.3.7.3 TrainModes

4.3.7.3.1 General

The full diagram of transition between the train modes is shown in Figure 5.

The following sub-clauses offer a description of each mode reported in the diagram.

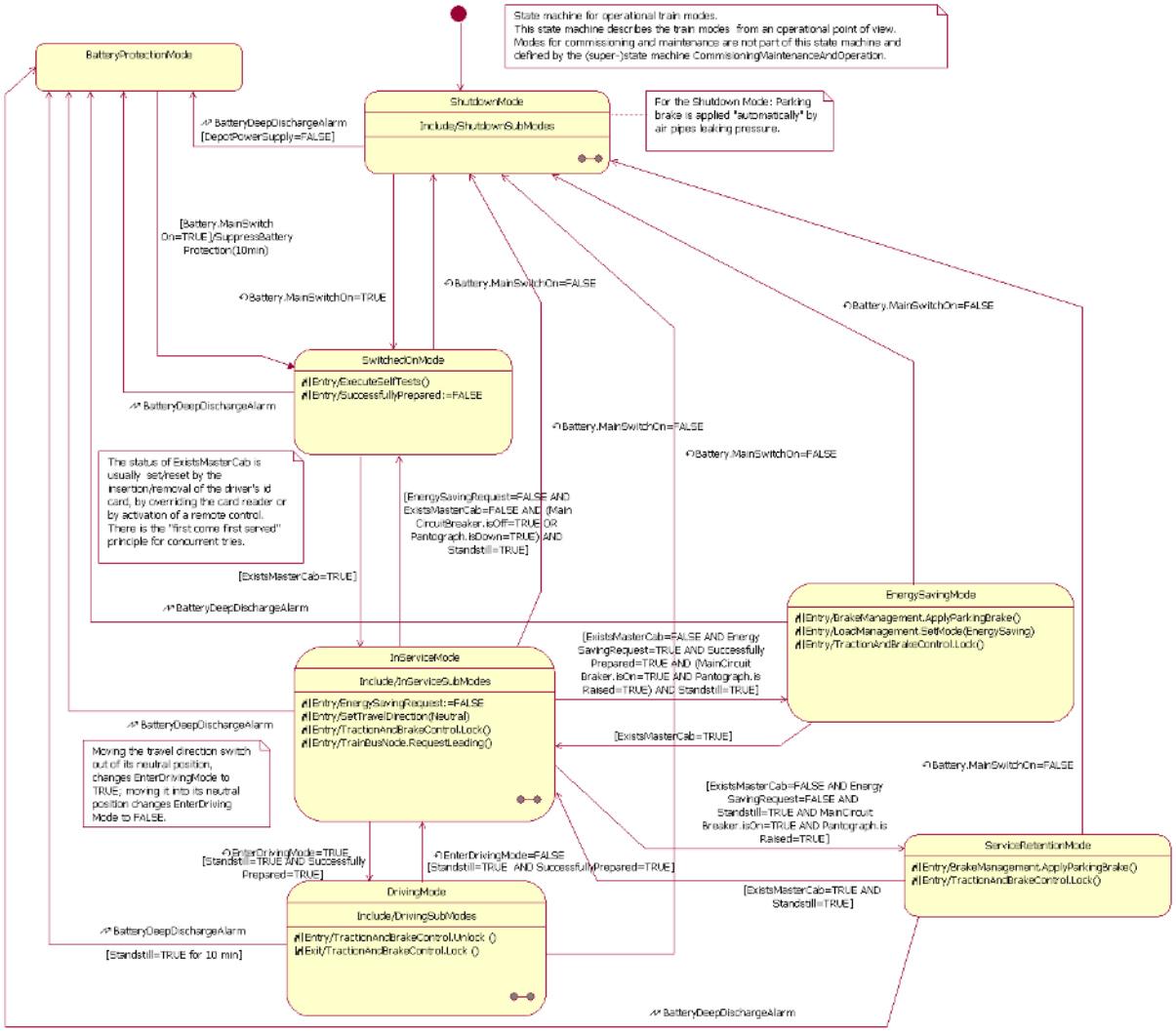

Figure 5 - Full diagram of transition between the train modes

4.3.7.3.2 BatteryProtectionMode

BatteryProtectionMode applies when the train is in standstill or towed by another mechanically and pneumatically coupled train or loco.

Battery-protection has switched off all electrical consumers after giving time for a controlled shutdown of those.

Only the battery protection device itself remains powered.

Brake pipe status remains unchanged (depends on previous mode).

Emergency brake is available

Microphone is available

For resetting this protection mode, the battery main switch is changed from "off" to "on" position.

4.3.7.3.3 ShutdownMode

ShutdownMode applies when the train is in standstill or is being pulled.

The battery main switch is off and no battery deep discharge has been signalled.

4.3.7.3.4 SwitchedOnMode

SwitchedOnMode applies when the train is in standstill and is the first step after startup.

Battery main switch is closed ("on"). All low voltage consumers are supplied.

Main reservoir is connected to the air consumers (operable, if pressure is present).

All DDUs are available for information only except for some control functions to be defined, e.g. train radio.

