EULYNX Initiative

Europe's Rail Joint Undertaking

Modelling Standard

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Contents

ID	Type	Requirements
Eu.ModSt.1	Head	**1 Miscellaneous**
Eu.ModSt.2	Head	**1.1 Release information**
Eu.ModSt.3	Info	[Eu.Doc.30] Modelling Standard CENELEC Phase: 4-5 Version: 4.1 (0.A) EULYNX Baseline Set: 4 Approval date: ---
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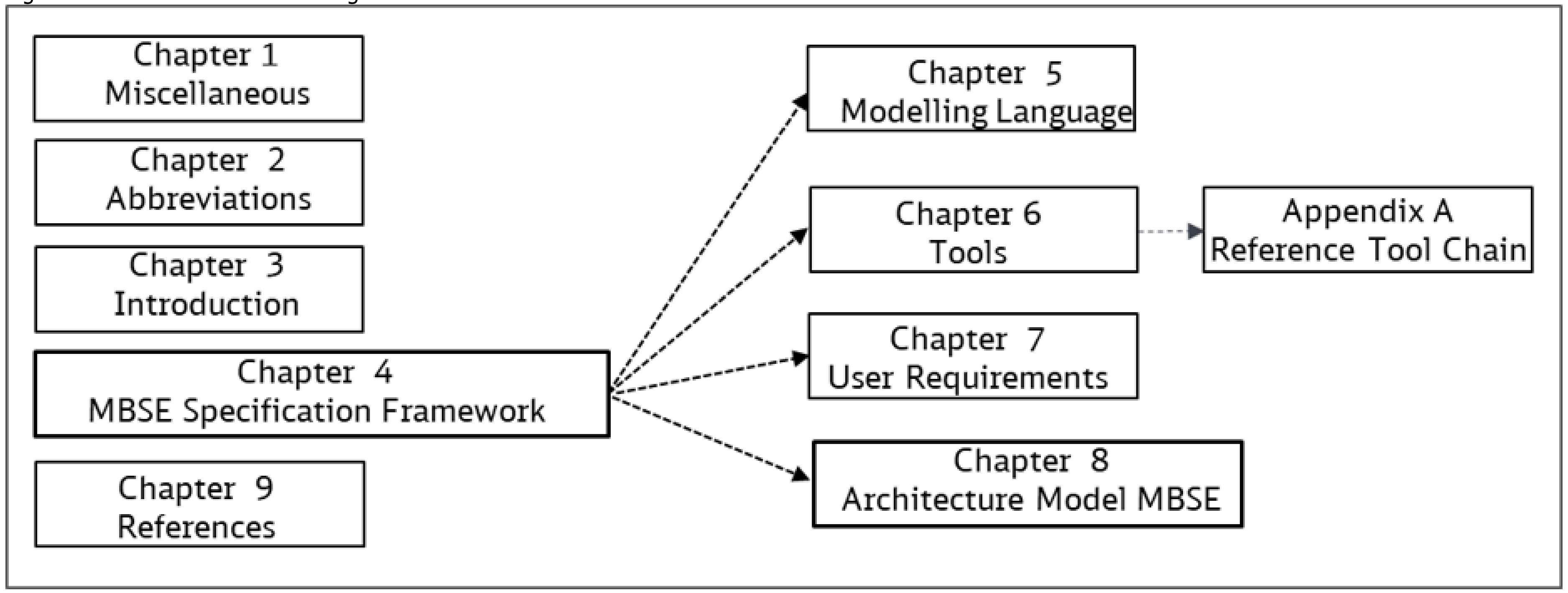
ID	Type	Requirements
Eu.ModSt.4	Head	**1.2 Impressum**
Eu.ModSt.5	Info	Publisher: **EULYNX Initiative** A full list of the EULYNX Partners can be found on www.eulynx.eu/index.php/members
Eu.ModSt.7	Info	Responsible for this document: EULYNX Project Management Office www.eulynx.eu
Eu.ModSt.1178	Info	Copyright EULYNX Partners All information included or disclosed in this document is licensed under the European Union Public Licence EUPL, Version 1.1.
Eu.ModSt.6	Head	**1.3 Purpose**
Eu.ModSt.49	Head	**1.3.1 About this Modelling Standard**
Eu.ModSt.50	Info	The goal of this Modelling Standard is to provide a mandatory guideline for Model-based Systems Engineering (MBSE) of digital Command Control and Signalling systems (CCS) in the railway domain.
Eu.ModSt.52	Info	According to MBSE introduced in this Modelling Standard the structure and functionality of digital CCS are specified using the engineering-oriented and standardised Systems Modeling Language (SysML) [1].
Eu.ModSt.1463	Info	Furthermore, the Systems Modelling Language is embedded in a specification framework compliant to the European standards on functional safety (EN 50126, EN 50128, EN 50129, EN 50159).
Eu.ModSt.53	Info	Based on the notion of a seamless development approach that heavily facilitates reuse, automation and innovation, an advanced and comprehensive modelling theory is used with the MBSE Specification Framework (MBSE SF) as core component. It enables a stepwise specification of digital CCS in a configurable, extendable, modular and reusable way.
Eu.ModSt.1975	Info	The MBSE Specification Framework (MBSE SF) contains, among others, an Architecture Model MBSE (AM MBSE) that facilitates the description of a digital CCS from different viewpoints capturing different stakeholder concerns and with varying degrees of granularity (different abstraction levels).
Eu.ModSt.54	Info	It should be noted that this document is a „living document", i.e. it will evolve over time. The present version reflects the procedures that are currently being applied and evaluated in the EULYNX Initiative. Future versions of the Modelling Standard will contain the topics left out in this version.
Eu.ModSt.864	Info	Correspondingly, as this standard is based on standard SysML, some example diagrams and pictures obtained from diverse sources, which show enhanced graphical features such as colours, shadows, 3D or embedded pictures, shall not be considered normative.
Eu.ModSt.7959	Info	It should also be noted that the inserted diagrams are only to be understood as examples for methodological explanation and, although there are similarities to the content of current specifications, are not intended to convey any specification-specific content. The relevant specifications should be consulted for specification-specific content.
Eu.ModSt.55	Head	**1.3.2 Audience**
Eu.ModSt.56	Info	The audience targeted by this Modelling Standard comprises engineers being familiar with CCS, modellers creating specification models in this domain, and parties interested in understanding the MBSE approach followed in EULYNX. Fundamental knowledge about requirements- and systems engineering methodology and the modelling language SysML, as, for example introduced in [24], is recommended.
Eu.ModSt.8	Head	**1.4 Terms and abbreviations**
Eu.ModSt.9	Info	The terms and abbreviations are listed in the EULYNX Glossary [Eu.Doc.9].
Eu.ModSt.853	Info	The present version of the Modelling Standard contains the abbreviations listed in *Chapter 2* of it.
Eu.ModSt.849	Head	**1.5 Related documents**
Eu.ModSt.850	Info	The current versions of documents related to this document are listed in the EULYNX Documentation plan [Eu.Doc.11].
Eu.ModSt.851	Info	• System Engineering Process [Eu.Doc.27]
Eu.ModSt.852	Info	• Interpretation rules for model-based requirements [Eu.Doc.29]
Eu.ModSt.10	Head	**2 Abbreviations**
Eu.ModSt.1262	Info	Abbr. Abbreviation

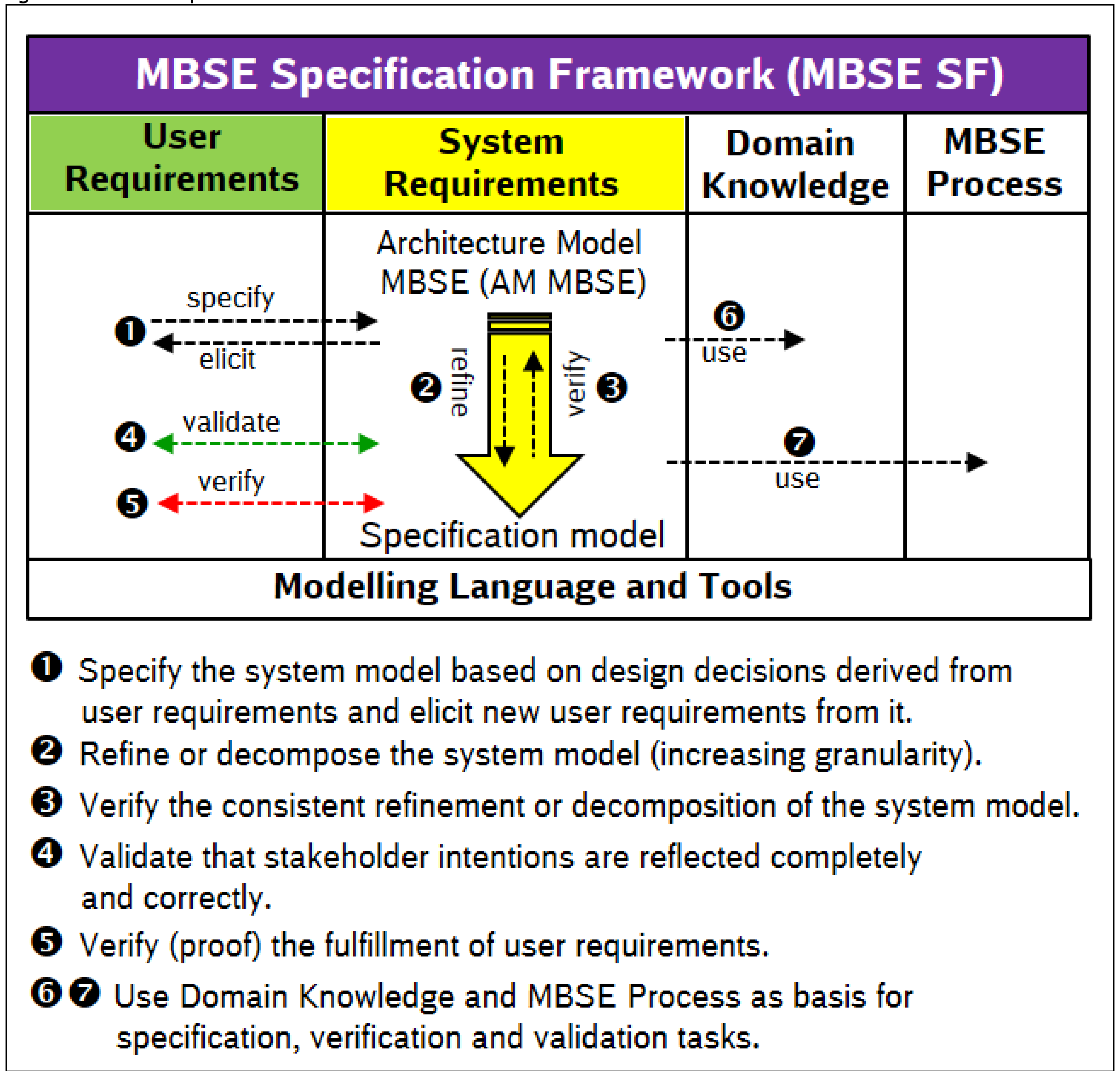
ID	Type	Requirements	
Eu.ModSt.11	Info	ASAL	Atego Structured Action Language
Eu.ModSt.1254	Info	AL	Abstraction level
Eu.ModSt.865	Info	AM	Architecture Model
Eu.ModSt.12	Info	bdd	Block definition diagram (SysML)
Eu.ModSt.13	Info	C	Command & Control layer
Eu.ModSt.1974	Info	CCS	Command Control and Signalling
Eu.ModSt.14	Info	Cd	Command
Eu.ModSt.7848	Info	CD	Connection Domain
Eu.ModSt.15	Info	CENELEC	European standards on functional safety (EN 50126, EN 50128, EN 50129, EN 50159)
Eu.ModSt.16	Info	Con	Configuration data
Eu.ModSt.1159	Info	DiaNo	Diagram number
Eu.ModSt.866	Info	D	Data
Eu.ModSt.17	Info	D-Port	Data port
Eu.ModSt.7879	Info	ESE	Environmental Structural Entity
Eu.ModSt.868	Info	EIL	Electronic interlocking
Eu.ModSt.20	Info	F	Field layer
Eu.ModSt.7874	Info	FA	Functional Architecture
Eu.ModSt.7875	Info	FE	Functional Entity
Eu.ModSt.22	Info	Gen	Generic
Eu.ModSt.23	Info	ibd	Internal Block Diagram (SysML)
Eu.ModSt.1976	Info	ILS	Interlocking System
Eu.ModSt.1522	Info	IM	Infrastructure Manager
Eu.ModSt.869	Info	ISE	Infrastructure Elements
Eu.ModSt.24	Info	LA	Logical Architecture
Eu.ModSt.27	Info	LS	Light Signal
Eu.ModSt.7876	Info	LSE	Logical Structural Entity
Eu.ModSt.28	Info	MBSE	Model-based systems engineering
Eu.ModSt.30	Info	MBSE SF	MBSE Specification Framework
Eu.ModSt.31	Info	MBSEP	MBSE Process
Eu.ModSt.32	Info	Msg	Message
Eu.ModSt.1299	Info	OE	Operational Entity
Eu.ModSt.1521	Info	ON	Operational Needs
Eu.ModSt.1266	Info	PDI	Process Data Interface

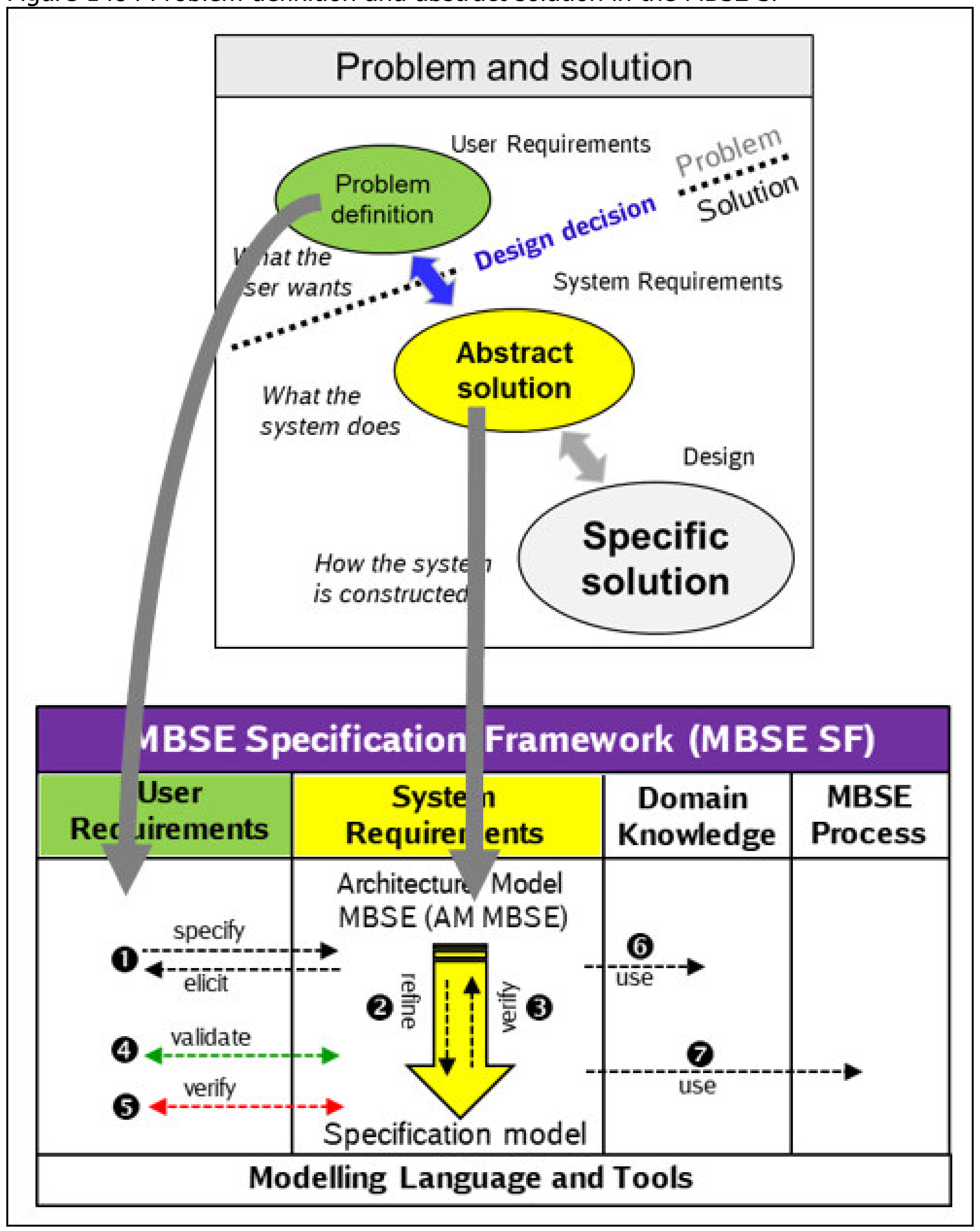
ID	Type	Requirements	
Eu.ModSt.1265	Info	PTC	Parametric Technology Corporation
Eu.ModSt.870	Info	RA	Risk Analysis and Evaluation
Eu.ModSt.34	Info	RAMS	Reliability, Availability, Maintainability, and Safety
Eu.ModSt.1977	Info	RCA	Reference CCS Architecture
Eu.ModSt.36	Info	S	Safety layer
Eu.ModSt.38	Info	SCI	Standard communication interface
Eu.ModSt.1450	Info	SCP	Safe Communication Protocol
Eu.ModSt.887	Info	SIUS	System Interface under Specification
Eu.ModSt.1982	Info	SoS	Systems of Systems
Eu.ModSt.7929	Info	SP	System Pillar
Eu.ModSt.875	Info	std	State diagram (SysML)
Eu.ModSt.1448	Info	stm	State machine
Eu.ModSt.37	Info	Sys	System
Eu.ModSt.873	Info	SysDef	System Definition
Eu.ModSt.44	Info	SubS	Subsystem
Eu.ModSt.874	Info	SUS	System under Specification
Eu.ModSt.41	Info	SysML	Systems Modeling Language
Eu.ModSt.42	Info	SySim	System simulation
Eu.ModSt.876	Info	T	Trigger
Eu.ModSt.7898	Info	TFA	Technical Functional Architecture
Eu.ModSt.7877	Info	TFE	Technical Functional Entity
Eu.ModSt.7878	Info	TSE	Technical Structural Entity
Eu.ModSt.43	Info	T-Port	Trigger port
Eu.ModSt.877	Info	ucd	UseCase diagram
Eu.ModSt.45	Info	UML	Unified modeling language
Eu.ModSt.46	Info	VAL	Validation
Eu.ModSt.47	Info	VER	Verification
Eu.ModSt.48	Head	**3 Introduction**	
Eu.ModSt.76	Head	**3.1 Motivation**	
Eu.ModSt.77	Info	Historically, operators of rail infrastructures were supplied with monolithic systems, based on proprietary interfaces. A few years ago, a re-orientation of the means of production of future systems was initiated. This entails purchasing modular systems. For example, an interlocking system (ILS) comprises an electronic interlocking (EIL), a command control system and field elements such as points, signals, and so forth. The fundamental concept of this new approach is having these parts supplied separately [12].	
Eu.ModSt.1465	Info	The new approach requires the development of standardised interfaces between the subsystems of a digital CCS such as a digital interlocking system. This will enable the different suppliers to supply compatible modules. This requires high quality specifications, as suppliers will be working with these blueprints and the operators of rail infrastructures will carry out the system integration tasks.	

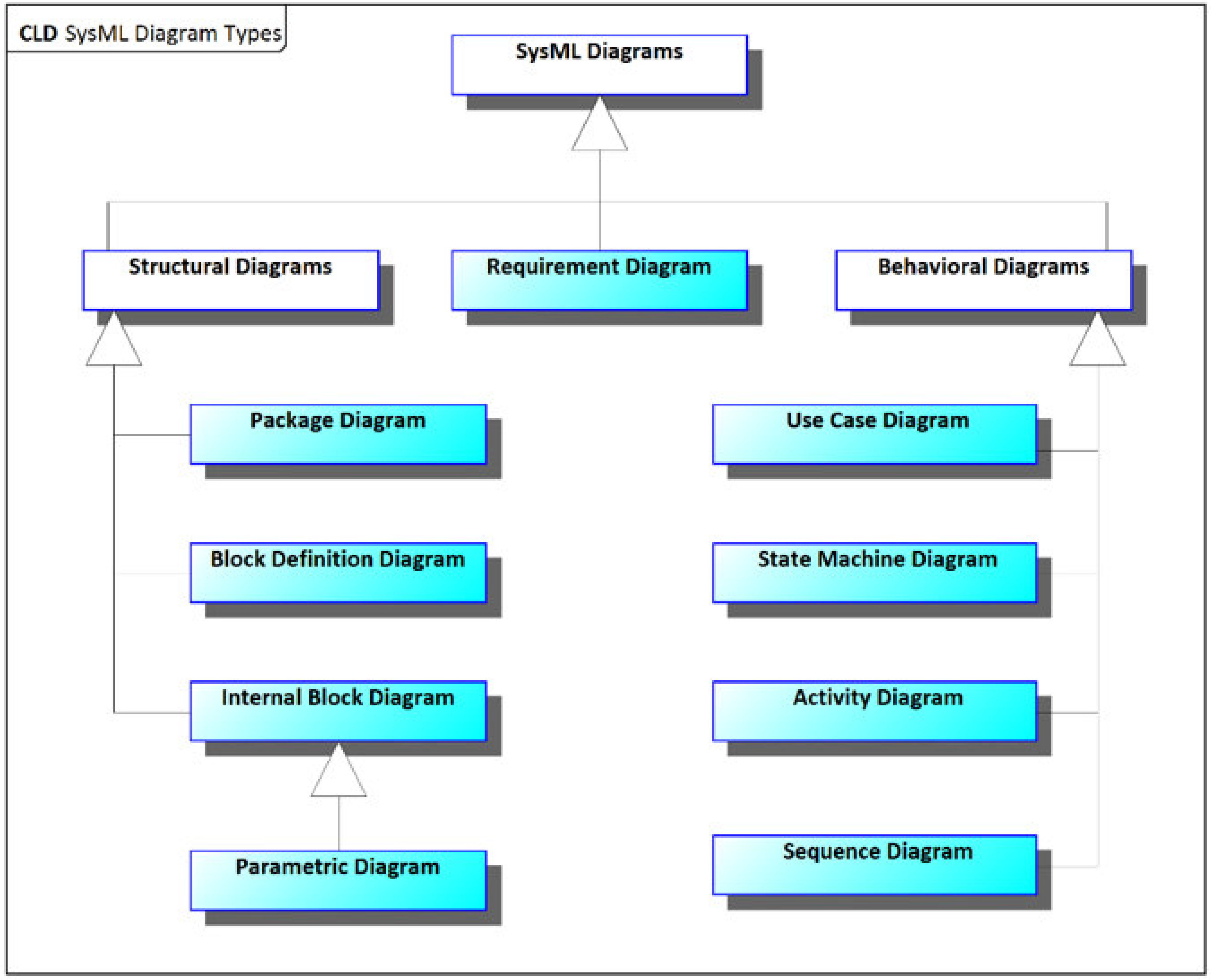
ID	Type	Requirements
Eu.ModSt.78	Info	Furthermore, the design of a harmonised railway system with the objective of a broad EU-wide implementation, as striven for in the System Pillar (SP), requires improving specification techniques**.** Thus, it is an important issue among infrastructure managers, the railway industry and researchers to find appropriate forms to specify the architectures of complex component systems right up to huge systems of systems (SoS).
Eu.ModSt.1464	Info	Different forms, like natural languages and graphical representations of system requirements, have been used and raised a number of criticisms. On the other hand, formal methods are considered to be one of the correct ways to specify and verify system requirements. They have been addressed in the railway domain for a number of years. To apply these formal methods, one needs a strong mathematical background.
Eu.ModSt.1978	Info	Thus, following the goal to create high quality specifications understandable also for people without a strong mathematical background, the popular systems modeling language (SysML) [1] is used as specification language in the MBSE approach introduced in this Modelling Standard.
Eu.ModSt.79	Info	The use of standardised interfaces and highly detailed system specifications creates a need for safety to be part of the specifications. The adoption of MBSE has therefore been part of this transformation, by proving through modelling and simulation that system specifications meet safety critical requirements.
Eu.ModSt.80	Info	Studies of system developments show that the capture of requirements is one of the most decisive and critical steps in system development. There are many problematic aspects connected to the identification and description of requirements in software-intensive projects. The following three form the most important aspects as mentioned in [4]: • requirements are not completely and accurately identified and understood by the application expert; • requirements are not correctly specified, although completely and accurately identified and understood; • requirements are correctly specified using informal techniques, that are not properly interpreted and conceived by the system designer or the implementer. All three problems may lead to a considerably more expensive and time consuming system development.
Eu.ModSt.81	Info	Based on these observations, an engineering-oriented model-based method for the stepwise specification of digital CCS using the Systems Modeling Language (SysML) [1] has been developed to support different professionals, especially railway engineers, to specify, validate and verify the corresponding system requirements.
Eu.ModSt.2010	Info	The model-based requirements definition is used to: • enable a continuous CENELEC-compatible top-down specification of a (sub)system (refinement of the requirements across different abstraction levels) • describe the functional requirements of a (sub)system or an interface operationally and therefore suitable for simulation, i.e. testable in a uniform format • support achieving consistency, non-ambiguity and completeness of the requirements as far as possible • allow for the testing by simulation of the functional requirements of a (sub)system or an interface already during the specification phase (moving error detection to the specification phase) • support the generation of (sub)system or interface test cases from the requirements specification
Eu.ModSt.2012	Info	The system requirements are described in a consistent, non-ambiguous and compact form using the standardised semiformal language SysML. It should be noted that the SysML model elements and their interaction are to be understood as a means of describing the system requirements and not as implementation specifications. They are to be implemented with regard to their semantics.
Eu.ModSt.7899	Info	The type of representation and the underlying methodology sometimes differs from common text-based specifications. However, the requirements can be further processed into functional specifications and products in accordance with the tested processes.
Eu.ModSt.65	Head	**3.2 Structure of the Modelling Standard**
Eu.ModSt.66	Info	The Modelling Standard is structured as depicted in *Figure 67*.