The preconditions for activating the pantograph shall be fulfilled:

- main circuit breaker is open ("off");
- pantograph is not available (due to aux pressure generated for the pantograph);
- no cab is activated as master;
- leading vehicle is undefined;
- ID card reader is available;
- head light control is available;
- cab and timetable light control is available;
- instrument light control is available.

Following functions are locally available:

- microphone;
- emergency brake;
- application of direct brake;
- switching off main circuit breaker;

- lower pantograph;
- communication with other driver cab via train radio.

Traction and brake control are not available.

If there is no battery charging for 45 min then the battery main switch will be opened (this will cause a transition to the ShutdownMode).

4.3.7.3.5 InServiceMode

InServiceMode applies when the train is in standstill, low voltage is supplied and one driver cab is activated .

In service mode, one cab has been activated as a train-wide master cab and the following conditions apply:

- battery main switch is closed ("on"). All low voltage consumers are supplied;
- main reservoir is connected to the air consumers (operable, if pressure is present);
- pantograph is available;
- main circuit breaker is available;
- direct brake is available;
- TCMS shall ensure that only one cab is activated as master.

After coupling or decoupling detected by TCMS, TCMS itself monitors continuously the train composition in order to be able to detect any modification.

After successful inauguration (no master conflict, degraded devices have been identified) the driver is requested to confirm the train composition in the DDU.

In case of a master conflict (= no or more than 1 master), a traction inhibition is commanded train-wide, the train inauguration configuration cannot be left successfully.

After driver confirmation following the successful train inauguration, the train composition applies. The duration of the train inauguration shall be less than 2 min.

The TCMS shall show in every non master cab that a master cab exists on the train.

After successful train inauguration:

- Leading vehicle is defined;
- DDUs are available for control in the active cab;
- train preparation and disposal can be executed in this mode from the master cab.

After successful train preparation (see sub-states of this mode), the following conditions apply:

- all functions are available from the master cab, except traction, electrical braking and brake pipe control (to be discussed);
- Master cab is able to control the travel direction; travel direction has not been chosen;
- other cabs than the master cab can only issue "local" commands in the vehicle and not train-wide commands, interaction with functions controlled from the master-cab is interlocked (by TCMS).

TCMS will ignore all train-wide commands from these other cabs and the driver in the master cab will be informed about this situation by the TDD.

For ETCS, all modes (except for SL) are available in the leading vehicle, the ETCS-Sleeping Mode (SL) is applied to other vehicles.

A command for a shutdown while HV supply is “on" has to organize the shutdown of all HV consumers, switch off the main circuit breaker, lower the pantograph, organize the shutdown of all LV consumers and set the battery main switch to "off".

4.3.7.3.6 DrivingMode

DrivingMode applies in standstill or running; low voltage is supplied, one driver cab is activated and operation mode requested.

In DrivingMode every function is available.

Normal operation mode, coupling master mode, washing mode and transition mode are specific sub-modes of the driving mode.

The following conditions apply:

- battery main switch is "on". All low voltage consumers are supplied and the relevant reservoirs are connected to the air consumers (operable, if pressure is present);
- pantograph is available;
- main circuit breaker is available;
- direct brake is available;
- holding brake is available;
- direction of travel choice is available;
- choice of operation sub-mode (normal, coupling master, washing, ...) is possible;
- traction, dynamic braking and brake pipe control available;
- brake pipe control can be locally switched off (e.g. if there is no train-bus connection between independent traction units, like in pushing (helper) operation);
- driver activity control (DAC) is active;
- Leading vehicle is defined;
- DDUs are available for control in the active cab;
- Train-wide control can be executed in this mode from the master cab.

TCMS ensures that only one cab is activated as master.

TCMS does not accept another card in parallel and in this case while running ignore any further ID-card and at stand-still trigger a train-wide traction-inhibition.

Other cabs than the master cab can only issue "local" commands in the vehicle and not train-wide commands, interaction with functions controlled from the master-cab is interlocked (by TCMS).

For ETCS, all modes (except for SL) are available in the leading vehicle; the ETCS-Sleeping Mode (SL) is applied to other vehicles.

4.3.7.3.7 EnergySavingMode

EnergySavingMod applies when the train is in Standstill; low voltage is supplied, train power line supplied (HV or external), no driver cab is activated, the energy consumption is in saving mode.

Energy Saving Mode means parking with energy-supply and preparation ability; all the following conditions apply:

- all Functions from the InService Mode can be made available again by only re-inserting the driver's ID card;
- battery main switch is closed ("on"). All low voltage consumers are supplied;
- main reservoir is connected to the air consumers (operable, if pressure is present);
- ETCS retains the last train data input, unless driver action;
- HVAC and other consumers are in energy saving mode:
- HVAC and consumers can be reactivated as well as tests can be started by timer, remote signal or frost protection;
- parking brake is applied;
- Leading Vehicle remains defined, train remains in prepared status.

If there is no battery charging for 45 min an organized shutdown will be executed; this will cause a transition to the Shutdown Mode).

4.3.7.3.8 ServiceRetentionMode

ServiceRetentionMode applies to the train when it is in standstill, low voltage is supplied, HV is supplied, no driver cab activated. This mode will be entered, if the driver changes cabs.