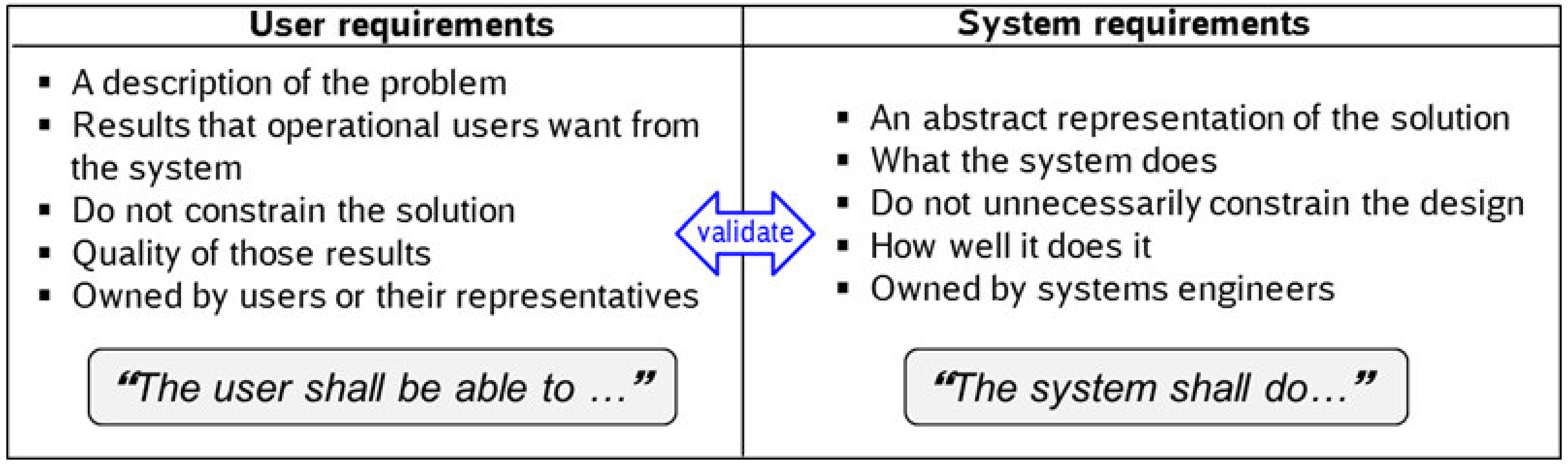
ID	Type	Requirements
Eu.ModSt.67	Info	Figure 67 Structure of the Modelling Standard 
Eu.ModSt.68	Info	The main contents of the Modelling Standard are covered in *Chapters 3 - 10*.
Eu.ModSt.69	Info	In ***Chapter 3***, an introduction to the Modelling Standard is given.
Eu.ModSt.71	Info	In ***Chapter 4***, an introduction to the structure of the MBSE Specification Framework (MBSE SF) is given. The MBSE SF is the basis for the development of a stepwise model-based specification of all the design decisions that are made during the different needed engineering activities.
Eu.ModSt.72	Info	In ***Chapter 5***, the modelling language being used is introduced.
Eu.ModSt.7928	Info	In ***Chapter 6,*** the requirements for supporting tools necessary to implement the EULYNX MBSE process are outlined. To complement this, the tool chain currently used in EULYNX is described in ***Appendix A***. It fully supports the EULYNX MBSE process and serves as a reference for the use of alternative tool chains.
Eu.ModSt.73	Info	In ***Chapter 7***, the area „User Requirements" of the MBSE SF is described.
Eu.ModSt.74	Info	In ***Chapter 8***, the Architecture Model MBSE (AM MBSE) is introduced and the constituent model views are described. The characteristics of the EULYNX subsystems are highlighted and the principles of model-based requirements definition are explained. Furthermore, the MBSE process is presented in a simplified way. The main part of the chapter is dedicated to the description of the model views and the corresponding modelling rules: 8.1 Overview of the EULYNX MBSE methodology 8.1.1 Characteristics of EULYNX subsystems 8.1.2 Principle of model-based definition of requirements 8.1.3 Overview introduction to the EULYNX MBSE Process **8.2 Model views - General modelling rules** 8.2.1 Binding of requirements 8.2.2 Modelling Pattern for interlocking systems 8.2.3 Introduction to basic structural model elements 8.2.4 Interface centric specification **8.3 Model views used to specify EULYNX subsystems** **8.4 Model views used to specify EULYNX interfaces** **8.5 Model views "Functional Entity" and "Technical Functional Entity" - Description** **8.6 Model views "Functional Entity" and "Technical Functional Entity" - Modelling rules**
Eu.ModSt.70	Info	In ***Chapter 9,*** the references are listed.
Eu.ModSt.7933	Info	***Appendix A (chapter 10)*** describes a reference tool chain that enables the implementation of the EULYNX process.
Eu.ModSt.236	Head	**4 MBSE Specification Framework**

ID	Type	Requirements
Eu.ModSt.1492	Info	Today's and, even more so, the future development of CCS systems in the railway domain faces a variety of challenges. Key success factors to meeting these challanges are suitable architecture description concepts for abstraction and structure CCS architectures at different levels of granularity. The result of these concepts is a seamless development approach that heavily facilitates reuse and automation. As stated in [25], a basic requirement for such a seamless approach is a clear notion of a system that is formalised by a comprehensive modelling theory. According to this modelling theory, a modelling framework has to provide appropriate models and description techniques for modelling the different aspects and artefacts of system development.
Eu.ModSt.237	Info	Inspired by [25] and [26], this Modelling Standard introduces the MBSE Specification Framework (MBSE SF) in order to meet those aforementioned challenges. Focusing on system requirements specification and interface requirements specification tasks to be carried out at the infrastructure manager side, it facilitates the seamless model-based specification of • **EULYNX subsystems under Specification (SUS)** or • **EULYNX adjacent System interfaces and subsystem Interfaces under Specification (SIUS)** as well as the verification and validation of the resulting specification artefacts.
Eu.ModSt.1493	Info	The MBSE SF consists of five areas (see *Figure 238*), namely • **User Requirements,** • **System Requirements,** • **Domain Knowledge,** • **MBSE Process** and • **Modelling Language and Tools.**
Eu.ModSt.1494	Info	Guided by a MBSE process and based on Domain Knowledge, these areas strictly distinguish between the **problem domain (User Requirements)** and the **solution domain (System Requirements)**.

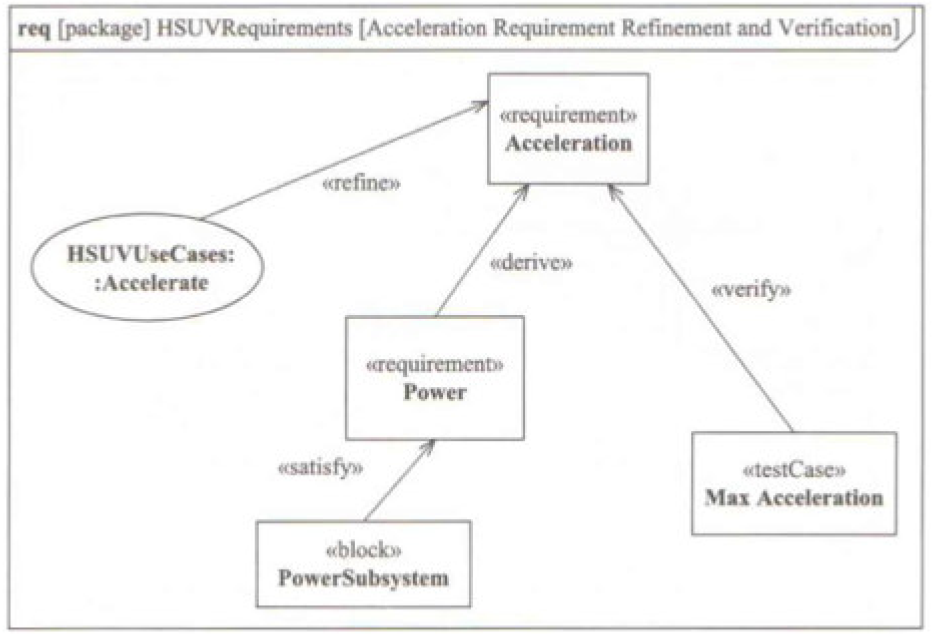
ID	Type	Requirements
Eu.ModSt.238	Info	Figure 238 MBSE Specification Framework 
Eu.ModSt.239	Info	**User Requirements** The area "User Requirements" contains the model of the problem domain (problem definition) in the form of user requirements (see Fig. 1484). User requirements allow the different stakeholders to explicitly state what is expected from the future system. They are the main source for the derivation of design decisions as basis for the creation of the artefacts of an abstract system solution (system model), which itself may be again the source for the elicitation of new (possibly more granular) user requirements.
Eu.ModSt.245	Info	It has to be verified that the design decisions derived from the user requirements are incorporated in the system model completely and correctly. In other words, it has to be proved that the system model fulfils all defined user requirements.
Eu.ModSt.1468	Info	Furthermore, user requirements are among others (e.g. domain knowledge), the source for the validating that the system model reflects the stakeholder intentions completely and correctly.
Eu.ModSt.1486	Info	The area "User Requirements" is described in more detail in *chapter 7*.
Eu.ModSt.240	Info	**System Requirements** The area "System Requirements" contains the model of the solution domain in the form of a system model representing an abstract solution of the system (see *Figure 1484*). There, the design decisions derived from the user requirements are documented (specified) traceable with varying degrees of granularity (different abstraction levels) based on the Architecture Model MBSE (AM MBSE). Each abstraction level represents design decisions about the refined or decomposed implementation of its predecessor (refine dependency).
Eu.ModSt.244	Info	The correct, complete and consistent refinement or decomposition has to be approved in verification steps (verify dependency).

ID	Type	Requirements
Eu.ModSt.1487	Info	The Architecture Model MBSE is described in more detail in *chapter 8*.
Eu.ModSt.243	Info	**Domain Knowledge** The Domain Knowledge model comprises the available knowledge of the problem domain, similar to a project glossary. It hence makes up part of the context of knowledge of the system and can be used to mitigate misinterpretation, to reduce ambiguity, and to provide a possibility for early verification and validation of the system model [25].
Eu.ModSt.1488	Info	The domain knowledge relevant for EULYNX is defined in Eu.Doc.9 EULYNX Glossary and Eu.Doc.10 EULYNX Domain Knowledge. The documents are available on the EULYNX website [31].
Eu.ModSt.242	Info	**MBSE Process** The relationships between artifacts of the system model are specified by relations. Such a relation can be expressed by a process activity that defines a general technique for artefact creation and analysis. In the MBSE Process, multiple of these process activities are combined to a sequence. The output of one process activity can be input of another process activity. Furthermore, one process activity's postcondition might ensure that another process activity's precondition is met.
Eu.ModSt.1489	Info	The EULYNX MBSE process is described in principle in *chapter 8.1*. A detailed description of the process steps will be given in a separate document in the future. The EULYNX System Engineering process is currently documented in Eu.Doc.27 and the procedure for verification and validation of the specification models in the EULYNX verification and validation plan (Eu.Doc.31). The documents are available on the EULYNX website [31].
Eu.ModSt.1467	Info	**Modelling Language and Tools** The suggested modelling language and the requirements for supporting tools necessary to implement the EULYNX MBSE process. are introduced in *chapter 5* and *chapter 6* respectively.
Eu.ModSt.1484	Info	Figure 1484 Problem definition and abstract solution in the MBSE SF 

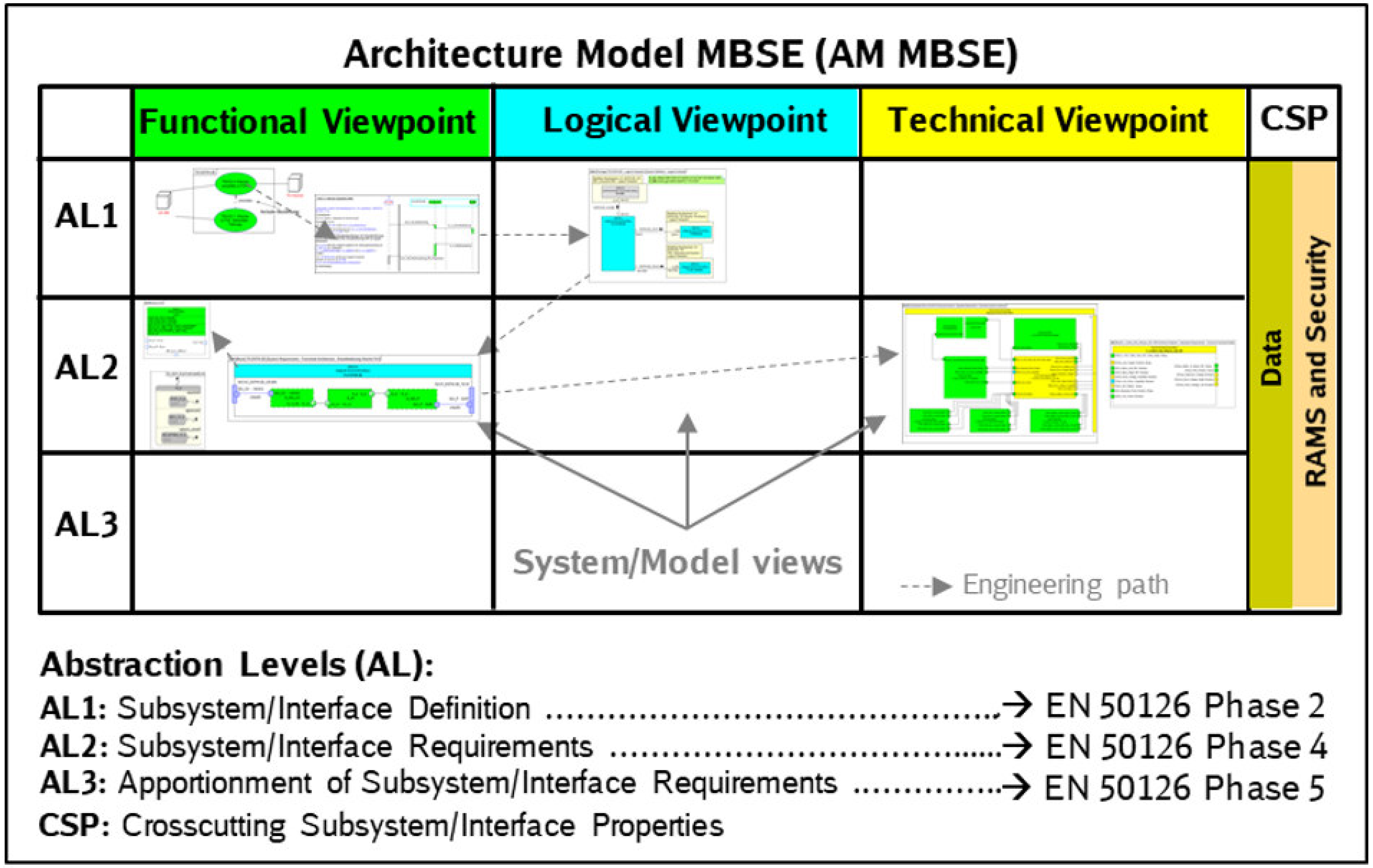
ID	Type	Requirements
Eu.ModSt.246	Head	**5 Modelling Language**
Eu.ModSt.247	Head	**5.1 Systems Modeling Language (SysML)**
Eu.ModSt.248	Info	The Systems Modeling Language [1] is used with the objective to document requirements and to specify artefacts in a standardised, correct, complete and consistent way within the framework of the MBSE specification structure, as outlined above.
Eu.ModSt.249	Info	SysML is a standardised modeling language dedicated to systems engineering applications. It is a UML profile that not only reuses a subset of UML 2.5 [2], but also provides additional extensions to better satisfy Systems Engineering's specific needs. It is intended to help to specify and design complex systems and their subsystems and enable their analysis, verification and validation. These systems may consist of heterogeneous components such as hardware, software, information, processes, personal and facilities [1].
Eu.ModSt.250	Info	Nine SysML diagrams (see Fig.251) define a concrete syntax that describes how SysML concepts are visualized graphically or textually. Each diagram represents a specific view of the model of the SUS or SIUS. In the SysML specification [1], this notation is described in tables that show the mapping of the language concepts into graphical symbols on diagrams. Diagrams used in this Modelling Standard will be outlined in the following chapters. For a detailed description, however, the SysML specification [1] shall be referred to.
Eu.ModSt.251	Info	Figure 251 SysML diagram taxonomy [1] 
Eu.ModSt.252	Head	**5.2 Action Language**
Eu.ModSt.253	Info	The specification approach described in this modeling standard follows the objective of creating executable specification models. In order to specify the necessary executable behaviours in SysML, such as block operations or transition effects on state machines the Atego Structured Action Language (ASAL) is used.
Eu.ModSt.254	Info	ASAL is an UML Action Language suitable for specifying executable algorithms in a target language independent way. It is used to specify the Event Action Blocks in SysML models that use state machine diagrams describing the stimulus-response behaviour of a SUS or a SIUS.

ID	Type	Requirements
Eu.ModSt.255	Info	Furthermore, ASAL is used to describe the transformational aspects of a SUS or SIUS (data flow). The logical structure of the input and output data, and the algorithm that computes the transformation are specified in the body of corresponding block operations.
Eu.ModSt.256	Info	A description of ASAL is provided in *chapter 8.6.8* (see also [13]).
Eu.ModSt.7697	Head	**5.2.1 The role of data types**
Eu.ModSt.161	Info	According to the specification approach described in this Modelling Standard, a data type is a classification based on identification of one of the various types of data (e.g. the type of a message sent along a SUS interface). The data type such as Boolean, Integer or String restrict the possible values corresponding to that type, the meaning of data, the way values of that type can be stored and how a state machine receiving such data reacts.
Eu.ModSt.162	Info	A data type may be refined in the tradition of data refinement [4]. We may, for example, type a message in the specification model as string, and after implementation level design of the SUS or SIUS instead of sending strings, bits are sent. Thus, a data type used in the specification model may be refined and an implementation-oriented data type may be used by the supplier of the SUS or SIUS. However, it must be ensured that the new data type complies with its predecessor (verification of the refinement).
Eu.ModSt.301	Head	**6 Tools**
Eu.ModSt.7912	Info	The EULYNX MBSE process shall be supported by a toolchain that enables the creation of SysML specification models, their static checking for completeness, correctness and consistency and the simulation-based validation of the models. It should be noted here that the creation of the executable models (virtual prototypes) can take place directly, i.e. without the need for the intermediate step of a model transformation.
Eu.ModSt.7913	Info	Furthermore, the application of formal methods must be made possible (e.g. formal proof of safety properties, model checking, etc.).
Eu.ModSt.7914	Info	The modelling tool shall provide a link to a requirements management tool that allows the representation of specification model elements in the form of atomic requirements. These must be able to be transformed into the standardised Requirements Interchange Format (ReqIF) and exchanged with suppliers.
Eu.ModSt.7915	Info	The tool chain currently used in EULYNX is shown serving as a reference for the use of alternative tool chains in Appendix A - Reference tool chain.
Eu.ModSt.312	Head	**7 User Requirements**
Eu.ModSt.313	Head	**7.1 Overview**
Eu.ModSt.107	Info	As many standards such as the EN 50126 [17] do not distinguish between a user requirements and system requirements definition phase, this has to be clarified in order to meet the objective of this Modelling Standard. The MBSE Specification Framework introduced in *chapter 4* takes account of this providing a structure to explicitly define user requirements separated from system requirements.
Eu.ModSt.314	Info	As already stated, user requirements are depicted in the area „User Requirements" of the MBSE SF and describe the problem domain (problem definition). They allow the stakeholders (users) to explicitly state what is expected from the SUS/SIUS. They should define the results wanted by the stakeholders i.e. what the stakeholders want to be able to do with the SUS/SIUS and the expected quality. However, they should not make any comments or statements about how the SUS/SIUS is to be created or provided.
Eu.ModSt.108	Info	User requirements define the results that the users want, irrespective of any functional breakdown (see *Figure 112*). They must be separate from system requirements and must be defined first.
Eu.ModSt.110	Info	The system requirements must solve the problem of the user, i.e. they must satisfy the user requirements. This has to be approved by means of validation.
Eu.ModSt.112	Info	Figure 112 Differentiating user and system requirements 
Eu.ModSt.1485	Info	The task of defining user requirements encompasses the whole MBSE Process. They are the main source for the creation of the model of an abstract system solution which represents the system requirements.

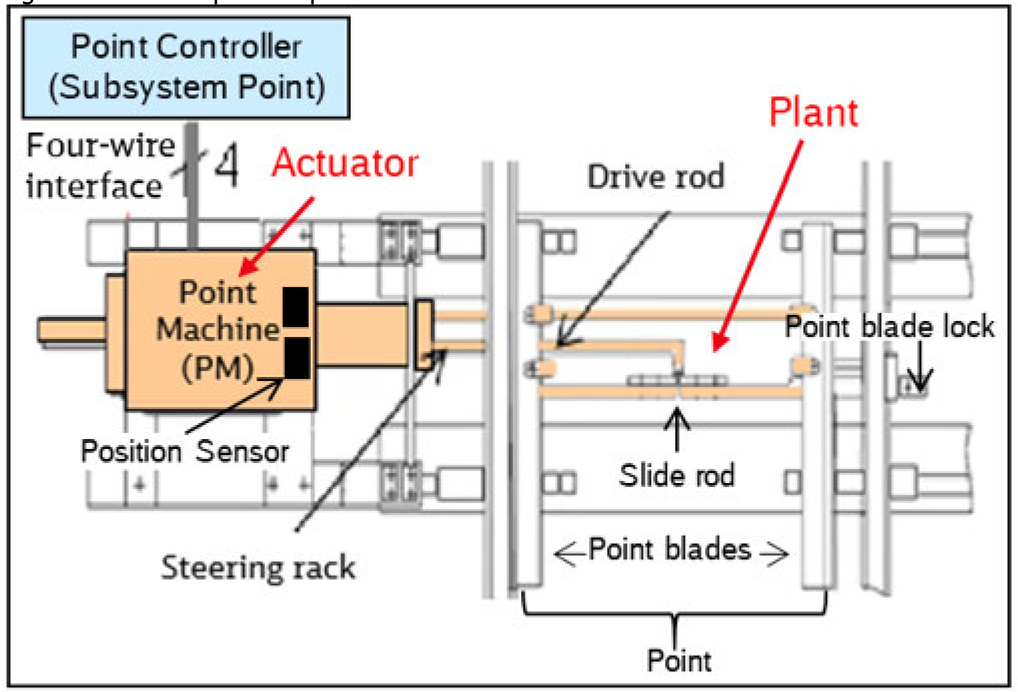
ID	Type	Requirements
Eu.ModSt.316	Info	User requirements should be stated by (or on behalf of) the stakeholders for whom the SUS/SIUS is being developed. Even if the stakeholders do not actually write the user requirements, they should review and when they are happy "endorse" them, and hence take an "ownership" of them.
Eu.ModSt.1473	Info	User requirements may be divided into different classes such as operational requirements, architectural requirements, technical constraints, quality requirements, safety requirements and so on. Safety requirements are an important class of user requirements and thus shortly introduced in *chapter 7.2*. As the main focus of this Modelling Standard is not the elicitation of user requirements, the other different types are not further described.
Eu.ModSt.1474	Head	**7.2 Safety requirements**
Eu.ModSt.1475	Info	Safety requirements, also referred to as safety goals, state safety invariants, i.e. conditions that could lead to hazardous situations if they are not met. They can be split into the following two categories [9]: - Safety invariants: What may not happen under any circumstances, - Safety overrides: Who may do what under which circumstances.
Eu.ModSt.1476	Info	The origin or approach for defining safety requirements can vary. In this section, characteristics of three different methods [26] to create safety requirements are outlined.
Eu.ModSt.1478	Info	**Ad-hoc elicitation** The first it is referred to as **ad-hoc**. Such requirements are specific to a particular system and are based on the design principles for that system. One such requirement for a relay-based interlocking may state that "Front coil of relay L may have current only if relay Ljg has dropped".
Eu.ModSt.1481	Info	**Regulations-based elicitation** The second is referred to as **regulations-based**. Requirements are based on safety standards, e.g. based on formalising requirements in applicable rules and regulations. One such requirement for an interlocking may state that "a main signal may clear only if there is an established flank protection", together with appropriate definitions of what "clear" means and what the requirements on flank protection means.
Eu.ModSt.1480	Info	**Hazard-based elicitation** The third is referred to as **hazard-based**. Requirements are based on making an analysis (hazard analysis) of the different types of possible hazards (e.g. frontal collision of trains, derailment and so on) and for each possible hazard, require that it is impossible. Essentially, the purpose of hazard analyses is to identify operational conditions of the SUS's functionality that could lead to harm. The main outputs of such an analysis are hazards and safety goals (i.e. safety requirements).
Eu.ModSt.1482	Info	Safety requirements should be documented separately from other user requirements and incorporated into the system`s requirements artefacts. The complete and correct incorporation of the safety requirements has to be assured using verification methods such as simulation-based falsification methods or formal verification methods [25].
Eu.ModSt.1490	Info	**Simulation-based falsification methods** can work directly on simulation models such as executable SysML state machines. In general, given a safety requirement in some form of logic, these methods leverage mathematical methods, trying to falsify the requirement. This means that the algorithms are geared towards identifying the "worst possible" simulation run with respect to the given requirement. If the method succeeds in producing a run which violates the requirement, it is falsified and the counterexample can be used to refine either the requirement or the simulation model. If it does not, no formal guarantees about the fulfillment of the requirement can be made.
Eu.ModSt.1491	Info	In contrast, **formal verification methods** aim to provide formal proof of the correctness of the requirement for the given model of the SUS/SIUS. Because this proof cannot be provided by simulation alone, a strictly formal model is required.
Eu.ModSt.317	Head	**7.3 Formulation of user requirements**
Eu.ModSt.318	Info	This Modelling Standard does not have the intention to impose obligations how user requirements have to be formulated, but suggests a formulation as textual requirements according to the SysML specification [1].
Eu.ModSt.319	Info	SysML introduces the requirement diagram which provides the means to depict requirements and to relate them to other specification, design or verification models. The requirements can be represented in graphical, tabular, or tree structure formats.
Eu.ModSt.320	Info	The strength and usefulness of a requirement diagram consists in the fact that it allows to easily understand the relations between the requirements and other model elements. The semantics of these relationships and other diagram elements are explained in [1].
Eu.ModSt.321	Info	A requirement can be decomposed into sub-requirements in order to organize multiple requirements as a tree of compound requirements. Moreover, a requirement can be related to other requirements as well as to other elements, such as analysis, implementation, and testing elements (see *Figure 323*).
Eu.ModSt.322	Info	Therefore, a requirement can be generated or extracted from another requirement by using the *derive* relationship. Furthermore, requirements can be fulfilled by certain model elements using the *satisfy* relationship. The verify relationship is used to verify a requirement by applying different test cases.
Eu.ModSt.1479	Info	User requirements (especially safety requirements) should be verifiable, so that it is possible to distinguish a system model satisfying the user requirements from one that does not do. Typical reasons for user requirements not being verifiable include: - The user requirement is incomplete. - The user requirement is poorly written. - The user requirement is not described at the level it will be verified.

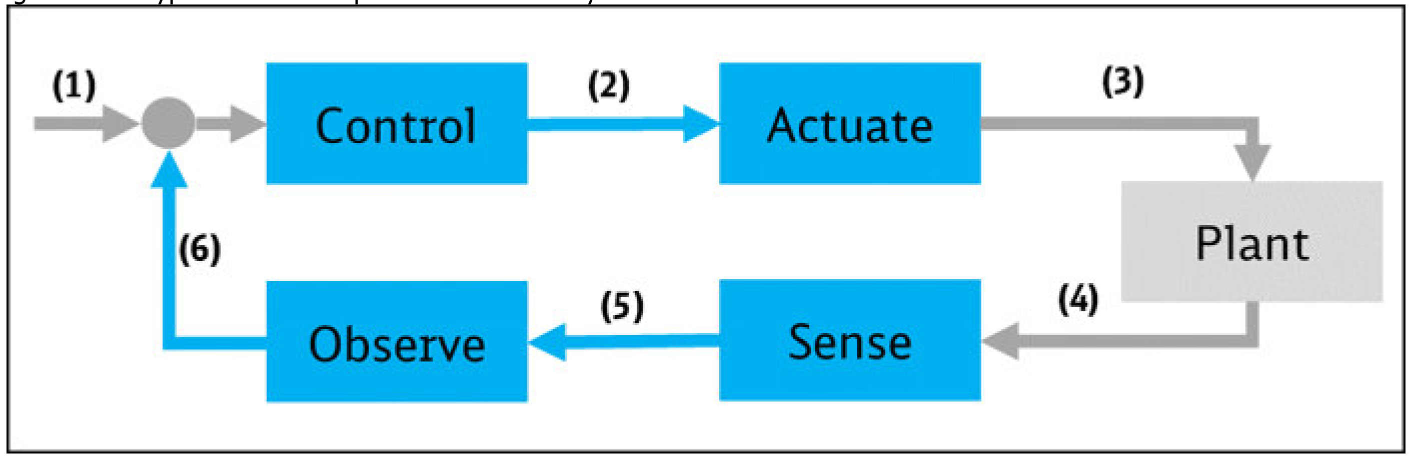
ID	Type	Requirements
Eu.ModSt.323	Info	Figure 323 Requirement diagram example [1] 
Eu.ModSt.332	Head	**8 Architecture Model MBSE**
Eu.ModSt.330	Info	The design decisions derived from the user requirements are documented traceable in the area "Architecture Model MBSE" of the SF MBSE in the form of a model of the abstract solution of a SUS or a SIUS.
Eu.ModSt.335	Info	Focusing on specification tasks to be carried out at infrastructure manager (IM) side, the Architecture Model MBSE (see *Figure 340*) facilitates the description of a SUS or a SIUS from different viewpoints capturing different stakeholder concerns and with varying degrees of granularity (different abstraction levels).
Eu.ModSt.1516	Info	**Viewpoint** A viewpoint is a specification of the conventions for constructing and using a view. Viewpoints comprise patterns or templates from which to develop individual views by establishing the purpose and audience for a view and the techniques for its creation and analysis (based on [29]).
Eu.ModSt.342	Info	**Abstraction level** An abstraction level defines a specific level of abstraction and granularity at which the SUS/SIUS is examined. The level of granularity of the respective abstraction level is in turn determined by a structural characteristic that stems from the layer above. Initially we consider the SUS/SIUS as a whole [25]. In other words, an abstraction level describes the whole of a SUS/SIUS under a certain degree of abstraction, i.e. it represents the amount of complexity by which a SUS/SIUS is viewed. The higher the level, the less detail. Any abstraction level contains several appropriate views.
Eu.ModSt.1561	Info	To change the degree of granularity for a given view to a higher degree, a low degree view is refined into a number of more detailed SUS/SIUS views following the principle of divide and conquer. This step can basically be performed from any viewpoint.
Eu.ModSt.357	Info	**Refinement** Refinement refers to the process of detailing an analysis or design element while preserving its semantics [25]. The degree of abstraction decreases from top to bottom, i.e. the lower the degree of abstraction the higher the degree of refinement of corresponding views.
Eu.ModSt.358	Info	The EULYNX MBSE methodology is based on two basic refinement relations, namely, behavioural and interface refinement. These relations are described as follows [4].
Eu.ModSt.360	Info	**Behavioural refinement** Behavioural refinement relates to specifications of the same syntactic interface. The refined (more precise) specification may impose further functional and non-functional requirements in addition to those imposed by the given (more abstract) specification.
Eu.ModSt.362	Info	**Interface refinement** Interface refinement relates to specifications of different syntactic interfaces. The refined specification is a „behavioural refinement" of the given specification with respect to a translation of its input/output histories. For example, interface refinement allows to replace a message by several messages, and vice versa or instead of transmitting natural numbers, bits may be sent (data refinement).
Eu.ModSt.1520	Info	**Decomposition** In contrast to refinement, decomposition denotes the partitioning of an analysis element or design element, or a logical/technical component into parts [25].
Eu.ModSt.336	Info	**View** A view is a representation of a whole SUS/SIUS from the perspective of a related set of concerns (based on [29]. In other words, a SUS/SIUS description from a specific viewpoint and with a specific degree of granularity is called a view [25]. Within the scope of this Modelling Standard, a view is synonymously referred to as "view", "model view" or "system view".

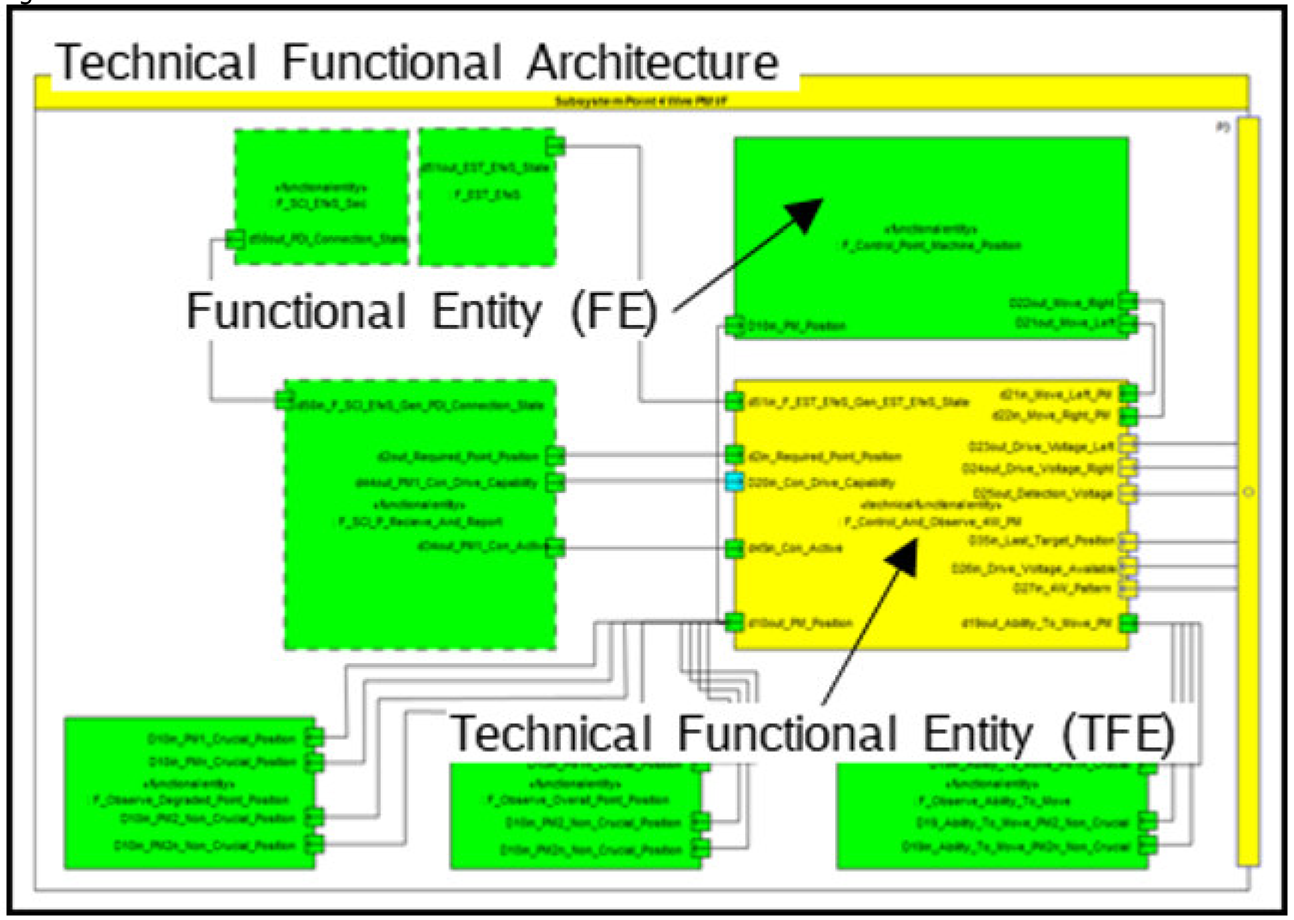
ID	Type	Requirements
Eu.ModSt.1336	Info	**Engineering path** As illustrated in *Figure 340* the development of views for a SUS or SIUS with a specific degree of granularity is summarised in an engineering path.
Eu.ModSt.334	Info	The AM MBSE facilitates the seamless, model based specification of digital CCS in the railway domain with three core IM-related viewpoints namely • **Functional Viewpoint**, • **Logical Viewpoint** and • **Technical Viewpoint**.
Eu.ModSt.331	Info	The viewpoints describe a SUS or a SIUS with respect to different concerns. However, these descriptions may vary in their degree of granularity. For complex SUS/SIUS in particular, it is reasonable to start with rather high-level descriptions. Once these high-level descriptions have been created, these views are typically refined and detailed step by step. Therefore, the AM MBSE supports views with different degrees of granularity i.e. views at different abstraction levels.
Eu.ModSt.333	Info	Following EN 50126 [17] the AM MBSE consists of three core IM-related abstraction levels (AL) namely **AL1: Subsystem/Interface Definition**, **AL2: Subsystem/Interface Requirements** and **AL3: Apportionment of Subsystem/Interface Requirements**.
Eu.ModSt.3561	Info	The AM MBSE can also be applied to specify an overall system, which is not the case in EULYNX at the moment. In this case, the abstraction levels are named as follows: AL1: System Definition, AL2: System Requirements and AL3: Apportionment of System Requirements.
Eu.ModSt.1526	Info	Each of the IM-related core AL may again be decomposed in further AL such as AL1.1, AL1.2 and so on as appropriate. Any AL represents design decisions about the refined or decomposed implementation of its predecessor and the specification of the outcome of this decisions by means of appropriate views.
Eu.ModSt.1525	Info	**Crosscutting system properties (CSP)** One of the principles of the AM MBSE is the continuous engineering of crosscutting system properties. This principle aims at establishing the ability to consider crosscutting properties of the SUS/SIUS. Typical crosscutting properties are RAMS [17], security and real-time properties of the SUS/SIUS: they must be considered in any engineering activity and the corresponding artefacts [25].
Eu.ModSt.337	Info	Safety, for example, typically defined as freedom from unacceptable risk (of harm), affects almost all process steps in a development lifecycle. For this reason, safety is not represented in a single viewpoint but as a quality aspect of the AM MBSE that has a crosscutting influence and is integrated into several viewpoints.
Eu.ModSt.1242	Info	The growing complexity of safety-critical railway systems is leading to increased complexity in safety analysis models. It is therefore not appropriate to develop functionality and consider safety in separate tasks. Safety aspects have to be integrated as tightly as possible into the development process and its models [25].

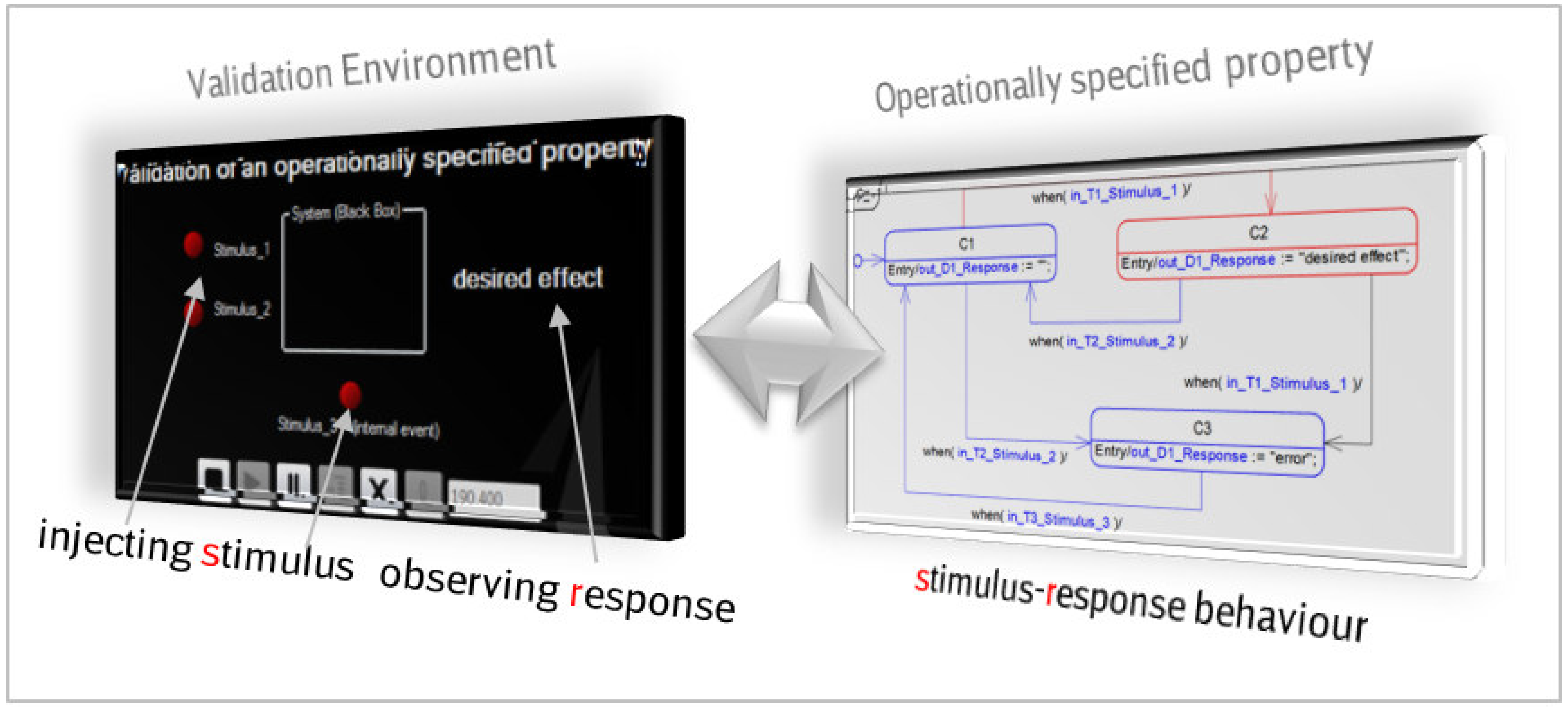
ID	Type	Requirements
Eu.ModSt.340	Info	Figure 340 Architecture Model MBSE 
Eu.ModSt.879	Head	**8.1 Overview of the EULYNX MBSE methodology**
Eu.ModSt.2110	Info	The EULYNX initiative is aiming at specifying EULYNX subsystems and standardising their interfaces (SCI, SMI, SDI) and the interfaces between adjacent systems.
Eu.ModSt.1663	Info	This chapter provides an overview of the used MBSE methodology. The EULYNX MBSE methodology assumes that a definition of the EULYNX architecture is known. Thus, it is currently not designed to describe system architectures but black-box specification models of EULYNX subsystems, their standardised interfaces and standardised interfaces between adjacent systems.
Eu.ModSt.7012	Head	**8.1.1 Characteristics of EULYNX subsystems**
Eu.ModSt.7014	Info	Command control and signalling (CCS) systems such as EULYNX subsystems are reactive control systems [32] and most of them safety-critical [11]. They are characterized by the constant interaction and synchronisation between the system and its environment.
Eu.ModSt.88	Info	The terms "system" and "reactive system" shall be explained first.
Eu.ModSt.7702	Head	**8.1.1.1 System**
Eu.ModSt.84	Info	A system is a technical or a sociological structure consisting of a group of entities combined to form a whole that can work, function, or move interdependently and harmoniously. A system may consist of various system elements called subsystems, that can be understood as systems on their own. Systems are thus hierarchically divided into subsystems [4]. Since the single system is, in turn, a part of a larger system, one may speak of an embedded system [5].