All Functions from the InServiceMode can be made available again by only re-inserting the driver's ID card.

In this condition:

- parking brake is applied;
- all cabs are available to be activated by the driver;
- TCMS retains the last train configuration.

ETCS retains the last train data input, unless driver action for a new input and if the train composition has not changed.

Leading Vehicle remains defined in this mode, until this mode will be left by changing the master cab or by a new train inauguration.

4.3.7.4 ShutdownSubModes

4.3.7.4.1 General

Figure 6 shows the UML diagram relevant to the sub-modes of the shutdown mode.

The conditions to trigger the transitions between the sub-modes are indicated in Figure 6.

The following sub-clauses describe the sub-modes of the shutdown mode.

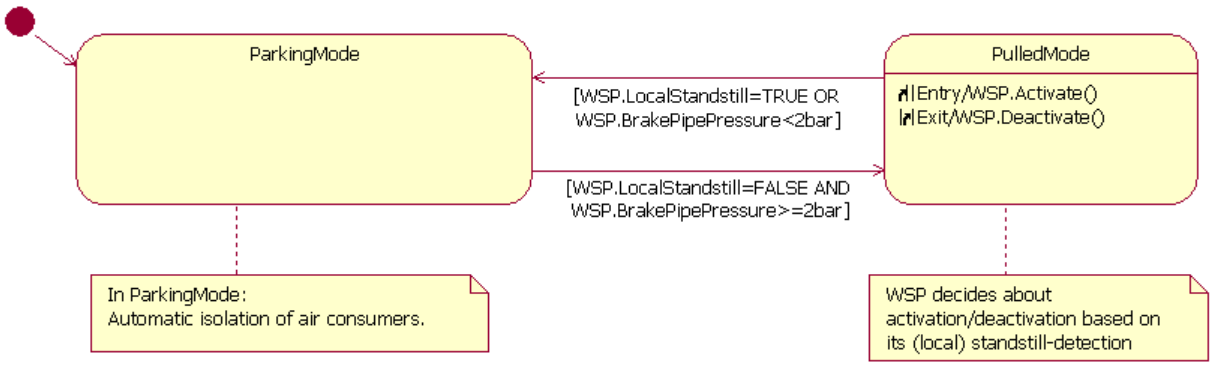

Figure 6 - Sub-modes of the shutdown mode.

4.3.7.4.2 ParkingMode

ParkingMode applies to the train when it is in Standstill with the battery main switch switched off.

All electrical consumers are switched off. Only those connected directly to the battery are supplied with power as indicated by the following list:

- battery deep discharge protection is active;
- interior light is available (if on, will be switched off automatically after 15 min);
- WSP is available (in stand-by);
- Trainbus-node is in sleep mode (and ready for switching on the battery);
- functionality to switch on the battery by radio remote connection is available (if such a functionality has been built in);
- brake mode selection is available;
- emergency brake is available:
- microphone is available.

Brake pipe is emptied and then isolated and automatic application of the parking brake. Unintentional feeding of the brake pipe by leakages of connections to main pipe or reservoirs is prevented.

Automatic parking brake (local) is compensating decrease of brake cylinder pressure (only controlled by reservoir).

ParkingMode is possible for at least 150 h without reaching the self protection mode.

4.3.7.4.3 PulledMode

PulledModeBeing applies to the train when it is pulled "as a wagon", i.e. towed by another mechanically and pneumatically coupled train or loco.

The following list shows the differences against the parking mode:

- WSP is active;
- brake mode selector is operational;
- brake isolation and release device is operational.

PulledMode shall be possible for at least 24 h without reaching the self protection configuration. The Emergency brake is available as well as the microphone.

4.3.7.5 InServiceSubModes

4.3.7.5.1 General

Figure 7 shows the UML diagram relevant to the sub-modes of the InServiceSubModes as well as the conditions to trigger the transitions between the sub-modes.

The following sub-clauses describe the sub-modes of the shutdown mode.