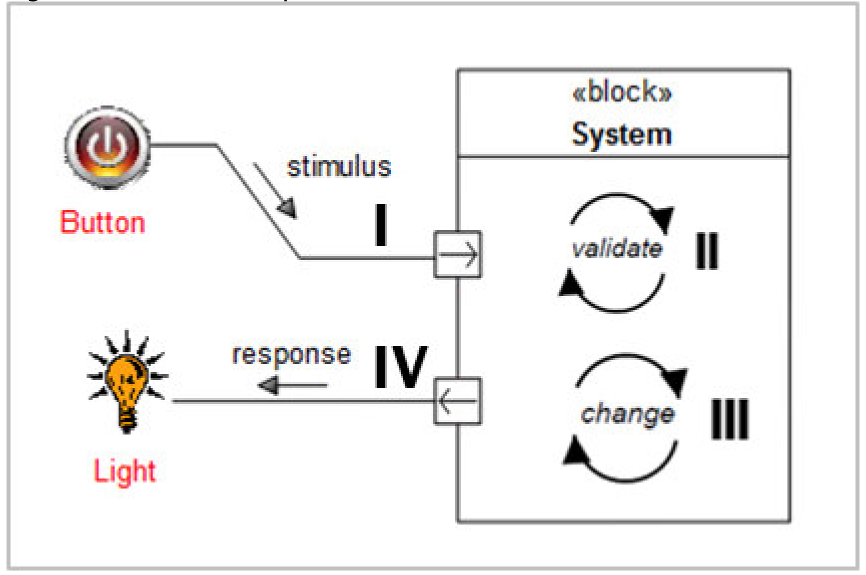
ID	Type	Requirements
Eu.ModSt.86	Info	EULYNX follows the objective of structuring the EULYNX overall CCS system hierarchically into subsystems in a way, that the resulting subsystems, referred to as modules, can be supplied by different suppliers and then integrated independent of a particular vendor [12]. As far as the specification of those modules, such as a Subsystem Light Signal, a Subsystem Point, a Subsystem LX and so on is concerned, they are fitted with standardised interfaces and seen as black boxes without any further decomposition.
Eu.ModSt.7059	Head	**8.1.1.2 Reactive system**
Eu.ModSt.1496	Info	A reactive system is a system that, when switched on, is able to create desired effects in its environment by enabling, enforcing, or preventing events in the environment.
Eu.ModSt.89	Info	Following the deterministic paradigm which is a key requirement for a safety-critical railway system, in contrast to non-deterministic systems, the same sequence of system inputs always produces the same sequence of system outputs.
Eu.ModSt.1497	Info	Safety is a major quality of safety-critical railway systems that must be considered in any activity during engineering. Safety can be characterized as the extent to which the SUS will not have effects on its environment that result in harm to people, significant monetary losses, or any other negative impacts to its environment [25].
Eu.ModSt.90	Info	Reactive systems have a number of characteristics [8]: • The system is in continuous interaction with its environment. • The process by which the reactive system interacts with its environment is usually nonterminating. If a reactive system terminates during its availability time, this is usually considered a failure. • In its interaction with the environment, the system will respond to external stimuli as and when they occur. The system must therefore be able to respond to interrupts, even if it is doing something else. • The response of a reactive system depends on its current state and the external event that it responds to. The response may leave the system in a different state than it was before. • The response consists of enabling, enforcing, or preventing interaction with its environment. • The behaviour of a reactive system often consists of a number of interacting processes that operate in parallel. • Often a reactive system must operate in real time and under stringent time requirements.
Eu.ModSt.91	Info	Although reactive systems may provide manifold functionality, they all engage in stimulus-response behaviour. Thus, for the specification of a reactive system appropriate techniques are needed for specifying stimulus-response behaviour.
Eu.ModSt.1499	Info	For the specification of the stimulus-response behaviour of a safety-critical railway system such as an interlocking system that may be described by discret states, finite state machines such as SysML state machines may be used.
Eu.ModSt.1498	Info	Similar to the characteristics of reactive systems are the characteristics of interactive systems. While for reactive systems the stimulus-response behaviour is determined by the physical-technical environment, the stimulus-response behaviour of interactive systems is determined by the system.
Eu.ModSt.93	Info	Reactive systems or interactive systems can be contrasted with transformational systems [8], which exist to transform an input into an output. A diagnostic expert system, for example, is a transformational system; it may enter an interactive dialogue to acquire all relevant data about a malfunctioning system, but when all data is provided, the expert system will produce its diagnosis as output and terminates.
Eu.ModSt.7015	Info	Since a EULYNX subsystem also has the characteristic of a control system, this term shall be explained next.
Eu.ModSt.7016	Head	**8.1.1.3 Control system**
Eu.ModSt.7017	Info	To control means to regulate or direct. Hence a control system is an arrangement of physical components connected in such a manner to direct or regulate itself or another system.
Eu.ModSt.7018	Info	If a lamp is switched ON or OFF using a switch, according to the example shown in *chapter 8.1.3*, the entire system can be called a control system. In short, a control system is in the broadest sense, an interconnection of physical components to provide the desired function, involving controlling action in it.
Eu.ModSt.7019	Info	For each control system, there is an input and an output. The input is the stimulus, excitation, or reference value applied to a control system to produce, depending on its internal state, a specific response and the output is the actual response obtained from the control system. The specification of a control system can thus basically be done in stimulus-response form.
Eu.ModSt.7020	Head	**8.1.1.4 Typical control loop of a EULYNX subsystem**
Eu.ModSt.7021	Info	*Figure 7022* shows a typical control loop of a CCS system such as a EULYNX subsystem. The "Plant" is the system being controlled such as the point in the environment of the control system consisting of point controller and point machine (see *Figure 705*1).

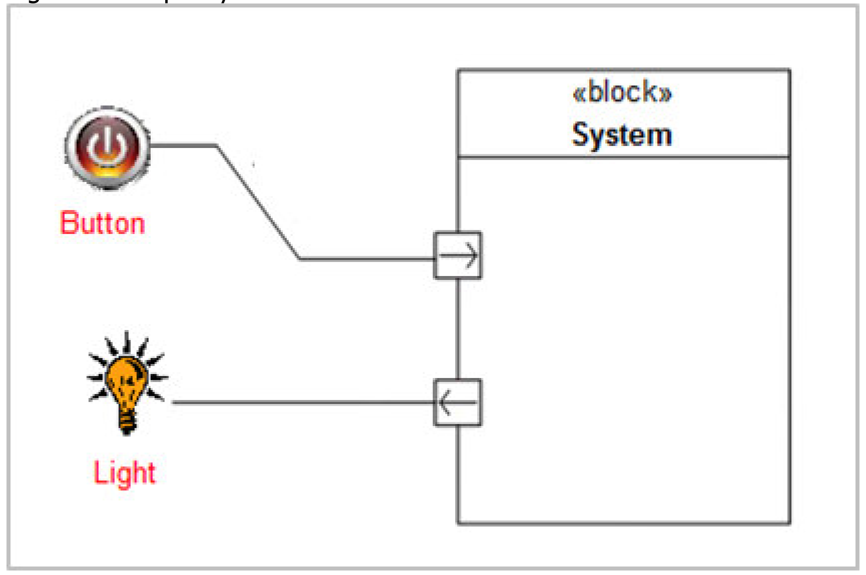
ID	Type	Requirements
Eu.ModSt.7051	Info	Figure 7051 Example of a plant 
Eu.ModSt.7023	Info	Most core control system functions can be assigned to one of the four categories listed below: • **Control**: the purpose of a control function is to transform information about a needed change of the plant's state into instructions or commands for the state of the actuators. Control functions are where all the decisions are made. • **Actuate**: the purpose of an actuate function is to transform instructions or commands into a physical state that has some effect on the plant's internal state. • **Sense:** the purpose of a sense function is to transform a physical external state of the plant into information about the plant's external state. • **Observe:** the purpose of an observe function is to transform information about the plant's external state into an observation about the plant's internal state. Observe functions are where inferences are made about the state of the plant given incoming data**.**
Eu.ModSt.7024	Info	Basically, only what can be observed can be controlled. This is not the same as saying that only what can be sensed can be controlled. Sensed data can be used to estimate an internal state that shall be controlled, but an internal state cannot be directly sensed. Only the external states of the plant can be sensed.
Eu.ModSt.7025	Info	The point state (LEFT, RIGHT or TRANSITION) of a railroad turnout, for example, is an internal state. It can be inferred by sensing the current flow via the point machine position sensor contacts. From these sensed current flow, we can infer the internal state that is the point state of the turnout.
Eu.ModSt.7026	Info	*Figure 7022* shows the flow of information between the functions [(2), (5), (6)] within the control system and between them and an external reference (1) and the "Plant" [(3), (4)] using a railroad turnout as an example. The information flows (4), (5) and (6) correspond to the "feedback" of a closed loop control system as described in [32]. The information flows are described below: (1) Required internal state of "Plant": e.g. required point state "LEFT", (2) Required external state of "Plant": e.g. connected voltage for moving the point machine to the left (four-wire interface), (3) Actual external input state of plant: e.g. movement of the point machine drive rod to bring the point into the left position, (4) Actual external output state of plant: e.g. switching position of the point machine position sensor contacts depending on the point machine drive rod position, (5) Sensed external output state of plant: e.g. current flow via the point machine position sensor contacts (four-wire interface), (6) Estimated internal state of plant: e.g. estimated point state "RIGHT" or "TRANSITION.

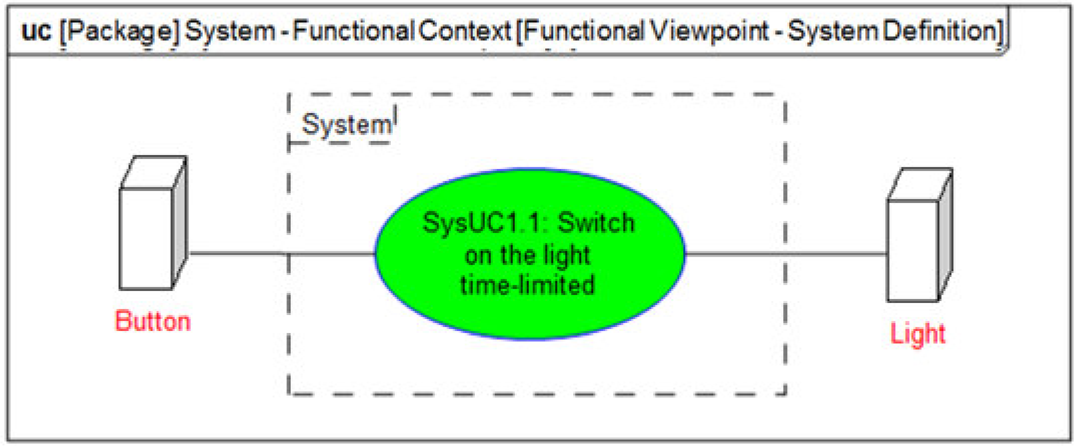
ID	Type	Requirements
Eu.ModSt.7022	Info	Figure 7022 Typical control loop of a EULYNX subsystem 
Eu.ModSt.7052	Head	**8.1.1.5 Interpretation of the concept of "Function"**
Eu.ModSt.201	Info	According to the EULYNX MBSE approach, use cases form the basis for the functions to be provided by a SUS at the highest level of abstraction, i.e. at abstraction level AL1 of the AM MBSE. They describe the functionality of a SUS in terms of how it is used to achieve the goals of its various users (see *chapter 8.1.2.2.3*). In other words, use cases create desired effects in the SUS environment.
Eu.ModSt.7699	Info	In contrast to a use case, a function is the ability of a SUS to create a desired effect in the system environment. So all use cases of a SUS are functions and each function realises one or more UseCases [8].
Eu.ModSt.7053	Info	At abstraction level AL2 of the AM MBSE, a function is represented by a Functional Entity (FE) or a Technical Functional Entity (TFE). Both encapsulate subsets of functional requirements of EULYNX SUSs or SIUSs in the form of function modules. They delimit the function modules from their environments and define the inputs and outputs.
Eu.ModSt.7058	Info	While FEs define technology-independent functional requirements derived from corresponding use cases defined on abstraction level AL1, TFEs describe technology-dependent ones.
Eu.ModSt.7056	Info	FEs and TFEs have SysML state machines and SysML block operations to describe behaviour. SysML state machines enable the specification of finite discrete event dynamic behaviour. SysML block operations are used to perform logical or algebraic transformations. The corresponding algorithms are defined in the operation bodies using the action language ASAL. Block operations are currently used as call operations. This means that they have a finite execution cycle (they are called, for example during state transitions, executed, and return a value).
Eu.ModSt.7057	Info	The EULYNX specification approach allows the description of functional control system architectures and their governing control loops through the "Functional Architecture" and "Technical Functional Architecture" model views of AM MBSE. As exemplified in Figure 7055, the functions of a control system are represented by interconnected FEs or TFEs.
Eu.ModSt.7321	Info	**Please note:** FEs and TFEs are used for the structured description of a SUS or SIUS and are not in themselves architectural specifications for the manufacturer. In other words, a manufacturer does not have to prove that it implements a particular FE or TFE. Proof is only required for the overall behaviour defined by the interconnected FEs or TFEs in a functional or technical functional architecture.

ID	Type	Requirements
Eu.ModSt.7055	Info	Figure 7055 FE and TFE in a Technical Functional Architecture 
Eu.ModSt.2041	Head	**8.1.2 Principle of model-based definition of requirements**
Eu.ModSt.2061	Head	**8.1.2.1 Applied description methods for model-based requirements**
Eu.ModSt.2044	Info	To best support the verification and validation effort of specified SUS/SIUS requirements and to keep the specification understandable for engineers, the EULYNX specification approach aims to describe the functional SUS/SIUS requirements in the form of operational specifications.
Eu.ModSt.2047	Info	As mentioned above, the CCS systems currently specified in EULYNX are reactive control systems and characterised by the constant interaction and synchronisation between the system and its environment.
Eu.ModSt.2048	Info	A reactive control system, when switched on, engages in stimulus-response-behaviour in order to create desirable effects in its environment. For that reason, the EULYNX methodology proposes the specification of the functional system requirements in stimulus-response form.
Eu.ModSt.2042	Info	As the focus of EULYNX is on the specification of interfaces, the behaviours of EULYNX systems are specified using an interface centric approach.
Eu.ModSt.2111	Info	In the following sections, the concepts of "operational specification", "stimulus-response specification" and "interface centric approach" are explained.
Eu.ModSt.2043	Head	**8.1.2.1.1 Operational specification**
Eu.ModSt.2045	Info	An operational specification describes the behaviour of a system using an abstract machine. This can be realized using data-flow diagrams that assemble functions connected by data flows. Since data flows may not always be natural for expressing control aspects, finite state machines can be preferred to describe the temporal and behavioural views of a system.
Eu.ModSt.2046	Info	Control is specified using states, events, and transitions in response to stimuli. There are many variants of state machine specification languages. A state machine can be executed, to validate the behaviour, and static analyses of the state machine can be performed (including consistency properties, and formal verification of properties).
Eu.ModSt.7067	Info	In general, using an operational specification of behaviour and requirements offers an advantage in that it enables to determine if a specific property holds or not. This can prevent communication issues between different actors (designers, builders, customers, and users) since the operational specification provides a reference model to check the property against.
Eu.ModSt.114	Info	For an operationally specified functional system property, there is a test that they can all perform and agree on the outcome - either the SUS/SIUS to be specified does or does not satisfy this property (see *Figure 115*).

ID	Type	Requirements
Eu.ModSt.7068	Info	Whether an operational specification exhibits a specific property may often-case be easy to determine but it may also offer a challenge, for various reasons. To determine if a property holds or not can be non-trivial due to e.g., specification complexity that may prevent inspection alone, state-space explosion impacting the results attainable in automated analysis, and semantics for interpretation that can complicate analyses.
Eu.ModSt.7069	Info	In general, it is desirable to have an implementation-independent operational specification, so that all stakeholders can agree on and use the same specification. The reason for this is to avoid, when the SUS/SIUS is delivered, that supplier and customer dispute about whether SUS/SIUS meet the desired properties or not. In general, it is recommended that SUS/SIUS specifications are operationalised as much as possible [8].
Eu.ModSt.115	Info	Figure 115 Test of an operationally specified system property 
Eu.ModSt.7066	Head	**8.1.2.1.2 Stimulus-response specification**
Eu.ModSt.7070	Info	Stimulus-response specifications are an important class of operational specifications.
Eu.ModSt.2049	Info	A **stimulus-response specification** has the form **s** AND **C = > r** where **s** is a stimulus, **C** is a condition on the system state, and **r** is a response. The design process consists of decisions about **r**.
Eu.ModSt.2050	Info	In a nutshell, whenever a stimulus occurs there will be a corresponding response. The kind of response depends on the condition on the state of the system. Please note: this is also said to be a response if a stimulus occurs and the system "keeps quiet".
Eu.ModSt.2051	Info	A single stimulus-response pair is henceforth also referred to as an interaction.
Eu.ModSt.2052	Info	An **interaction** is generally formulated according to the following action block schema comprising four action steps (see *Figure 173*): **Interaction:** **I.** - The SUS or SIUS receives a stimulus. **II.** The SUS or SIUS validates the stimulus. **III.** The SUS or SIUS changes its internal state (or not). **IV.** The SUS or SIUS responds with the result (Please note: a result may also be that the SUS or SIUS "keeps quiet"). However, there may be more than four action steps applied or fewer.

ID	Type	Requirements
Eu.ModSt.173	Info	Figure 173 The four steps of an action block 
Eu.ModSt.2053	Info	An interaction always starts with the stimulus identified by a dash "-" (see step I in ID 355 above). A stimulus may have its origin • in the **request of a primary actor** (a primary actor is an actor in the environment of the SUS or SIUS who requires a service from it), • in a **timed trigger**, • in an **intrasystem event** (that is, an event that occurs in the system) or • in the **entering or leaving a system state**.
Eu.ModSt.2054	Info	**Interactions** may be extended to **contracts**.
Eu.ModSt.2055	Info	The central idea of contracts is a metaphor on how the SUS or SIUS and the actors collaborate on the basis of mutual obligations and benefits. Having written functional requirements in the style of interactions, those contracts can easily be obtained - interactions together with pre- and postconditions.
Eu.ModSt.2056	Info	If a SUS or SIUS provides a certain functionality, it may **a)** expect a certain condition to be guaranteed on entry by an actor that sends the request: the precondition of the interaction - an obligation for the actor, and a benefit for the SUS or SIUS, as it relieves it from having to handle the cases outside of the precondition. **b)** guarantee a certain property on exit: the postcondition of the interaction - an obligation for the system, and obviously a benefit (the main benefit of the request) for the actor.
Eu.ModSt.2057	Info	The following applies for preconditions and postconditions in this context: **a)** The interaction may only be triggered by the actor if the precondition is met; this presupposes that the actor knows the current system condition, **b)** The system must ensure in turn that the postcondition is met after the completion of the interaction. If no explicit postcondition has been defined (indicated by three dashes "---"), the requirement applies that the postcondition is identical to the precondition.
Eu.ModSt.2058	Info	A **contract** is formulated according to the following schema: **Precondition**: Definition of the precondition **Interaction:** **I.** - The SUS or SIUS receives a stimulus. **III.** The SUS or SIUS changes its internal state (or not). **IV.** The SUS or SIUS responds with the result (Please note: a result may also be that the SUS or SIUS "keeps quiet"). **Postcondition:** Definition of the postconditions
Eu.ModSt.2059	Info	Alternatively to this, functional system requirements may be written without using **contracts**. In these cases it can not be assumed that the actor knows the current SUS or SIUS condition and complies with the precondition. The preconditions of the interactions are empty and the SUS or SIUS must first check on itself whether the preconditions are met before responding to the stimulus. The above schema is modified as follows (see text in italics):

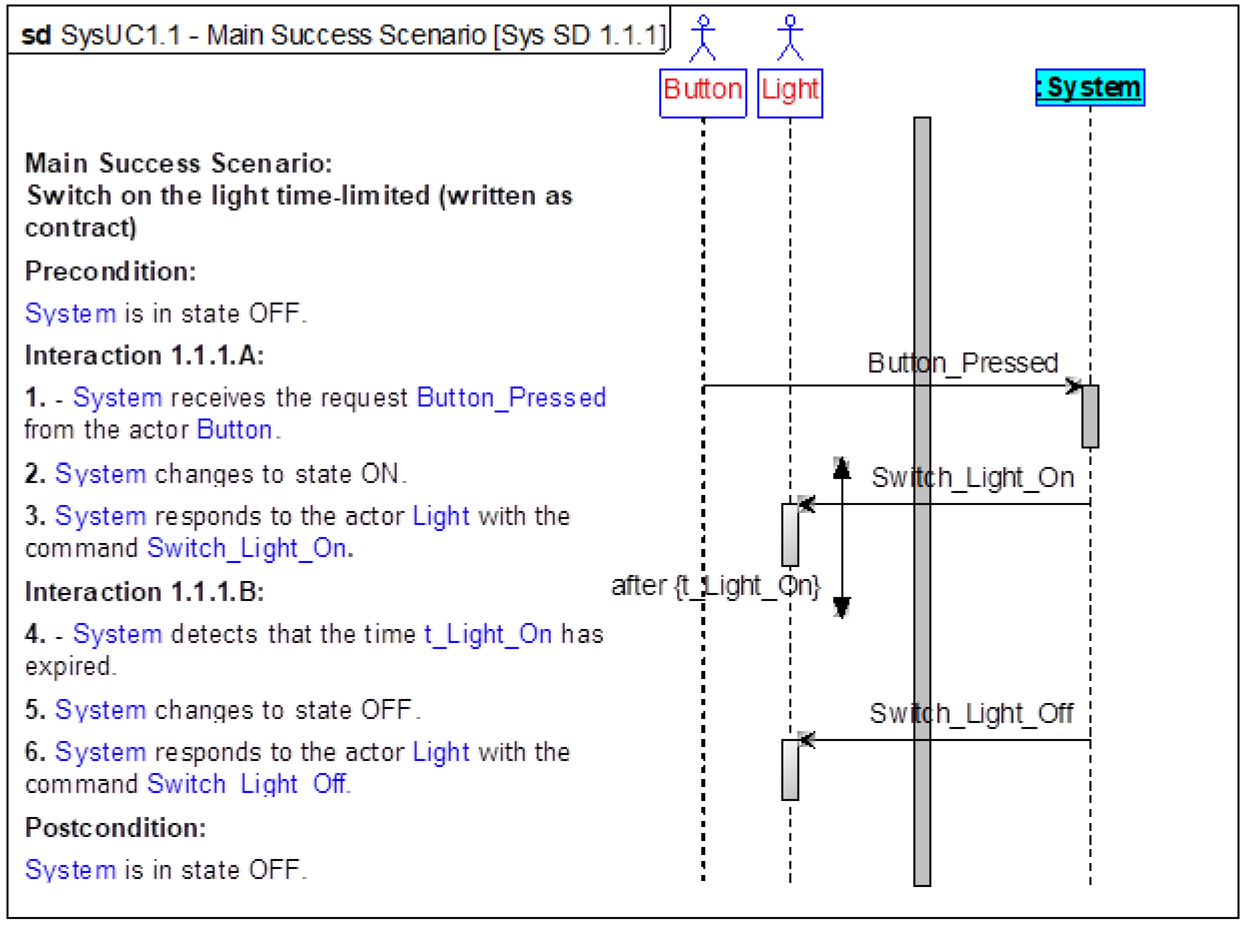
ID	Type	Requirements
Eu.ModSt.2059		**Precondition**: --- **Interaction**: **I.** - The SUS or SIUS receives a stimulus. **II.** *The SUS or SIUS validates the stimulus considering the current internal state*. **III.** The SUS or SIUS changes its internal state (or not). **IV.** The SUS or SIUS responds with the result (Please note: a result may also be that the SUS or SIUS "keeps quiet"). **Postcondition:** Definition of the postconditions
Eu.ModSt.2060	Info	In those cases, the check may fail in the second step. From this step on, a different internal condition might need to be entered and a different response might need to take place. **Variants of the interaction** would therefore have to be considered.
Eu.ModSt.2062	Info	**Interactions** and **contracts**, as defined above, provide the basic schemata for the model-based description of functional system requirements in **stimulus-response form**. Depending on the abstraction level two model-based description methods are used: • **Use case scenarios** (interaction scenarios) are used at abstraction level AL1 Subsystem Definition defining the interaction of the subsystem with its environment. • **State machines** are used at abstraction level AL2 Subsystem Requirements completely refining the externally visible stimulus-response behaviour described by means of the use case scenarios at abstraction level AL1 Subsystem Definition.
Eu.ModSt.2063	Info	These two model-based description methods will be demonstrated defining the functional system requirements of a simple system based on the **functional user requirements (FUR)** listed below: **FUR1:** The user wants to switch on the light by pressing a button if the light is off, **FUR2:** The user wants the light to be switched off automatically after a defined time.
Eu.ModSt.2064	Info	As shown in *Figure 3* the **SUS** named "**System**" is connected to the two actors "**Light**" and "**Button**" in the environment.
Eu.ModSt.2065	Info	Figure 3: Simple system 
Eu.ModSt.2066	Info	According to the functional user requirements described above the SUS is required to fulfil the functional system requirements (FSR), described in classical textual form below: **FSR1:** The system shall switch on the light if the light is switched off and the button is pressed, **FSR2:** The system shall switch off the light automatically after the time t_Light_On has expired.
Eu.ModSt.2067	Head	**8.1.2.1.3 Description method using use case scenarios**

ID	Type	Requirements
Eu.ModSt.2068	Info	The functional user requirements **FUR1** and **FUR2** defined above (see ID 215) require the SUS "System" to provide a service for the users. As shown in *Figure 2070*, this service is defined as system use case "SysUC1.1: Switch on the light time-limited".
Eu.ModSt.2069	Info	System use cases describe the functionality of a SUS or SIUS in terms of how it is used to achieve the goals of its various users. The users of a SUS or SIUS are described by actors (i.e. "Button" and "Light"), which may represent external systems or humans who interact with the system. A UseCase is denoted by an ellipse, and the actors participating in the UseCase are connected to the ellipse by solid lines.
Eu.ModSt.184	Info	On the original work on UseCases by Ivar Jacobson, Jacobson defines a UseCase as follows [20]: *„A use case is a sequence of transactions performed by a system, which yields an observable result of value for a particular actor. A transaction consists of a set of actions performed by a system and is invoked by a stimulus from an actor to the system, or by a timed trigger within the system".*
Eu.ModSt.186	Info	To understand transactions in the database sense is too narrow, because if a transaction succeeds then changes are made to the system (committed), otherwise the system is reverted to the original state (rollback).
Eu.ModSt.187	Info	Cockburn interprets in his book [22] what Jacobson [20] means by a transaction in the four steps of an action block (see *Figure 173*) representing an interaction.
Eu.ModSt.189	Info	The flow between the trigger and the result of a use case has a time coherence, i.e. no domain interruption is possible.
Eu.ModSt.2070	Info	Figure 2070: UseCase shown in a UseCase diagram 
Eu.ModSt.2071	Info	A complete use case, i.e. a primary UseCase consists of one or multiple interactions which can alternatively be formulated as contracts. A UseCase having only one interaction is an interaction written as a use case.
Eu.ModSt.2072	Info	The interactions specifying a UseCase such as "SysUC1.1: Switch on the light time-limited" are described in a model-based way by use case scenarios. Use case scenarios are represented by SysML sequence diagrams.
Eu.ModSt.2073	Info	The specification of the use case scenarios may cover a standard sequence and one or several alternative sequences, e.g. to represent a failed validation of the stimulus. Normally, the "good case" of an use case scenario is specified in the "standard sequence" and deviating sequences in "alternative sequences". If no unique standard sequence can be determined, it is also possible that only "alternative sequences" exist.
Eu.ModSt.2074	Info	For this reason, a use case may be defined by use case scenarios in the following compositions: - **one** Main Success Scenario and any number of Alternative scenarios, - **only one** Main Success Scenario, - **any number** of Alternative Scenarios without a Main Success Scenario.
Eu.ModSt.2075	Info	Several interactions may be combined directly after each other without explicitly depicting the pre- and postconditions between them in an interaction scenario if the postconditions of the previous interaction are identical to the preconditions of the subsequent interaction.
Eu.ModSt.2076	Info	If it can be assumed that the current state of the SUS is visible in its environment, the textually formulated functional requirements **FSR1** and **FSR2** (see ID *Eu.ModSt.2066*) can be described as contracts: **FSR1:** **Precondition:** System is in state OFF **Interaction:** **I.** - System receives the request "Button_Pressed" from the actor "Button". **III.** System changes to state "ON". **IV.** System responds to the actor "Light" with the command "Switch_Light_On". **Postcondition:**

<table>
<tr><th>ID</th><th>Type</th><th>Requirements</th></tr>
<tr><td>Eu.ModSt.2076</td><td></td><td>System is in state ON

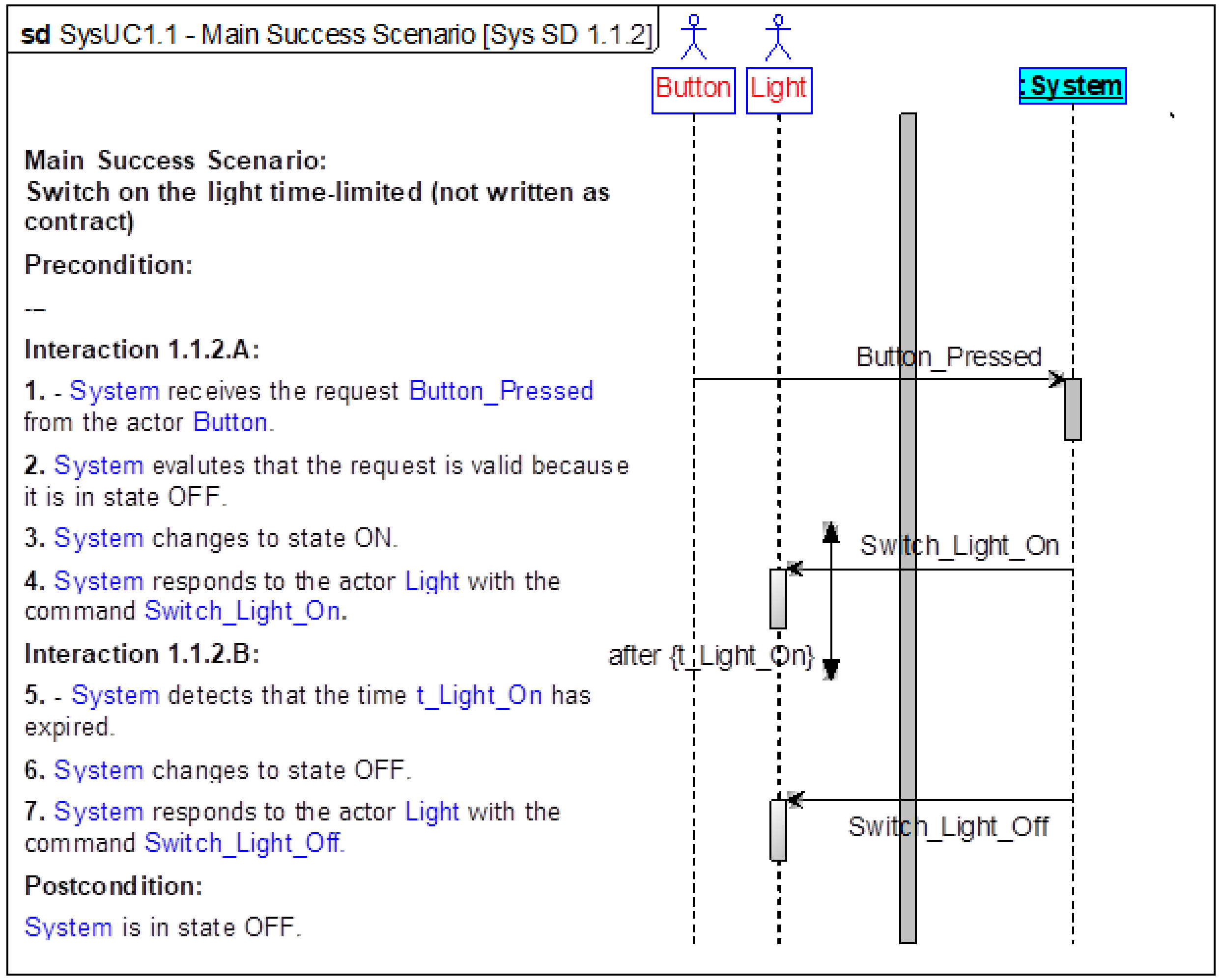
FSR2:
Precondition:
System is in state ON

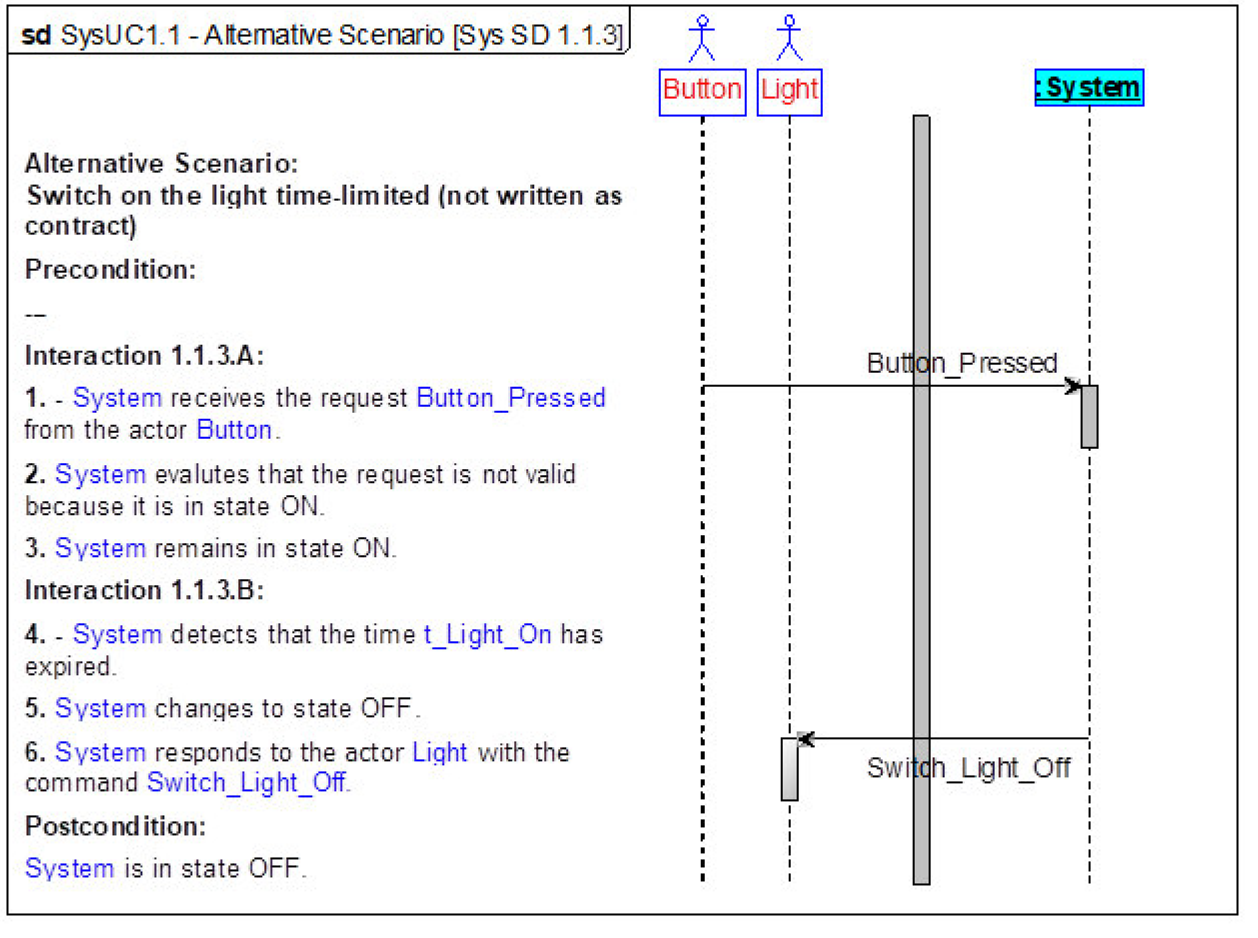
Interaction:
I. - System detects that the time "t_Light_ON" has expired.
III. System changes to state "OFF".
IV. System responds to the actor "Light" with the command "Switch_Light_OFF".

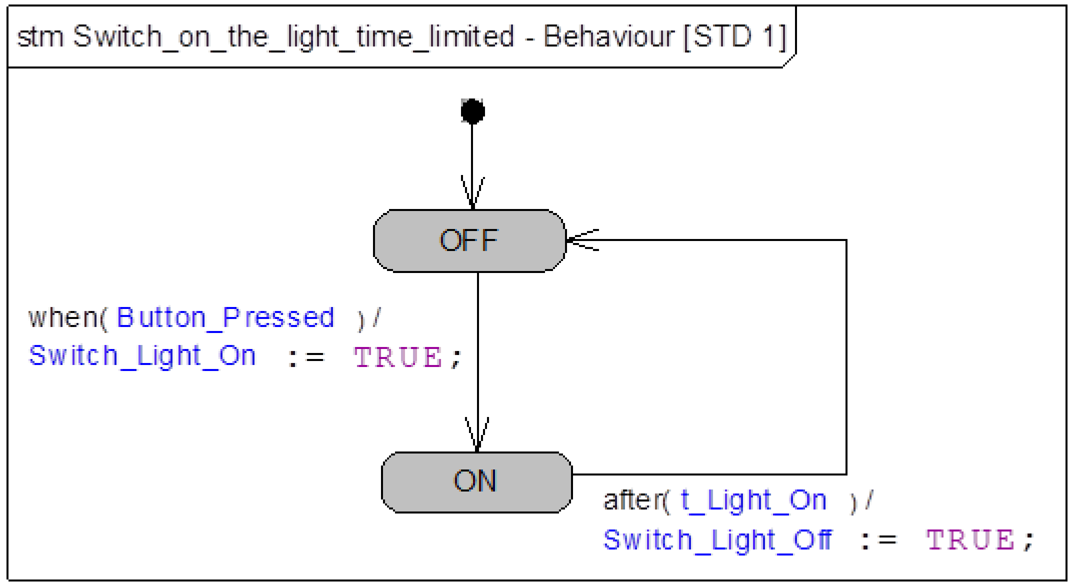
Postcondition:
System is in state OFF</td></tr>
<tr><td>Eu.ModSt.2077</td><td>Info</td><td>The corresponding use case scenario in the form of a Main Success Scenario is depicted in Fgure 2078. FSR1 and FSR2 are written as contracts and as a consequence no Alternative Scenarios are required. As the precondition of FSR2 is identical to the postcondition of FSR1 they are not explicitly depicted in the use case scenario.</td></tr>
<tr><td>Eu.ModSt.2078</td><td>Info</td><td>Figure 2078 Main Success Scenario with FSR1 and FSR2 written as contracts

</td></tr>
<tr><td>Eu.ModSt.2079</td><td>Info</td><td>If it can not be assumed that the current state of the SUS is visible in its environment, the textually formulated functional requirement FSR1 is to be described as interaction without precondition. FSR2 may be described as contract because the interaction is internally time-triggered and it is required that the current state may only be changed by this trigger:

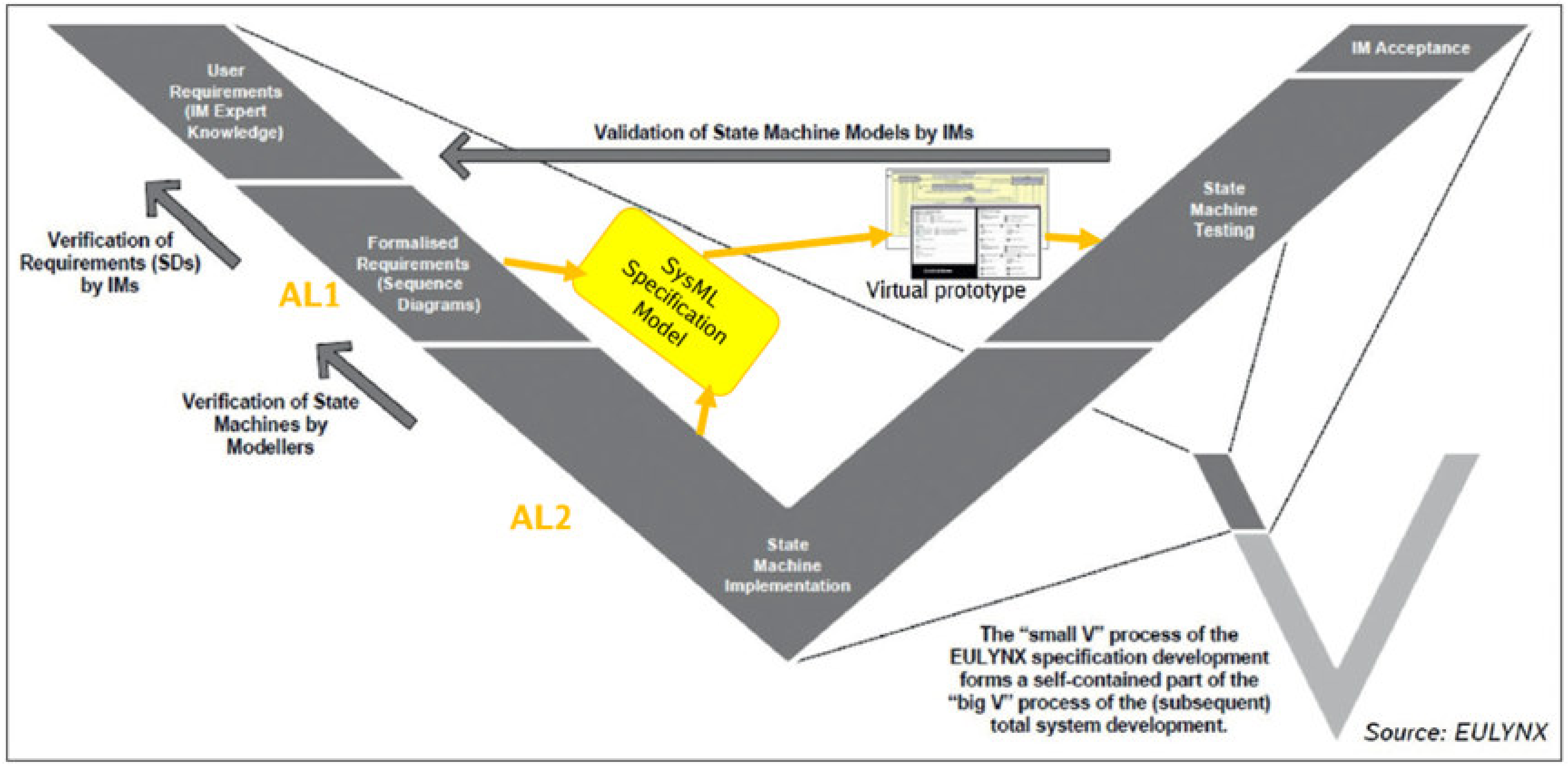
FSR1:
Precondition:

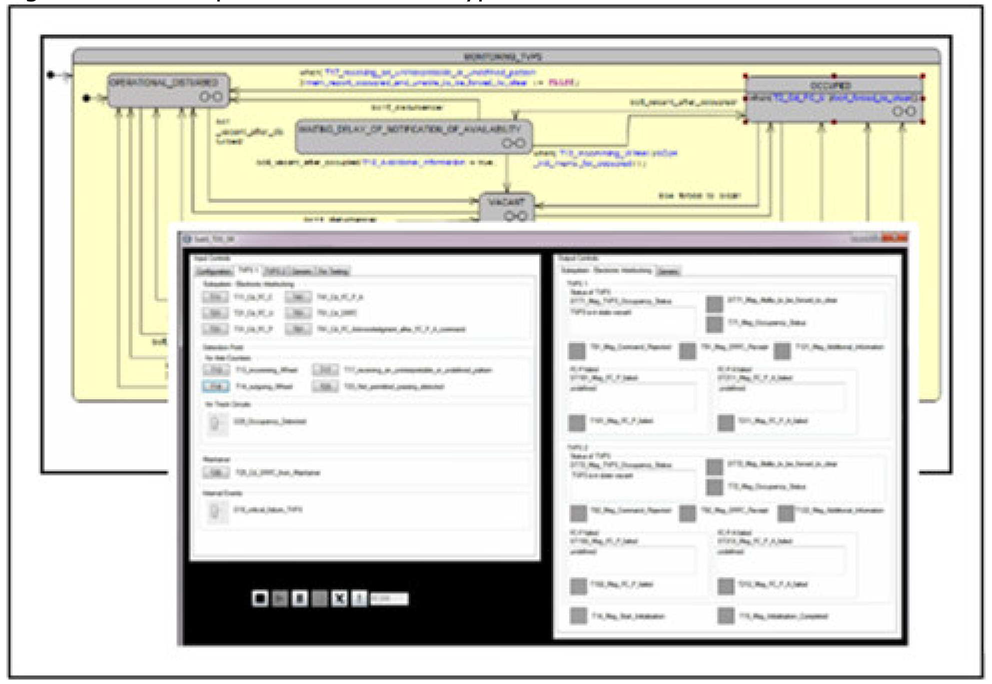
Interaction:
I. - System receives the request "Button_Pressed" from the actor "Button".
II. System evaluates that the request is valid because it is in state OFF.
III. System changes to state "ON".</td></tr>
</table>