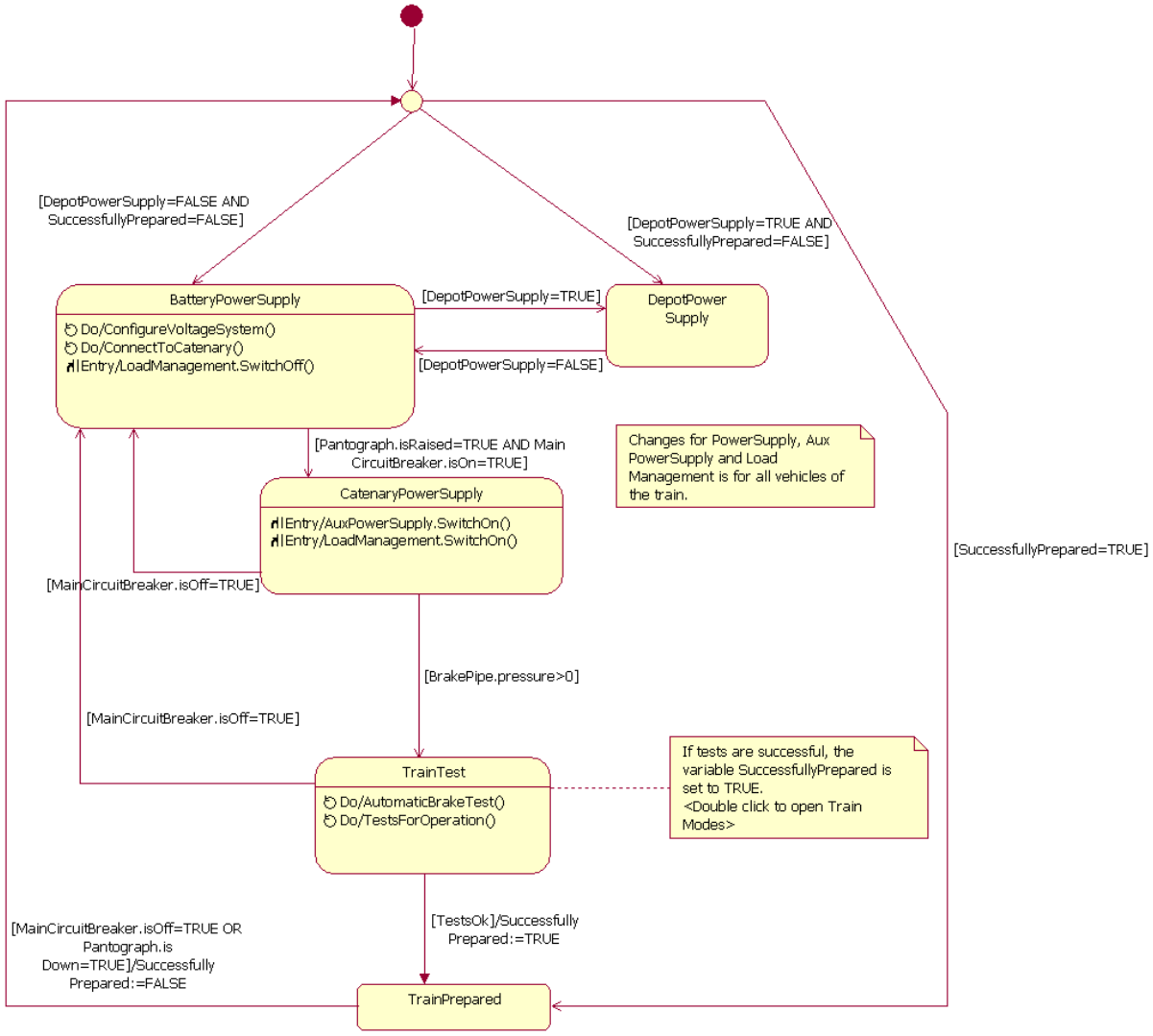

Figure 7 - InServiceSubModes UML diagram

4.3.7.5.2 BatteryPowerSupply

In this sub-mode, LV consumers, connected to battery, are supplied.

4.3.7.5.3 DepotPowerSupply

In this sub-mode, depot power supply provides power to additional LV consumers; restrictions to performance apply.

Depot power supply has to be switched off to raise pantograph and to connect to HV.

4.3.7.5.4 CatenaryPowerSupply

In this sub-mode, connection to HV power supply is provided implying configuration of voltage systems, energy transformation and distribution.

4.3.7.5.5 TrainTest

Tests to ensure the ability of the train to operate safely are executed in this sub-mode.

4.3.7.5.6 TrainPrepared

When in this mode, the train has been successfully prepared and is ready for driving.

4.3.7.6 DrivingSubModes

4.3.7.6.1 General

Figure 8 shows the UML diagram relevant to the sub-modes of the driving mode.

The diagram shows also the conditions to trigger the transitions between the sub-modes.

The following sub-clauses describe the sub-modes of the driving mode.

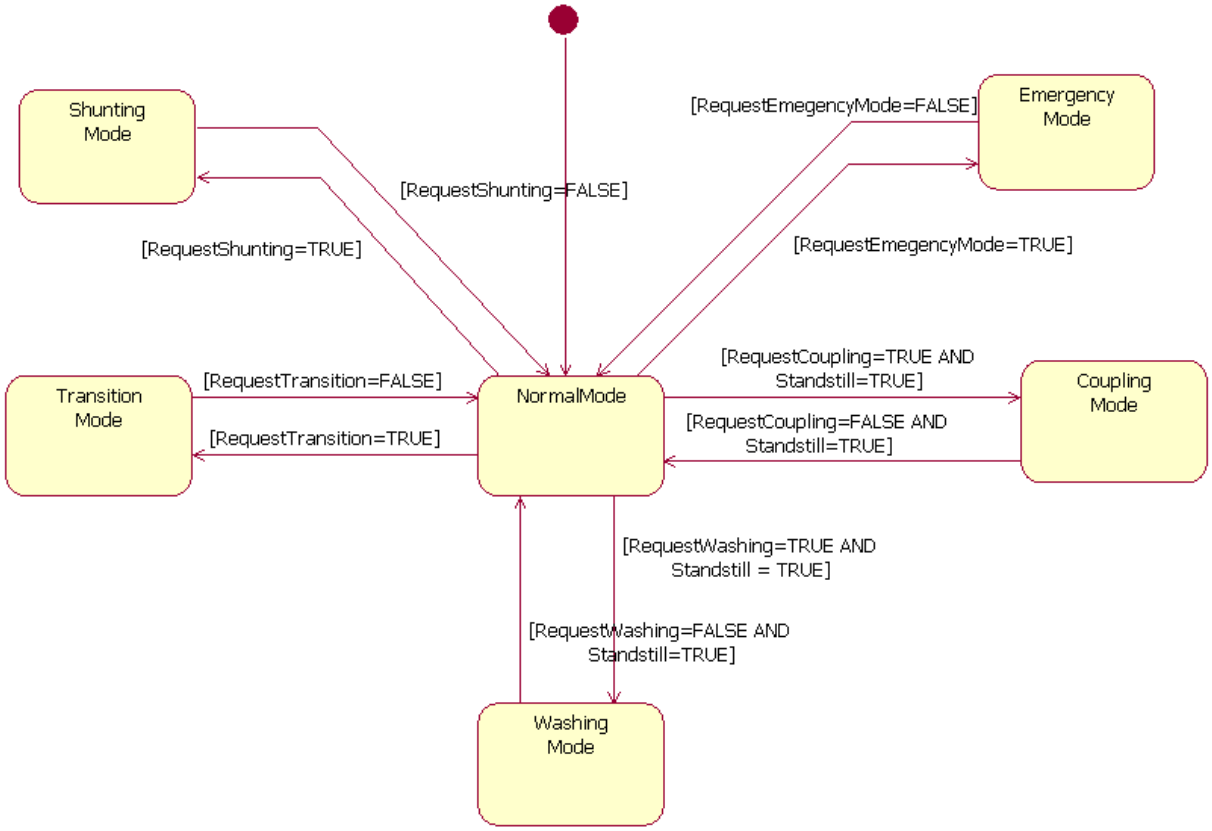

Figure 8 - Driving diagram including sub-modes

4.3.7.6.2 NormalMode

In this sub-mode, the train is available for driving. In case of a second master locomotive the driver on the second master locomotive shall apply a push button in order to isolate the driver's automatic brake controller and ETCS/STM.

In case of a master locomotive, the train inauguration by TCMS triggers the other locomotives in slave operation.

TCMS ensures that only one cab is activated as master.

TCMS does not accept another card in parallel and in this case while running ignore any further ID-card and at stand-still trigger a train-wide traction-inhibition.

In active cab DDU are available for complete control.

Train-wide control can be executed in this configuration from the master cab.

Other cabs than the master cab can only issue "local" commands not related to the train. TCMS will ignore all train-wide commands from these other cabs and the driver in the master cab will be informed about this situation by the TDD.

For shunting operation, the door-loop will be disabled locally, so this is not a separate train-wide operational mode.

Transition due to change of characteristic of the railway network section (i. e. control-command and/or energy subsystem) is done automatically by track balise/beacon or radio signal or by the driver activating a soft-key in the TDD (network section, STM) triggering the change of power supply and/or STM and/or TCMS network section specific configuration (e. g. language, parameters)

For multiple traction or push-pull train (top and tail) the activation is carried out as follows:

The interoperable control-line has to be coupled or radio connection has to be activated,

In all units participating in the train-wide communication the same configuration of train-bus-operation shall be selected,

The unit, in which the direction of travel is selected, is defined to be master.

After the direction of travel is chosen, the train is initialized. The slave locomotives and all further communicating rolling stock are displayed on the main screen of the TDD in the activated cab of the master locomotive. In case of faults, each unit (master and slaves) protects itself and the failure management applies.

4.3.7.6.3 CouplingMode

Operational scenario:

The front (coupler) covers are open and the speed is limited at 3 km/h. If there is no front (coupler) covers, then the train inauguration by the TCMS shall inform the driver about the detected train composition. The other train to be coupled can be in any configuration. But coupling will not result in successful train inauguration in “self protection configuration”: driver shall detect the self protection unit during the train inauguration.

The activation criterion is Soft-key “coupling” in the TDD.

TCMS ensures that only one cab is activated as master. TCMS does not accept another ID card in parallel and in this case while running ignore any further ID-card and in stand-still trigger a train-wide traction-inhibition.

TCMS ensures that coupling can be performed in any possible train configuration.

During connection of the couplers, TCMS accepts the presence of two ID cards until the coupling is finished.

All functions are available from the master cab

Other cabs than the master cab can only issue "local" commands not related to the train. TCMS will ignore all train-wide commands from these other cabs and the driver in the master cab will be informed about this situation by the TDD.

Speed is limited by TCMS at 3 km/h and can be varied by the driver using the speed selector linear between 0 and 3 km/h.

TCMS ensures that the selected speed is maintained and will not be exceeded.

After successful train coupling, the train composition is automatically entered and the holding brakes or a full service brake are train-wide applied. The driver shall confirm the train-composition in the TDD and then the train is automatically in In-service configuration.