ID	Type	Requirements
Eu.ModSt.2079		**VI.** System responds to the actor "Light" with the command "Switch_Light_On". **Postcondition:** System is in state ON **FSR2:** **Precondition:** System is in state ON **Interaction:** **I.** - System detects that the time "t_Light_ON" has expired. **III.** System changes to state "OFF". **IV.** System responds to the actor "Light" with the command "Switch_Light_OFF". **Postcondition:** System is in state OFF
Eu.ModSt.2080	Info	The corresponding use case scenario in the form of a Main Success Scenario is depicted in *Figure 2081*.
Eu.ModSt.2081	Info	Figure 2081 Main Success Scenario with FSR1 not written as contract 
Eu.ModSt.2082	Info	As FSR1 is not written as a contract, action step 2 of the corresponding interaction may be evaluated as not valid. As a consequence, an alternative variant of the interaction has to be described: **FSR1:** **Precondition:** ---

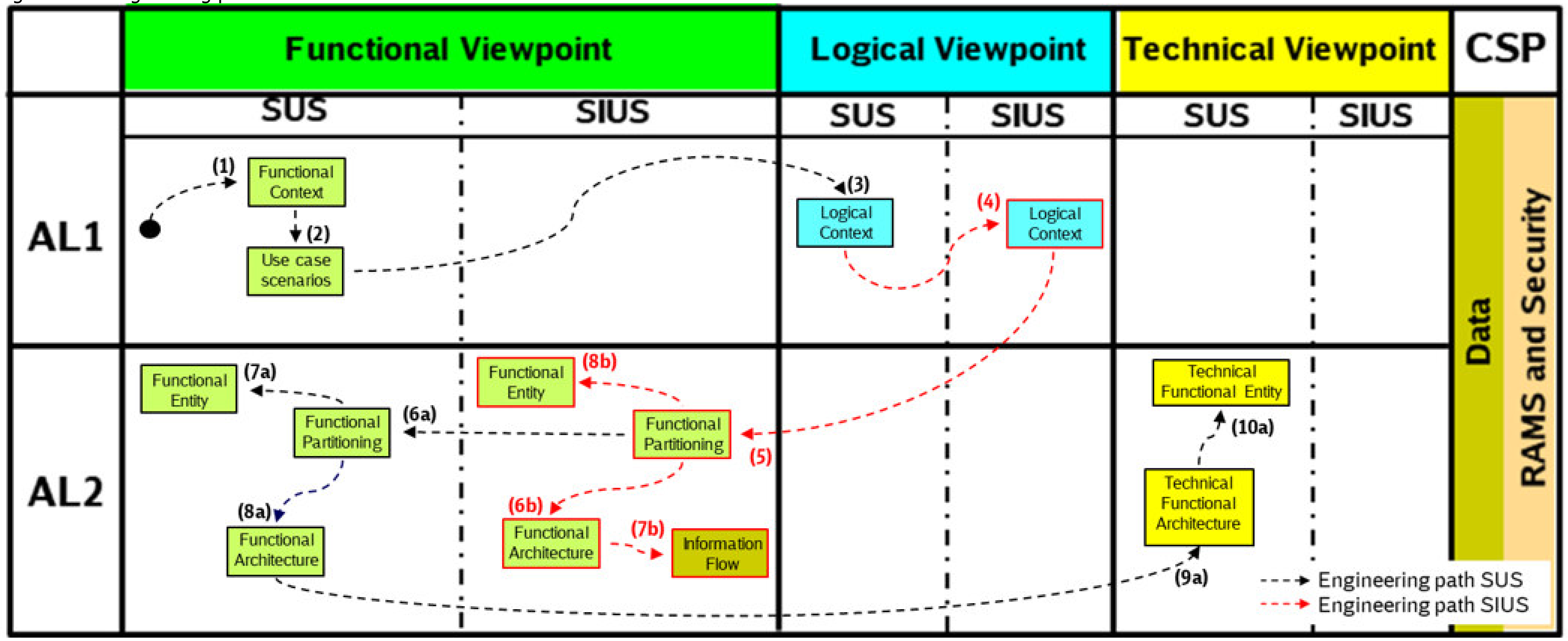
ID	Type	Requirements
Eu.ModSt.2082		**Interaction:** **I.** - System receives the request "Button_Pressed" from the actor "Button". **III.** System evaluates that the request is not valid because it is in state ON. **IV.** System remains in state "ON". **Postcondition:** System is in state ON **FSR2:** **Precondition:** System is in state ON **Interaction:** **I.** - System detects that the time "t_Light_ON" has expired. **III.** System changes to state "OFF". **IV.** System responds to the actor "Light" with the command "Switch_Light_OFF". **Postcondition:** System is in state OFF
Eu.ModSt.2083	Info	The corresponding use case scenario in the form of an Alternative Scenario is depicted in *Figure 2084*.
Eu.ModSt.2084	Info	Figure 2084 Alternative Scenario 
Eu.ModSt.2085	Head	**8.1.2.1.4 Description method using state machines**
Eu.ModSt.2086	Info	**State machines** are used at abstraction level AL2 System Requirements to completely refine the stimulus-response behaviour which has been described by means of the use case scenarios at abstraction level AL1 System Definition.
Eu.ModSt.2087	Info	*Figure 2088* shows a state machine specifying the stimulus-response behaviour of the UseCase "SysUC1.1: Switch on the light time-limited".

ID	Type	Requirements
Eu.ModSt.2088	Info	Figure 2088 FSR1 and FSR2 specified using a state machine 
Eu.ModSt.2089	Info	The declaration of this state machine is identical to the original textual requirements (see ID 93) **FSR1** (Transition from state "**OFF**" to state "**ON**") and **FSR2** (Transition from state "**ON**" to state "**OFF**"): **FSR1:** The system shall switch on the light ("**Switch_Light_On := TRUE**") if the light is switched off (state "**OFF**") and the button is pressed ("**when(Button_Pressed)**"). The **Transition from state "OFF" to state "ON"** represents a **functional system requirement** and may be textually formulated in the requirements specification document as shown below: **Info | OFF** **Req | when(Button_Pressed)/Switch_Light_On := TRUE {OFF - ON}** **Info | ON** **FSR2:** The system shall switch off the light ("**Switch_Light_OFF := TRUE**") automatically after the time t_Light_On has expired ("**after(t_Light_On)**"). The **Transition from state "ON" to state "OFF"** represents a **functional system requirement** and may be textually formulated in the requirements specification document as shown below: **Info | ON** **Req | after(t_Light_On)/Switch_Light_Off := TRUE {ON - OFF}** **Info | OFF**
Eu.ModSt.7013	Head	**8.1.3 Overview introduction to the EULYNX MBSE Process**
Eu.ModSt.1659	Info	The EULYNX MBSE process is part of the EULYNX systems engineering process with the main process tasks documented in the EULYNX verification and validation plan [31]. The EULYNX systems engineering process is closely oriented on the CENELEC system life cycle defined in EN 50126 and covers the phases listed below: Phase 1: Concept, Phase 2: System definition, Phase 4: System requirements, Phase 5: Apportionment of system requirements, Phase 10: System acceptance and Phase 11: Operation and maintenance,
Eu.ModSt.1662	Info	The CENELEC system life cycle follows the V-model, which highlights verification and validation, especially regarding the fulfilment of safety requirements, as important tasks.
Eu.ModSt.7101	Info	Already during the specification phases of the V-model, verification and validation are important activities, applied to assure the quality of the specification itself.
Eu.ModSt.7102	Info	This is especially necessary for the context of the EULYNX MBSE approach, where models of the required system behaviour represent abstract reference implementations of the future system (virtual prototypes) and are regarded as mandatory requirements in tender specifications.
Eu.ModSt.7103	Info	Following this notion, it is necessary to provide a "small V"-process, guiding the top-down development of those virtual prototypes using executable SysML state machines and their validation and verification within the specification phases of the underlying "big V"-CENELEC process.

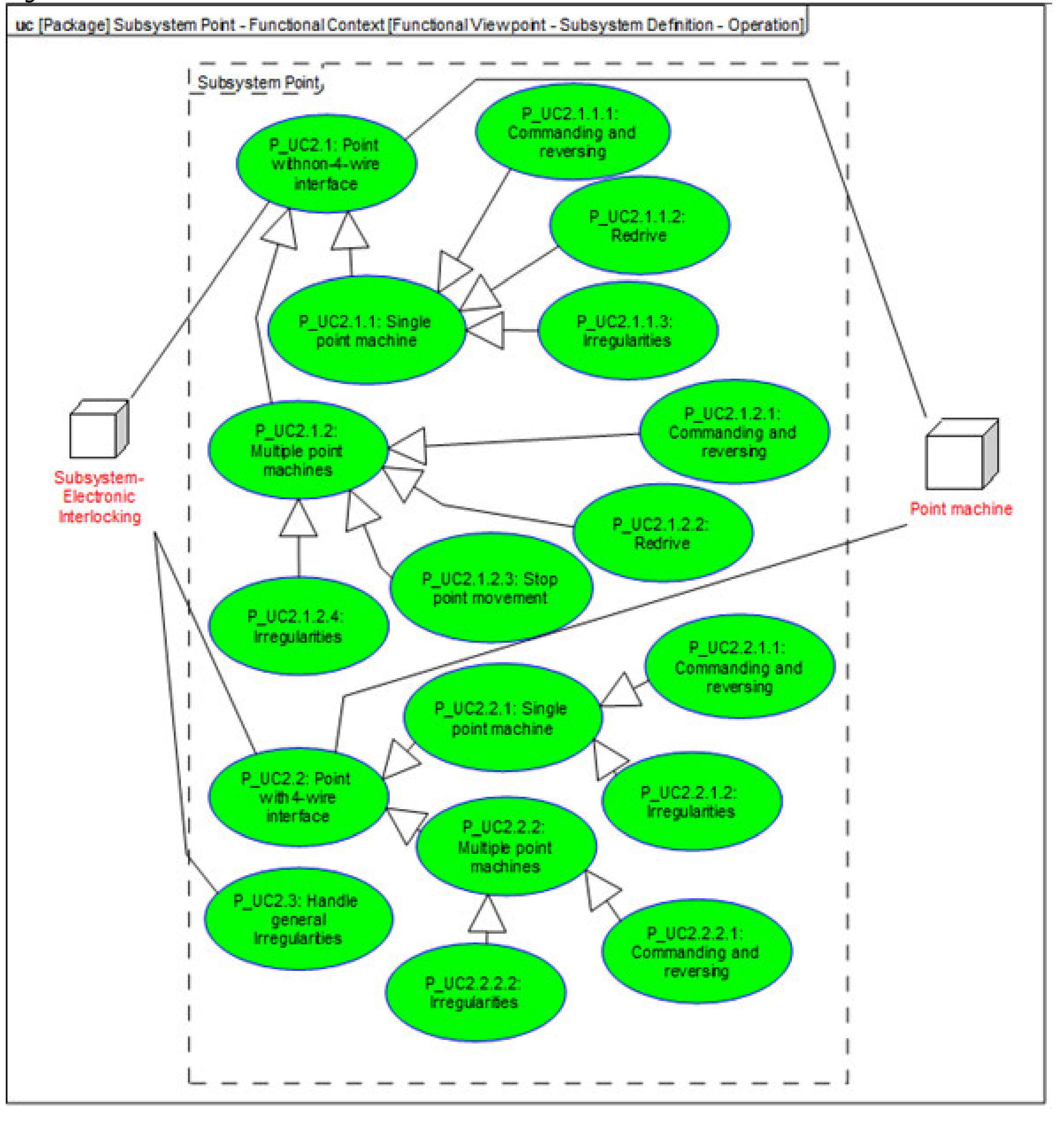
ID	Type	Requirements
Eu.ModSt.7104	Info	In *Figure 1658*, the "small V" is highlighted in the "big V" and pictures the relationships of verification and validation as part of the virtual prototype development.
Eu.ModSt.1658	Info	Figure 1658 EULYNX "smal V" model 
Eu.ModSt.1539	Info	The AM MBSE essentially covers the "Formalised Requirements" and "State Machine Implementation" phases of the "small V" process. It defines the model views at abstraction levels AL1 and AL2 for the creation of: • **specification models of subsystems (SUS) and** • **specification models of interfaces (SIUS).**
Eu.ModSt.7469	Info	The requirements at abstraction level AL3 of the AM MBSE are currently not defined in EULYNX in a model-based manner.
Eu.ModSt.1555	Info	The behaviour of EULYNX SUS/SIUS is specified from the black box perspective. In a black box specification only the black box behaviour of the SUS/SIUS is considered, i.e. only the external properties of the SUS/SIUS are defined (externally visible input/output behaviour).
Eu.ModSt.7105	Info	User Requirements derived from infrastructure manager (IM) expert knowledge are represented in both cases in the requirements management tool in the form of a "Function List". It lists the required functions used as input information for the creation of the model views at abstraction level "AL 1 Subsystem Definition" "or "Interface Definition" of the AM MBSE using the modelling tool.
Eu.ModSt.7931	Info	If an architectural description of the overall system is available in the form of an analysis model, the model artefacts of the analysis model required for the creation of the respective EULYNX specification model are transferred to the EULYNX specification model by model-to-model transformation.
Eu.ModSt.7470	Info	At this point, the SUS use cases (services) are defined with their stimulus-response behaviour selectively specified by means of use case scenarios using SysML sequence diagrams (Formalised Requirements).
Eu.ModSt.7471	Info	Subsequently, the conformity of the model to the SysML specification and the modelling rules defined in the EULYNX Modelling Standard is statically checked using the modelling tool by a modeler in the role of a model verifier.
Eu.ModSt.7472	Info	Additionally, the use case scenarios are validated by means of inspection by the corresponding IMs in the roles of model validators.
Eu.ModSt.7473	Info	In the next step, the system views created at abstraction level "AL 1 Subsystem Definition/Interface Definition" are refined at abstraction level "AL 2 Subsystem Requirements/Interface Requirements" by means of executable SysML state machines (State Machine Implementation).
Eu.ModSt.7474	Info	The conformity of the model to the SysML specification and the EULYNX Modelling Standard is verified tool-based and by means of inspection by the model verifier.
Eu.ModSt.7475	Info	To implement the state machines as a virtual prototype, simulation code is generated. Subsequently, the GUI of the virtual prototype is designed, and an executable is created.
Eu.ModSt.7476	Info	The executable representing the virtual prototype enables both the tool-independent standalone simulation of the specified behaviour and when connected to the simulation tool the simulation together with the animation of the corresponding state machines.

ID	Type	Requirements
Eu.ModSt.7477	Info	The virtual prototype enables simulation-based testing of the specified behaviour by injecting stimuli on the GUI and observing the responses optically indicated. The principle of a virtual prototype is depicted in Figure 7481.
Eu.ModSt.7478	Info	In the following step (State Machine Testing), the conformity of the behaviour defined by the state machines to the use case scenarios in the overlying abstraction level “AL1 Subsystem Definition/Interface Definition” is dynamically verified by simulation-based testing of the virtual prototype carried out interactively by the model verifier.
Eu.ModSt.7479	Info	For this purpose, the scenarios are used as test cases and in parallel, the animated state machines observed (white box testing of the behaviour). Additionally, the correct creation of the state machines such as freedom of deadlocks is verified by the model verifier using interactive state machine animation based on a dedicated test specification.
Eu.ModSt.7480	Info	The standalone virtual prototype is then handed over to the IMs to validate the behaviour specified by the state machine by means of simulation-based testing (black-box testing of the behaviour). The validation process is finished successfully when all participating IMs provide evidence that their user requirements (including safety requirements) are satisfied by the specified behaviour. The successful validation process leads to the production of a new baseline.
Eu.ModSt.7481	Info	Figure 7481 Principle of a virtual Prototype 
Eu.ModSt.7094	Info	*Figure 7116* shows the commonly used engineering paths for generating the model views of the SUS or SIUS specification models in conformity with the "small V" shown in *Figure 1658*. Depending on the project-specific input conditions, the engineering paths can also be applied in a modified form.
Eu.ModSt.7118	Info	In general, the engineering path for creating the SUS model views (black dashed arrows) includes the engineering path for creating the SIUS model views (red dashed arrows).
Eu.ModSt.7117	Info	The model views used reflect the current state of the EULYNX MBSE methodology and may be complemented by further model views in the future (e.g. model views of the Technical Viewpoint or model views on AL3).

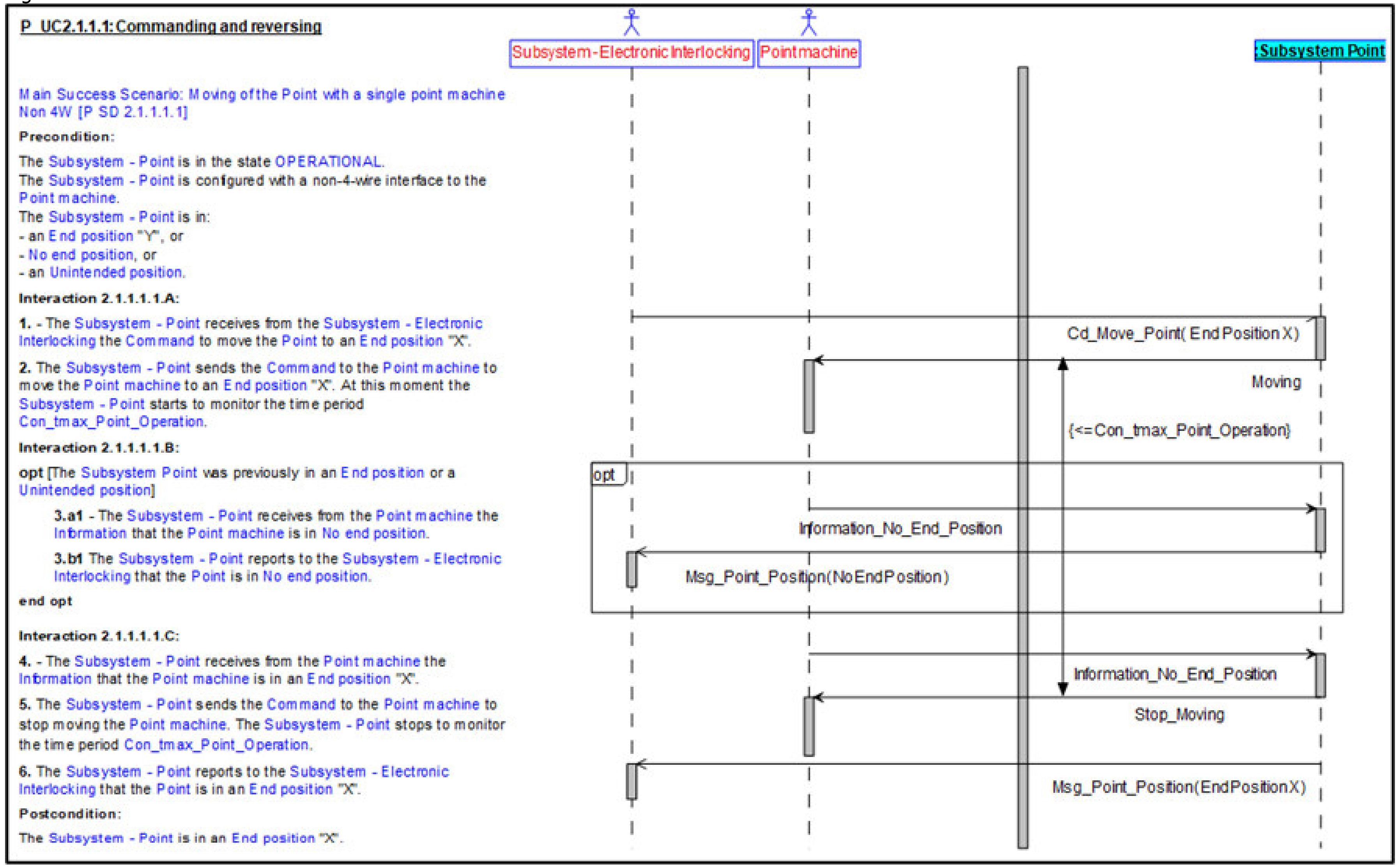
ID	Type	Requirements
Eu.ModSt.7116	Info	Figure 7116 Engineering paths of the EULYNX "smal V" model



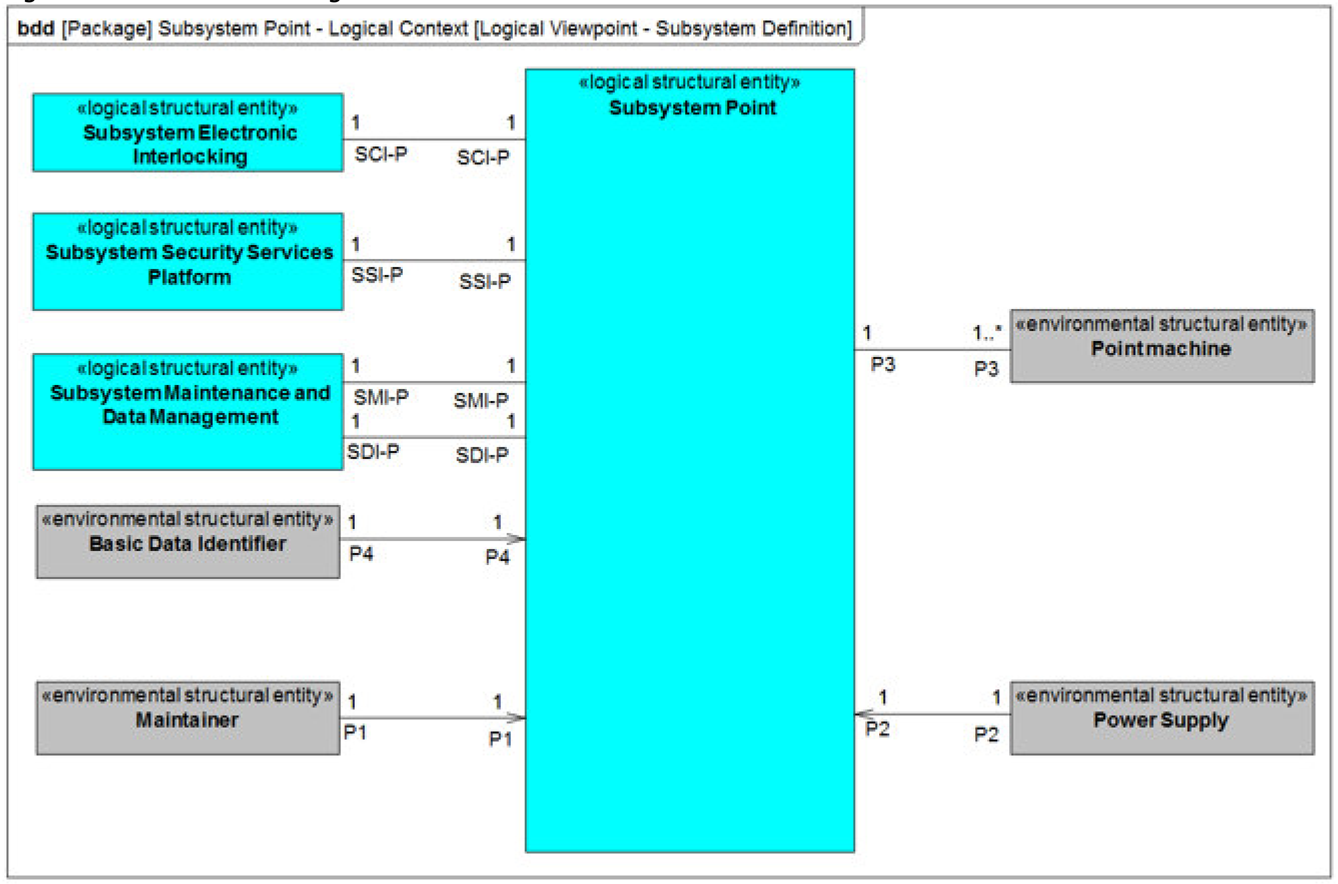
ID	Type	Requirements
Eu.ModSt.1549	Info	The engineering path for creating the SUS model views starts at the Functional Viewpoint on abstraction level AL1.
Eu.ModSt.1241	Info	**Task (1): creation of model view "Functional Context"** Based on stakeholder requirements (for example IM requirements) which are defined in the area User Requirements of the MBSE SF, for example in the form of a function list, the model view "Functional Context" is created **(1)**.
Eu.ModSt.1630	Info	As shown in *Figure 1633*, the model view Functional Context summarises the use case structure graphically and names all use cases the SUS is expected to perform. Furthermore, it allocates the use cases to the SUS and defines their interrelations as well as their relations to the actors in the SUS environment.
Eu.ModSt.1557	Info	Use cases describe the functionality of a SUS such as "Subsystem Point" in terms of how it is used to achieve the goals of its various users. In model view "Functional Context" they are denoted by ellipses, and the actors participating in the use cases are connected to the ellipses by solid lines.
Eu.ModSt.1623	Info	The users of a system are described by actors, which can represent external systems such as "Point machine" or people who interact with the system.
Eu.ModSt.1628	Info	Consequently, a use case does not contain any information how it is implemented in the SUS.