4.3.7.6.4 WashingMode

Operational scenario:

The blowers are switched off and the speed is limited at 3 km/h.

The activation criterion is Soft-key “washing” in the TDD.

However, the soft-key for activating the washing program is working only if:

- the locomotive is stationary;
- direction of travel "F" or „R“ has been selected;
- the Traction / dynamic brake controller has been set to "0";
- the main circuit breaker has been switched on;
- the driver’s automatic brake controller is set in running position.

After pushing the Soft-key “washing” in the TDD the TCMS sets the speed-limit according to the selected network (SNCF/Trenitalia: Vtarget = 3 km/h, DB: Vtarget = (1,5 +/- 0,5) km/h). The ASC-system is switched on automatically in order to maintain the selected speed-limit. TCMS applies automatically the holding brake to secure the train in stand-still. The driver shall use the direct brake or the traction / dynamic brake controller in any traction force position in order to release the holding brake and start the train for washing. When the Traction / dynamic brake controller is shifted from "F" to "0", the locomotive will continue to roll without power (coasting).

TCMS ensures that only one cab is activated as master. TCMS does not accept another ID card in parallel and in this case while running ignore any further ID-card and in stand-still trigger a train-wide traction-inhibition.

Train-wide control can be executed in this configuration from the master cab.

All functions are available from the master cab

Other cabs than the master cab can only issue "local" commands not related to the train. TCMS will ignore all train-wide commands from these other cabs and the driver in the master cab will be informed about this situation by the TDD.

Speed can be varied by the driver using the speed-selector linear between 0 and 3 km/h.

By driver-activation of the soft-key “washing finished” on the TDD the normal operation is activated again.

4.3.7.6.5 TransitionMode

The TransitionMode applies to the case when a traction and/or leading vehicle passes from one specific network section to another, its system-relevant functions shall be adapted to the network section-specific conditions by means of transition and all following traction units in the train shall be configured in a compliant way.

The transition process is subject to the following propositions:

- the driver is responsible for carrying out of the transition, if this is not automated;
- in the case of a stationary transition, the change-over is carried out at standstill at a convenient halt near the border prior to or after crossing the border;
- in the case of a transition while the train is in motion, the commutation is carried out during the journey within a route section intended for this purpose;
- transition is triggered or monitored by means of signals from the infrastructure depending on the case.

The control operation shall meet the following requirements:

- control of the transition process is designed so that accidental triggering of transition is prevented;
- driver is able to see clearly that the triggered transition process has been fully completed;
- the selection of the activated network section is visible and verifiable by the driver in the activated driver's cab.

Train safety equipment is designed so that:

- by means of the activation of the applicable train safety information in the activated driver's cab, each operation status of the automatic train protection system is clearly visible.
- train safety devices, specific to one network section and not used in another one, are switched and positioned, during transition, in a manner so that vehicle antennas etc. of these systems do not interfere with the infrastructure;
- an automatic emergency brake can be applied in case of faults of the transition process of the train safety equipment depending on the network transition.

Network section selection process consists in the following:

- if requested by the Infrastructure Register, the MCB is set off and, depending on network section, pantograph is set down;
- the selection of the new network section may be automatic or manual;
- confirmation of the selected network section by the driver by means of TDD;
- configuration is performed automatically;
- if the position of the traction units in the train is known by TCMS in absolute distances, the lifting of pantographs / closing MCB's can be performed "way-delayed", i. e. after each unit concerned enters the new line section;
- all locomotives are configured again (pantograph filling position) and all of the prepared locomotives fully in new network section -> pantograph up -> pantograph lifted for the new network section;
- pantograph detects the new contact wire voltage in the new network-section (validity check: catenary voltage with network section selection, optionally by GPS or Euro-balise) and continues with the new configuration for the selected network section;
- after new configurations are complete, TCMS validates the set network sections of all slave locomotives to the master locomotive. If a traction vehicle cannot select the new network section, the locomotive shuts down (pantograph down) and reports a fault;
- in case of a wrong selection detectable by TCMS, TCMS shall cancel the transition and lower the pantographs.

4.3.7.6.6 ShuntingMode

The ShuntingMode asks for driving with open doors or in condition of door control failure.

The activation criterion is rotating the switch "door control override".

In this mode, the train can be operated with open doors (for shunting staff) and no speed restriction applies.

The battery main switch is "on"; all low voltage consumers are supplied and all relevant reservoirs are connected to the air consumers.

The following functions are available:

- pantograph;
- main circuit breaker;.
- direct braking;.
- holding brake.

TCMS ensures that only one cab is activated as master. TCMS accepts another ID card in parallel and in this case while running ignore any further ID-card and in stand-still trigger a train-wide traction-inhibition.

The following conditions apply:

- leading vehicle is defined (locomotive in “shunting mode”);
- all functions of DDU are available in active cab;
- train-wide control can be executed in this mode from the master cab;
- all functions are available from the master cab which is in “shunting mode”;
- master cab is able to control the direction of travel.

Other cabs than the master cab can only issue "local" commands in the vehicle and not train-wide commands, interaction with functions controlled from the master cab is interlocked by TCMS (see table “cab mode”: “Functions available in the non active cab”).