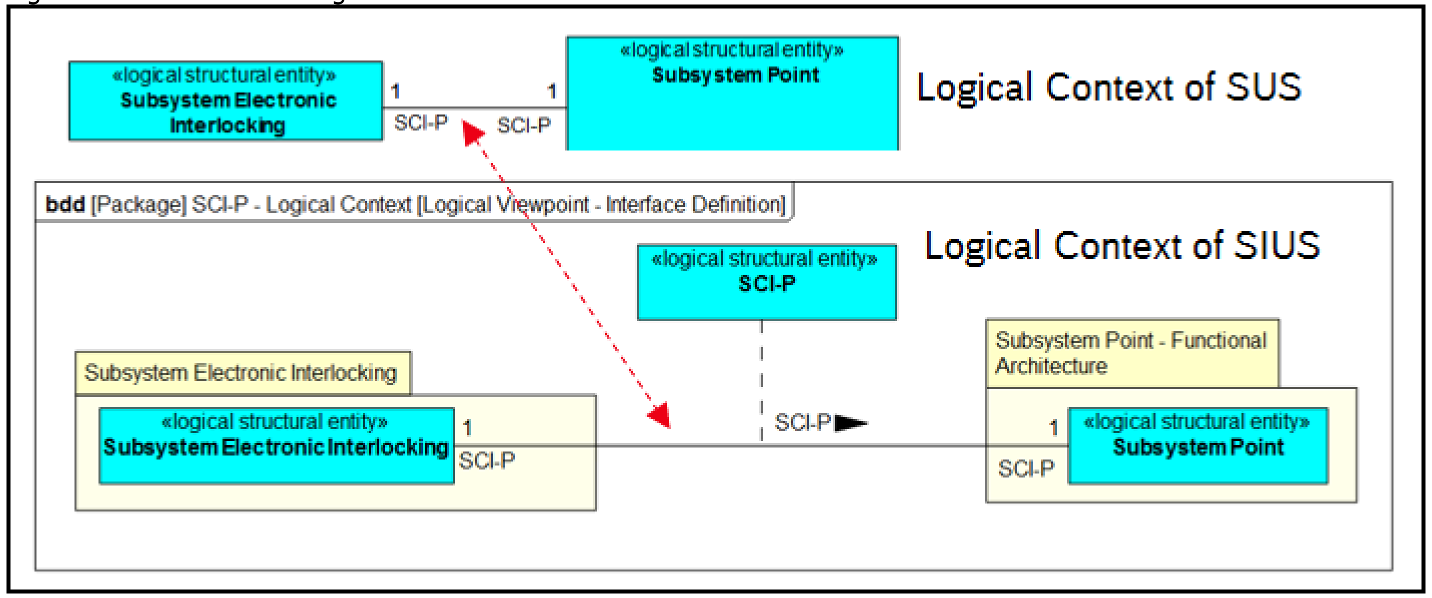
ID	Type	Requirements
Eu.ModSt.1633	Info	Figure 1633 Model view "Functional Context" of a SUS 
Eu.ModSt.1622	Info	**Task (2): creation of model view "Use case scenarios**" Based on the definitions in the model view "Functional Context", the model view "Use case scenarios" is subsequently created.
Eu.ModSt.1653	Info	A use case may be defined by one or more use case scenarios (SysML sequence diagrams) in order to describe the exchange of messages between the SUS and its environment. It is the central construct to define parts of behaviour of the SUS that can be observed at the system boundary.
Eu.ModSt.1634	Info	An example use case scenario of the use case "P_UC2.1.1.1: Commanding and reversing" is depicted in *Figure 1635*.

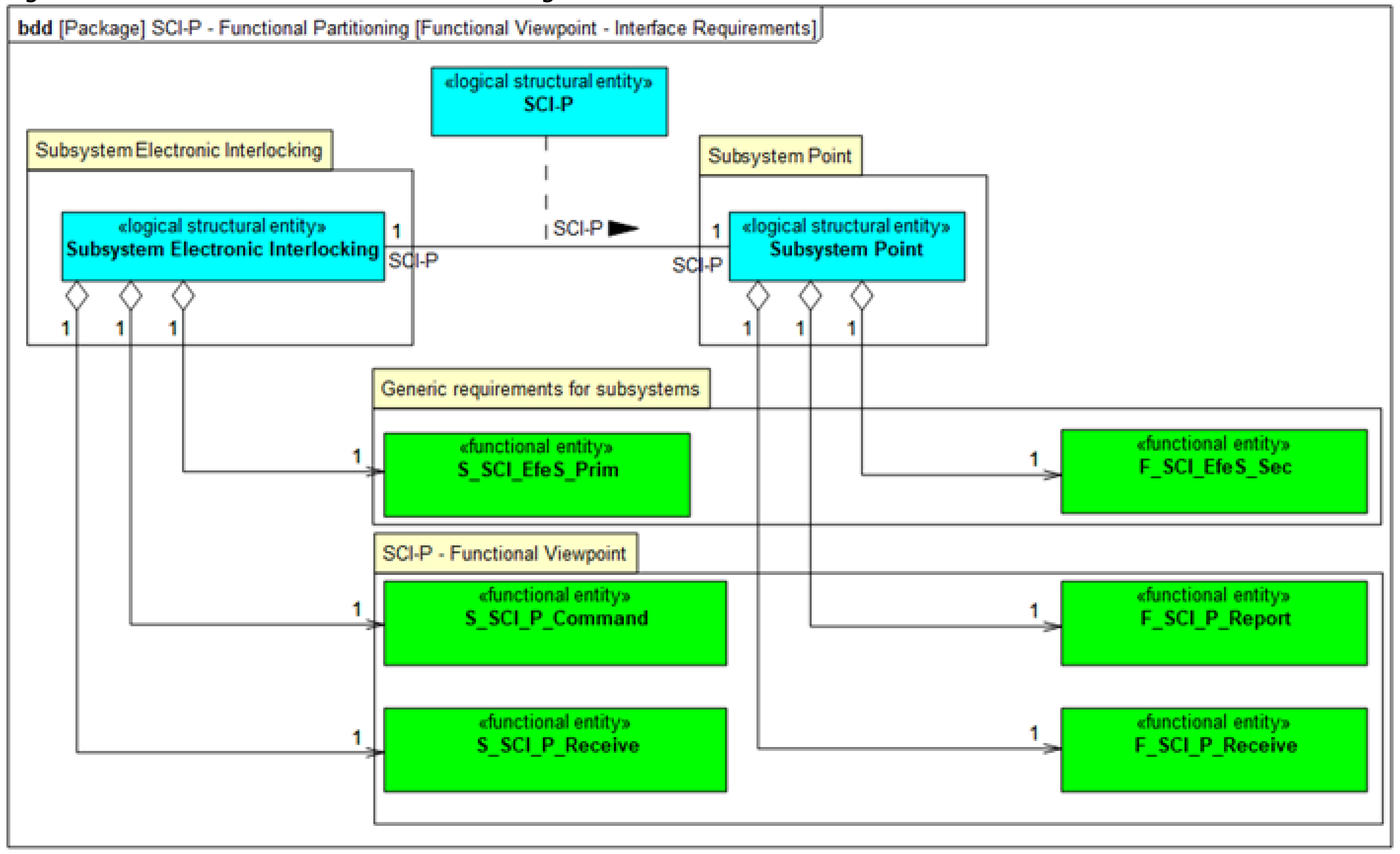
<table>
<tr><th>ID</th><th>Type</th><th>Requirements</th></tr>
<tr><td>Eu.ModSt.1635</td><td>Info</td><td>
Figure 1635 Model view "Use case scenario" of a SUS

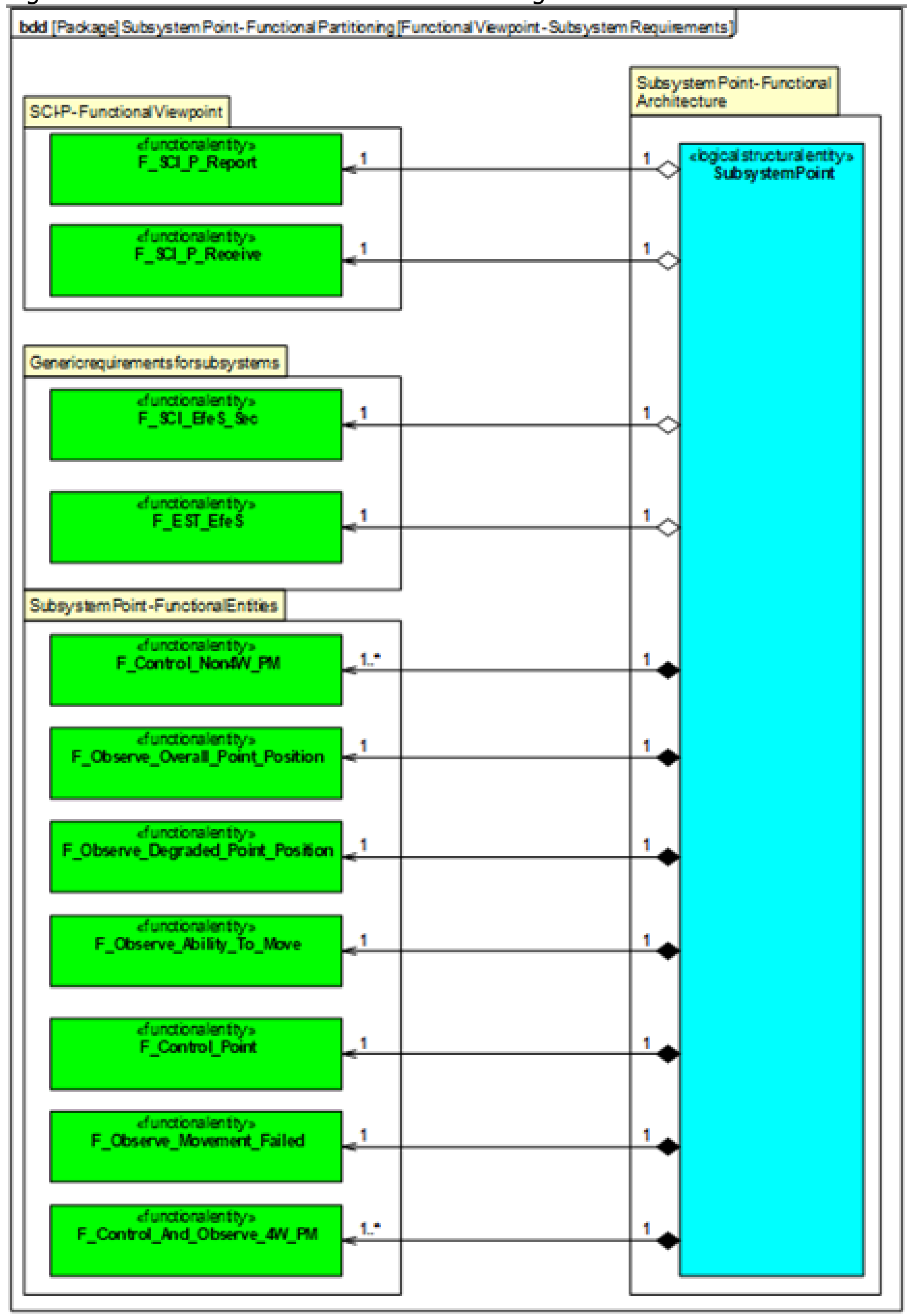


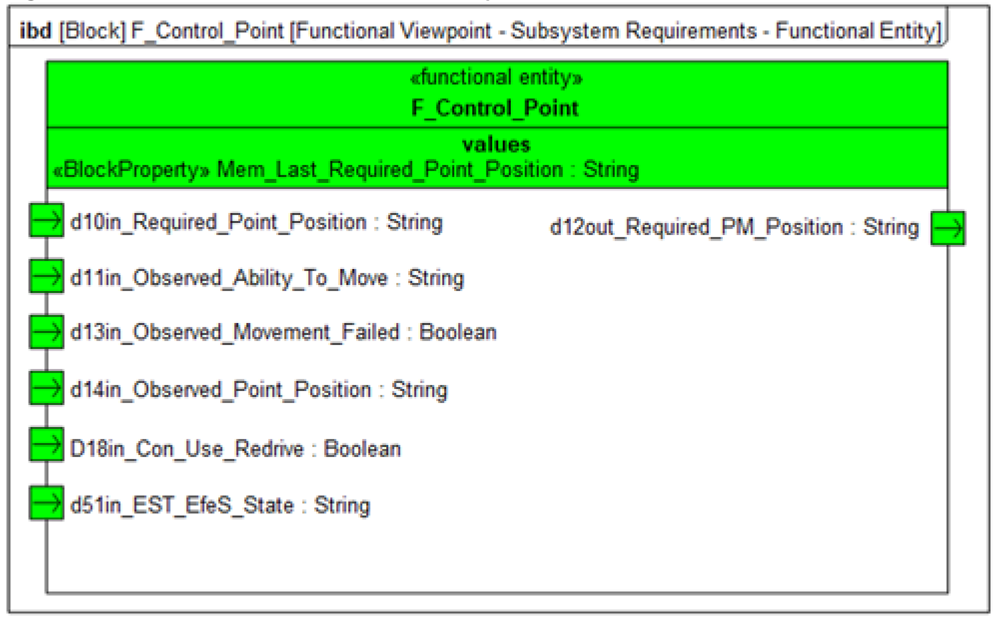
</td></tr>
<tr><td>Eu.ModSt.1629</td><td>Info</td><td>Task (3): creation of model view "Logical Context" of a SUS
Based on the definitions in the model views "Functional Context" and "Use case scenarios" the model view "Logical Context" is subsequently created at the Logical Viewpoint on abstraction level AL1.</td></tr>
<tr><td>Eu.ModSt.1535</td><td>Info</td><td>In the example shown in Figure 1540 the model view "<u>Logical Context</u>" is depicted. It describes the structure of the SUS at the top level and the actors in the environment interacting with it and their quantity structure (multiplicities). Furthermore, the logical interfaces such as SCI-P, SSI-P, P3 and so on between the SUS and the actors are defined.</td></tr>
</table>

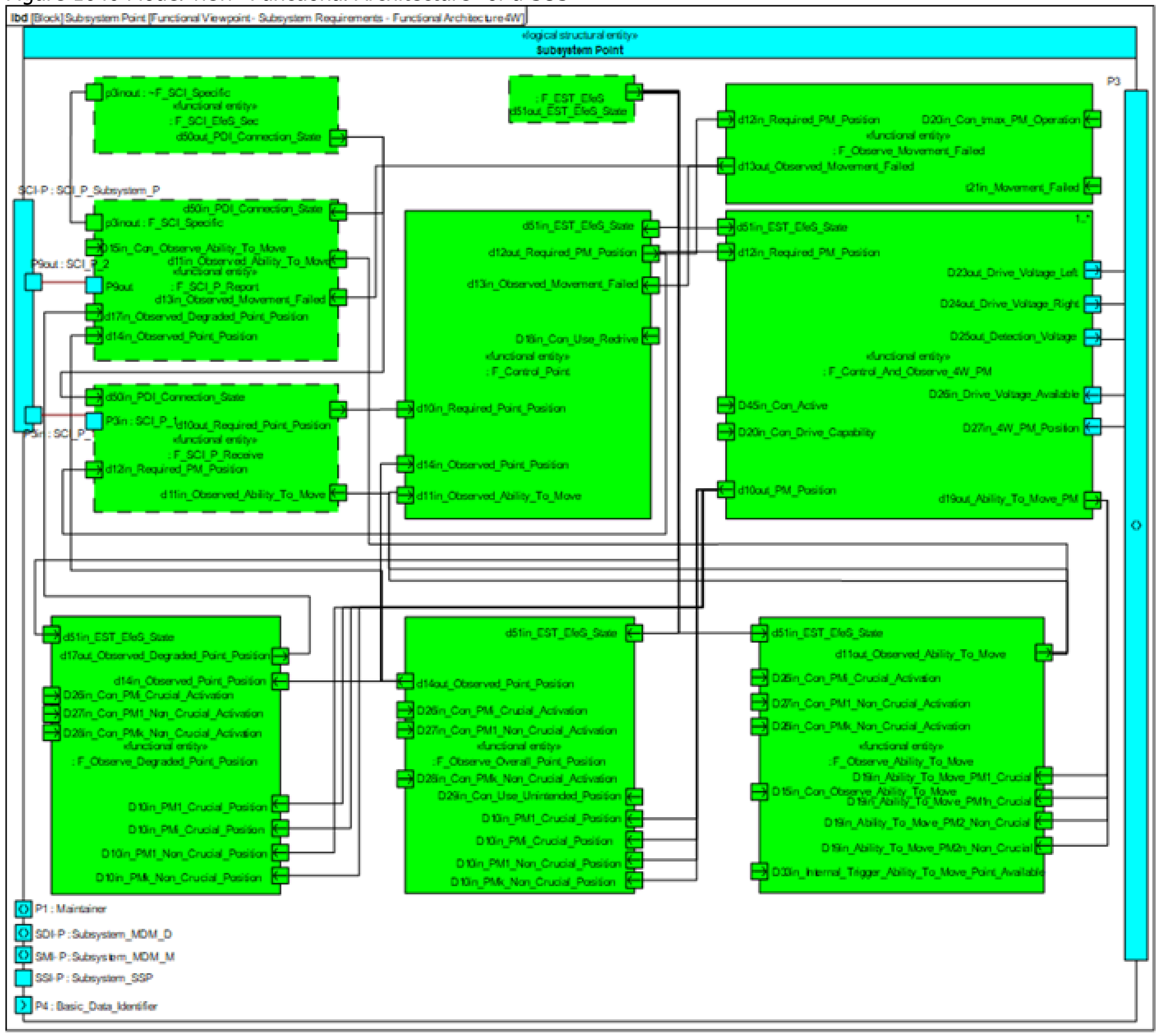
ID	Type	Requirements
Eu.ModSt.1540	Info	Figure 1540 Model view "Logical Context" of a SUS 
Eu.ModSt.1562	Info	**Task (4): creation of model view "Logical Context" of the interfaces to be standardised** Based on the definitions of the logical interfaces defined in model view "Logical Context" of a SUS, the model view "Logical Context" of its standardised interfaces (SIUS) is subsequently created at the Logical Viewpoint on abstraction level AL1.
Eu.ModSt.7122	Info	At the upper level of abstraction an interface is represented by a SysML association. An association is depicted as a continuous line between the communication participants. The association that represents a logical interface in the model view "Logical Context" of the SIUS corresponds to the respective association in the model view "Logical Context" of the SUS.
Eu.ModSt.1626	Info	The model view "Logical Context" of a SIUS as shown in *Figure 1637* describes the logical view of an interface at the upper level of abstraction.
Eu.ModSt.7123	Info	The SysML association is linked to a SysML association block, which serves to refine the relationship. The global behaviour of the application protocol (Railway Control Protocol: RCP) is then specified in this later.