For ETCS, shunting mode (SH) is available in the leading vehicle, ETCS-Sleeping Mode (SL) in other vehicles.

By reset of the rotating switch “door control override” the normal operation mode is activated again.

4.3.7.6.7 EmergencyMode

Emergency mode disables all electrical locks for braking and driving functions.

Indirect brake is available via driver's brake valve.

4.3.8 <<Control>> <Class> CabModeMgt

4.3.8.1 General

Control class CabModeMgt is managing the modes of a single driver's cab; it is a local function within a trainset.**CabModes**

4.3.8.2.1 General

Figure 9 is the UML state diagram relevant to the CabModes. Sub-modes and conditions to trigger the transition between sub-modes is shown.

Each driver's cab is represented by one instance of state-machine shown in Figure 9.

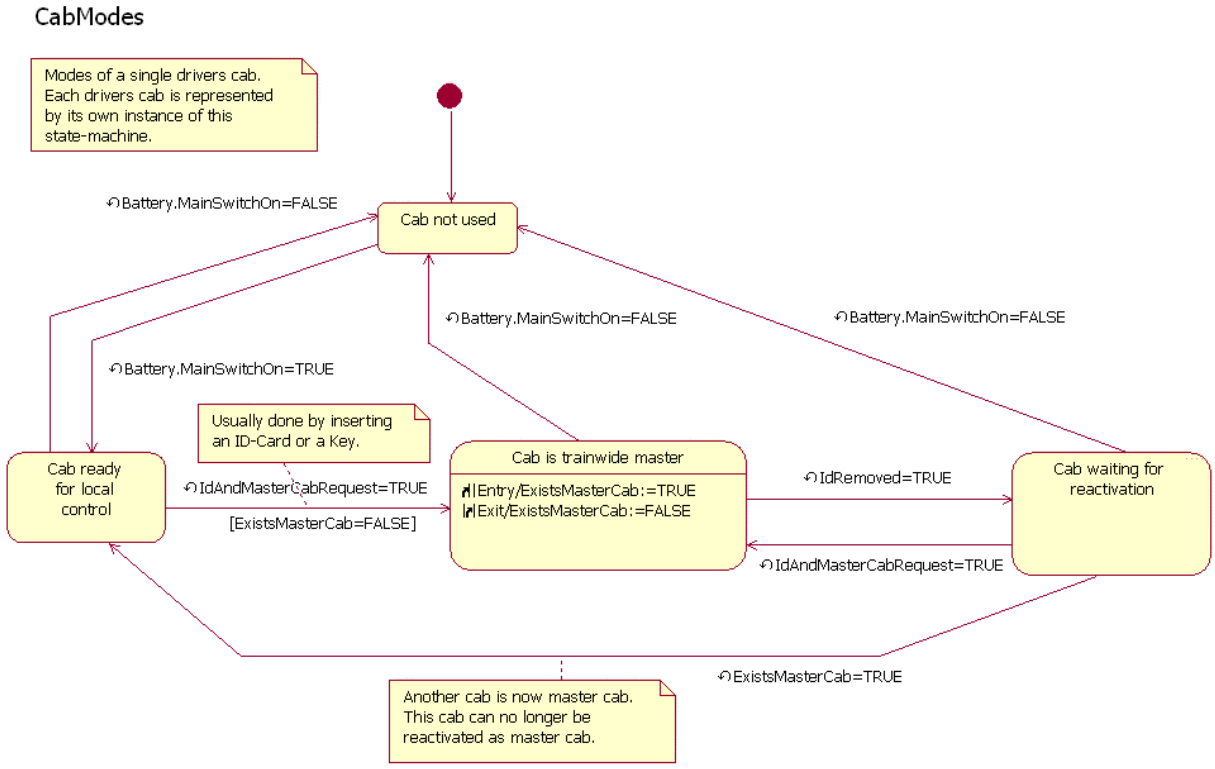

Figure 9 - Modes of a single driver's cab

4.3.8.2.2 Cab not used

No personnel are in the drivers cab or the cab has been entered by operator's personnel who are not ready to take control or provide information, because TCMS is not functional.

4.3.8.2.3 Cab ready for local control

Cab is functional for local control and information.

In this state the cab is ready to take control as train-wide master (if no other cab already has taken this role). In this state the cab is not able to issue train-wide commands, except the request to become master cab.

4.3.8.2.4 Cab is train-wide master

The cab is master cab for train-wide control. Train preparation, stabling and train-wide commands can be issued from this cab.

4.3.8.2.5 Cab waiting for reactivation

The cab has been master cab before, and can be reactivated as master cab as long as no other cab becomes master cab.

Cab is functional for local control and information. In this state the cab is not able to issue train-wide commands, except the request to become master cab.

4.3.9 <<Control>> <Class> CabManagement

Control class CabManagement is managing the modes of the driver's cabs in a trainset.

4.4 Explanation of Notation

Figure 10 provides explanation on notation used in state diagram and on the state diagram itself.

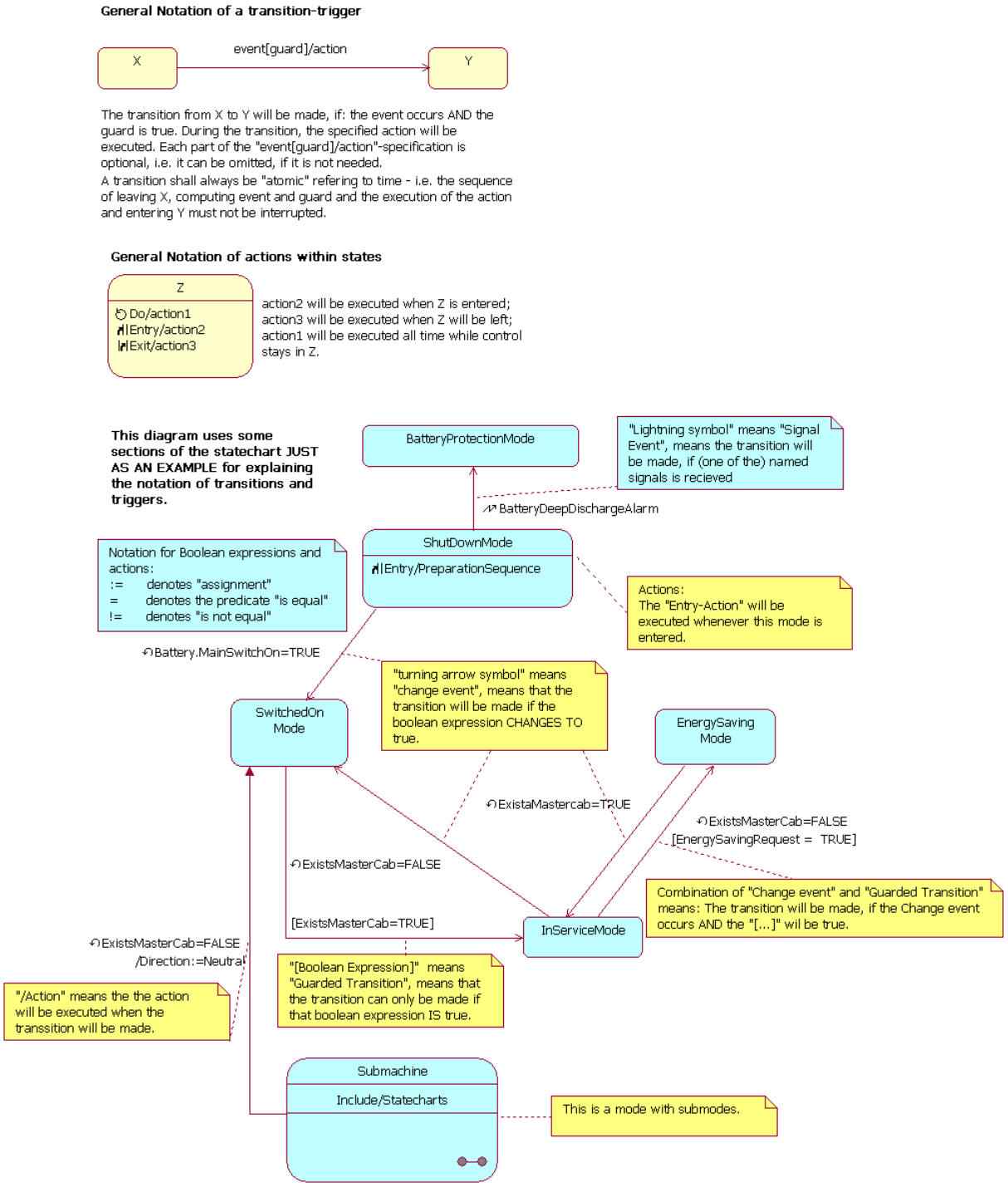

Figure 10 - Explanation for notation and block diagram

4.5 Open points and differences to current UIC 612-1

During a comparison between UIC 612-1 and the elaboration of this FIS, the following differences have been found:

- "shunting mode" is not specified UIC 612-1, but this mode might not be necessary, because several functions change when shunting (disabling the door-loop locally, change in exterior lighting, etc.);

- "emergency mode" is not specified UIC 612-1, but it is needed for disabling restrictions to retain traction-functionality in case of fire. This mode should only be activated by an explicit action of the driver;

- in UIC 612-1 the modes "switched on" "stand by" and "energy saving" refer to the "holding brake" to prevent the train from moving. For these modes this FIS uses "parking brake" (German:" Feststellbremse", "nicht: Haltebremse"):

- in this FIS, the battery main switch switches the battery power on or off only. The function "switch the battery power off after allowing time for a controlled shutdown of these consumers" and performing automated shutdowns (like those mentioned in UIC 612-1) are TCMS operations which can be triggered from HMI or other buttons, but not from by the battery main switch directly;

- direct transition from "switched on" to "stand by" (FIS: "service retention") according to UIC 612-1, sec. 4.4, transition "G", is not possible, because in "stand by" HV has to be supplied according to UIC 612-1, sec. 4.2;

- Cab Modes in this FIS represent the modes of a single cab; UIC 612-1, sec. 4.3, shows the relation between such cab modes and the train modes.

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