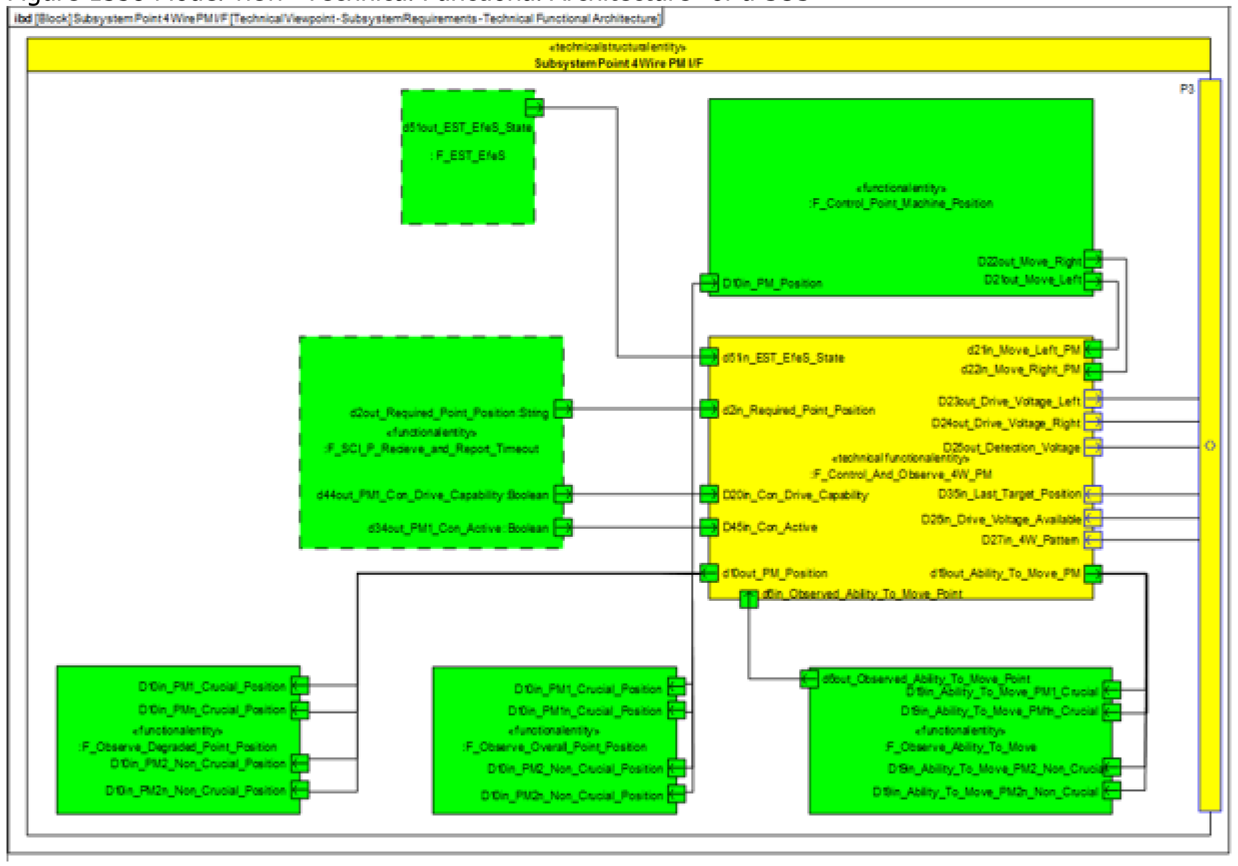
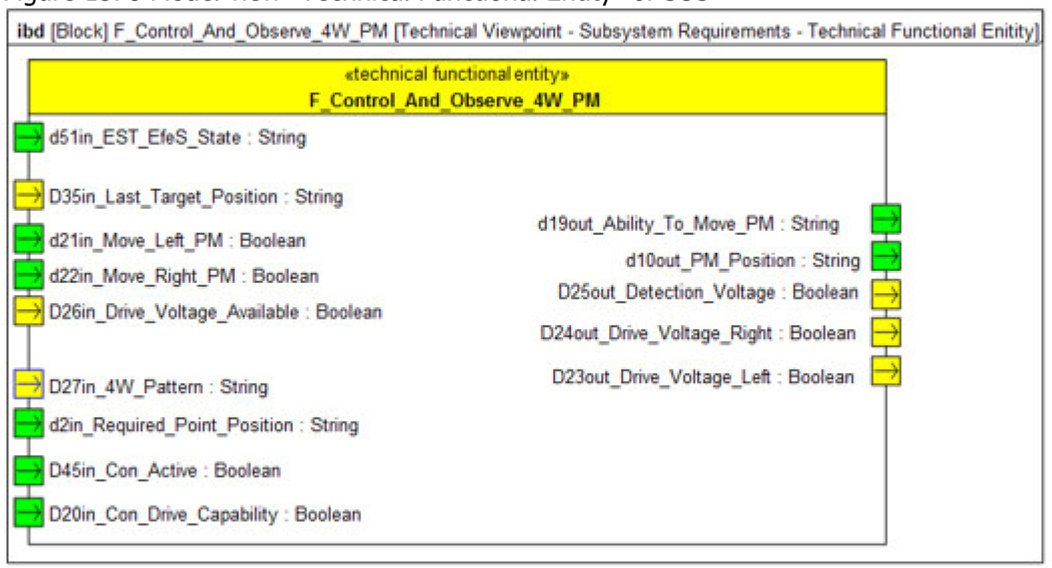
ID	Type	Requirements
Eu.ModSt.1637	Info	Figure 1637 Model view "Logical Context" of a SIUS 
Eu.ModSt.1627	Info	**Task (5): creation of model view "Functional Partitioning" of the interfaces to be standardised** Based on the definition of the model view "Logical Context" of the relevant interfaces, the model view "Functional Partitioning" is subsequently created at the Functional Viewpoint on abstraction level AL1.
Eu.ModSt.1636	Info	The model view "Functional Partitioning" as shown in *Figure 1643* describes the refinement of the interface defined in model view "Logical Context" using FEs. These FEs specify the local behaviours (see *chapter 8.2.4*) of the application layer (PDI: Process Data Interface Protocol) of the communication protocol stack on each side of the communication link.
Eu.ModSt.7901	Info	The FEs are assigned to the involved subsystems via reference associations (marked with a white diamond). The reference associations express that the FEs are not part of the subsystems, but are only used there. They are part of the PDI.
Eu.ModSt.7319	Info	In addition, the respective possible number of FEs is determined by multiplicities.
Eu.ModSt.7320	Info	The model view "Functional Partitioning" of a SIUS is the basis for the model view "Functional Architecture" of a SIUS. While the former, however, defines the absolute behaviour (the maximum possible number of FEs is defined), the model view "Functional Architecture" also allows an excerpted description (Description of different configurations).

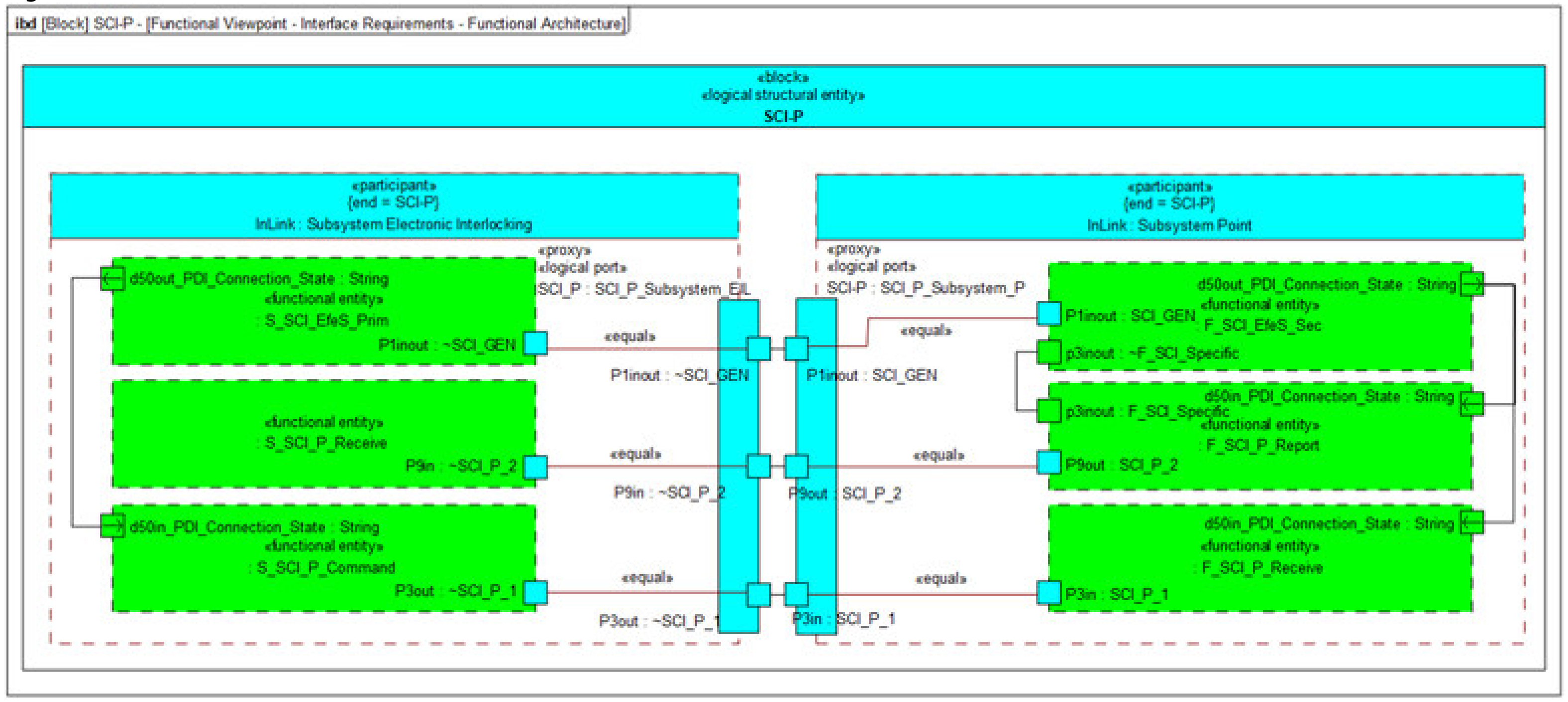
ID	Type	Requirements
Eu.ModSt.1643	Info	Figure 1643 Model view "Functional Partitioning" of a SIUS 
Eu.ModSt.1640	Info	Since the FEs defined in the model view "Functional Partitioning" are used for the further specification of both the SUS and the SIUS, the engineering path splits at this point. The further creation of the model views takes place along two different engineering paths, which are described in the following two *subchapters 8.1.3.1 Engineering path SUS and 8.1.3.2 Engineering path SIUS*.
Eu.ModSt.1927	Head	**8.1.3.1 Engineering path SUS**
Eu.ModSt.1537	Info	**Task (6a): creation of model view "Functional Partitioning" of a SUS** Starting from the model view "Functional Partitioning" of the involved SIUS, the engineering path continues with the generation of the further model views of the SUS at the Functional Viewpoint at abstraction level AL2.
Eu.ModSt.208	Info	First, the model view "Functional Partitioning" of the SUS as depicted in *Figure 1451* is created. It describes the refinement of the SUS by means of the FEs defined in the SIUS model view "Functional Partitioning", which represent the local behaviours of the PDI, as well as the FEs specific to the SUS (linking behaviour according to *chapter 8.2.4*).
Eu.ModSt.7902	Info	FEs which are assigned to the subsystem via reference associations (marked with a white diamond) are not part of the subsystem, but are only used there. They represent the local behaviour of the PDI and are part of it.
Eu.ModSt.7903	Info	FEs which are assigned to the subsystem via composite associations, i.e. so-called whole-part relationships (marked with a black diamond) are part of the subsystem. They represent the specific behaviour of the subsystem that influences more than one interface. This so-called "linking behaviour" is also used to link the behaviour assigned to the interfaces.
Eu.ModSt.7318	Info	In addition, the respective possible number of FEs is determined by multiplicities.
Eu.ModSt.1930	Info	The model view "Functional Partitioning" of a SUS is the basis for the model view "Functional Architecture" of a SUS. While the former, however, defines the absolute behaviour (the maximum possible number of FEs is defined), the model view "Functional Architecture" also allows excerpted descriptions (Description of different configurations).

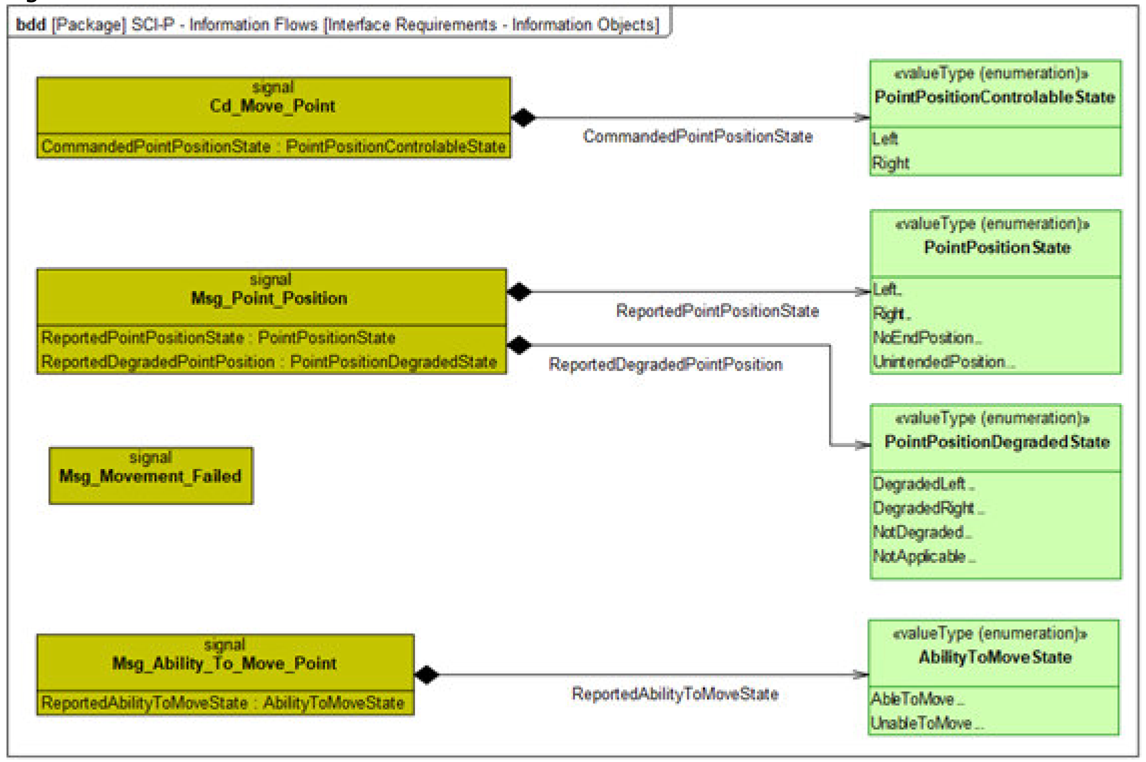
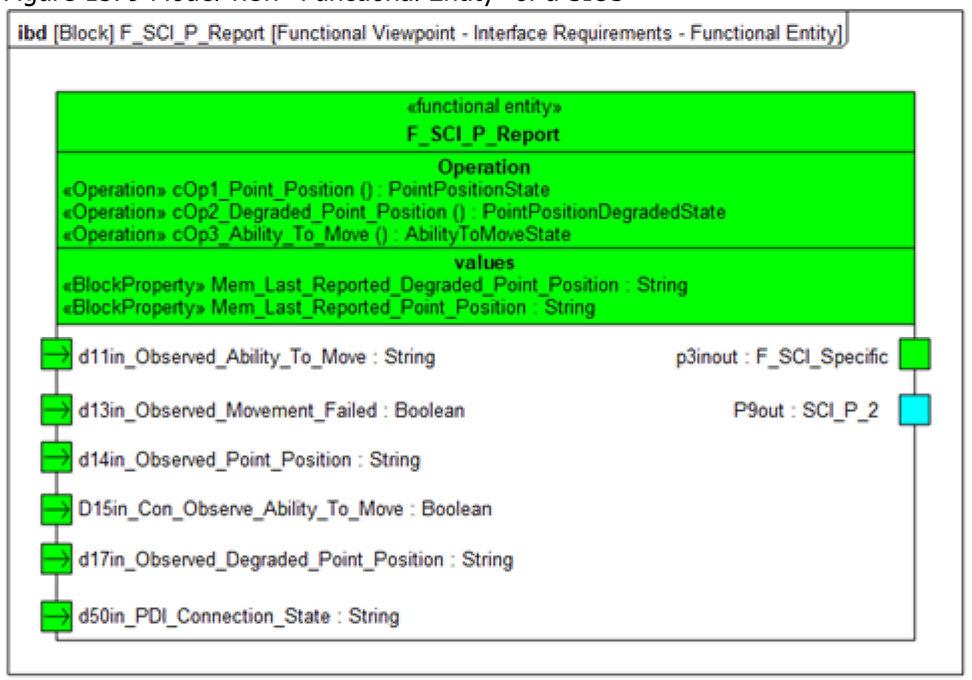
ID	Type	Requirements
Eu.ModSt.1451	Info	Figure 1451 Model view "Functional Partitioning" 
Eu.ModSt.1647	Info	**Task (7a): creation of model view "Functional Entity" of a SUS** Based on the SUS-specific FEs defined in the model view "Functional Partitioning" of a SUS, the model view "Functional Entity" as shown in *Figure 1644* is created for these FEs.
Eu.ModSt.7322	Info	SUS-specific FEs represent control system functions such as "F_Control_Point" (see *Figure 1644*). They have executable SysML state machines and SysML block operations to describe behaviour. SysML state machines enable the specification of finite discrete event dynamic behaviour. SysML block operations are used to perform logical or algebraic transformations.
Eu.ModSt.7463	Info	The model view "Functional Entity" describes the behaviour or part of the behaviour of a SUS independent of technology.

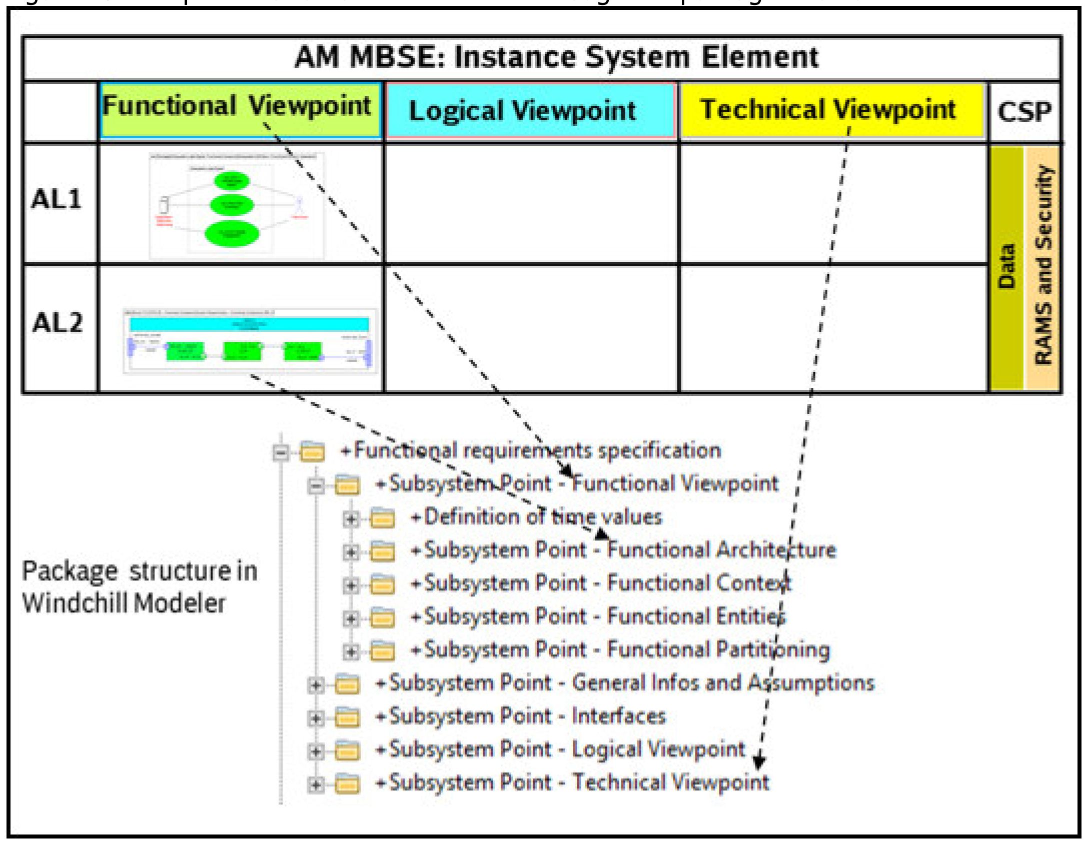
ID	Type	Requirements
Eu.ModSt.1644	Info	Figure 1644 Model view "Functional Entity" of a SUS 
Eu.ModSt.1645	Info	**Task (8a): creation of model view "Functional Architecture" of a SUS** Based on the model view "Functional Partitioning" of the SUS, the model view "Functional Architecture" is created.
Eu.ModSt.7459	Info	The model view "Functional Architecture" as shown exemplarily in *Figure 1646* describes the external visible stimulus-response behaviour of a SUS represented by a Logical Structural Entity (LSE) that is structured in a way that enables an interface centric specification approach as described in *chapter 8.2.4*. The behaviour of the SUS is divided into FEs, which communicate with each other via internal interfaces and with the environment via external interfaces.
Eu.ModSt.7460	Info	The model view "Functional Architecture" describes the behaviour of a SUS independent of technology.

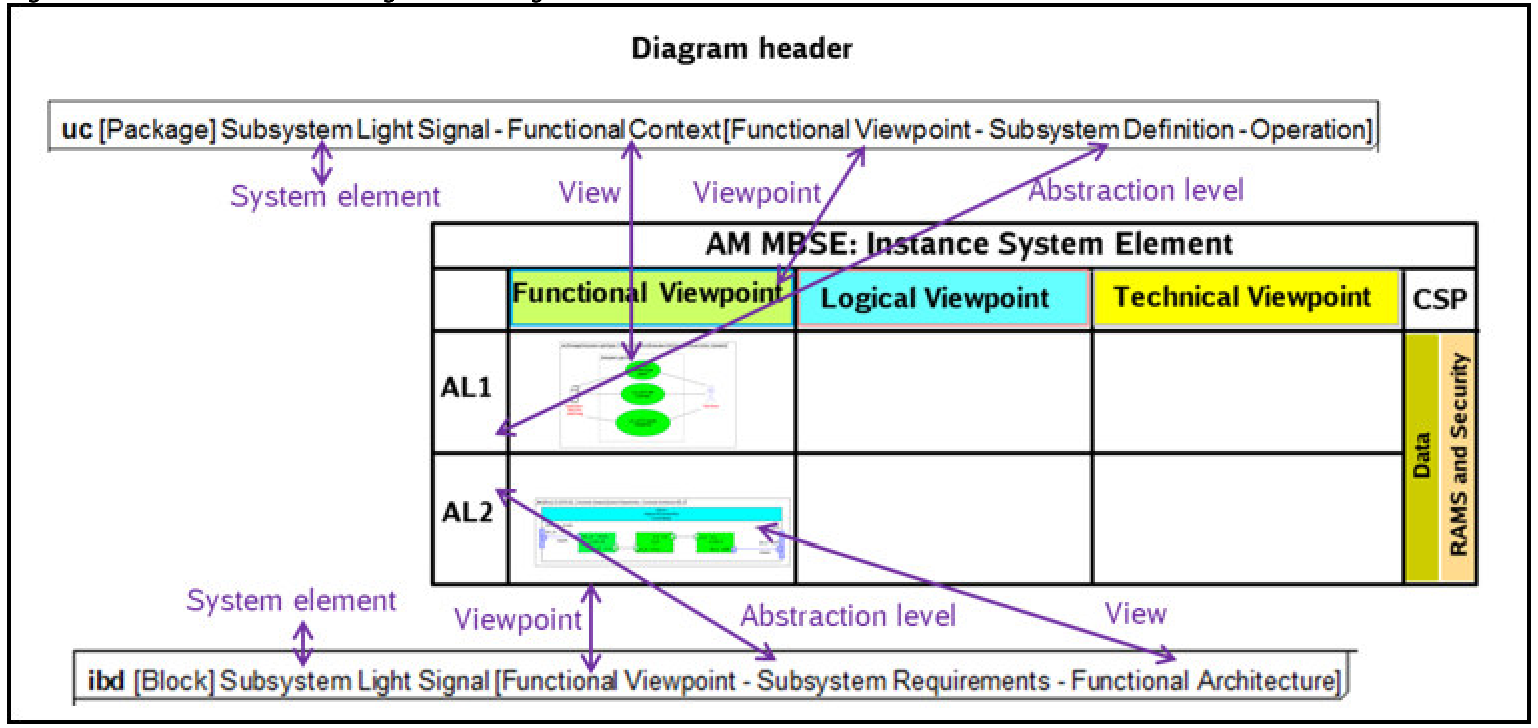
ID	Type	Requirements
Eu.ModSt.1646	Info	Figure 1646 Model view "Functional Architecture" of a SUS 
Eu.ModSt.1654	Info	**Task (9a): creation of model view "Technical Functional Architecture**" **of a SUS** Based on the model view "Functional Architecture" of the SUS, the model view "Technical Functional Architecture" is created at the Technical Viewpoint on abstraction level AL2. This model view is only created if technical functional requirements are to be described in a model-based manner.
Eu.ModSt.7461	Info	The model view "Technical-Functional Architecture" of the SUS, as exemplified in *Figure 1558*, describes the externally visible stimulus-response behaviour of a SUS represented by one or more TSEs based on technical requirements. The SUS is represented by a technical structural entity (TSE).
Eu.ModSt.7462	Info	The technology-independent behaviour described in the Functional Viewpoint in the form of a Functional Architecture through FEs is complemented or substituted by technology-dependent behaviour in the form of TFEs. TFEs are coupled with each other, with already defined FEs or with the environment via external technical interfaces.

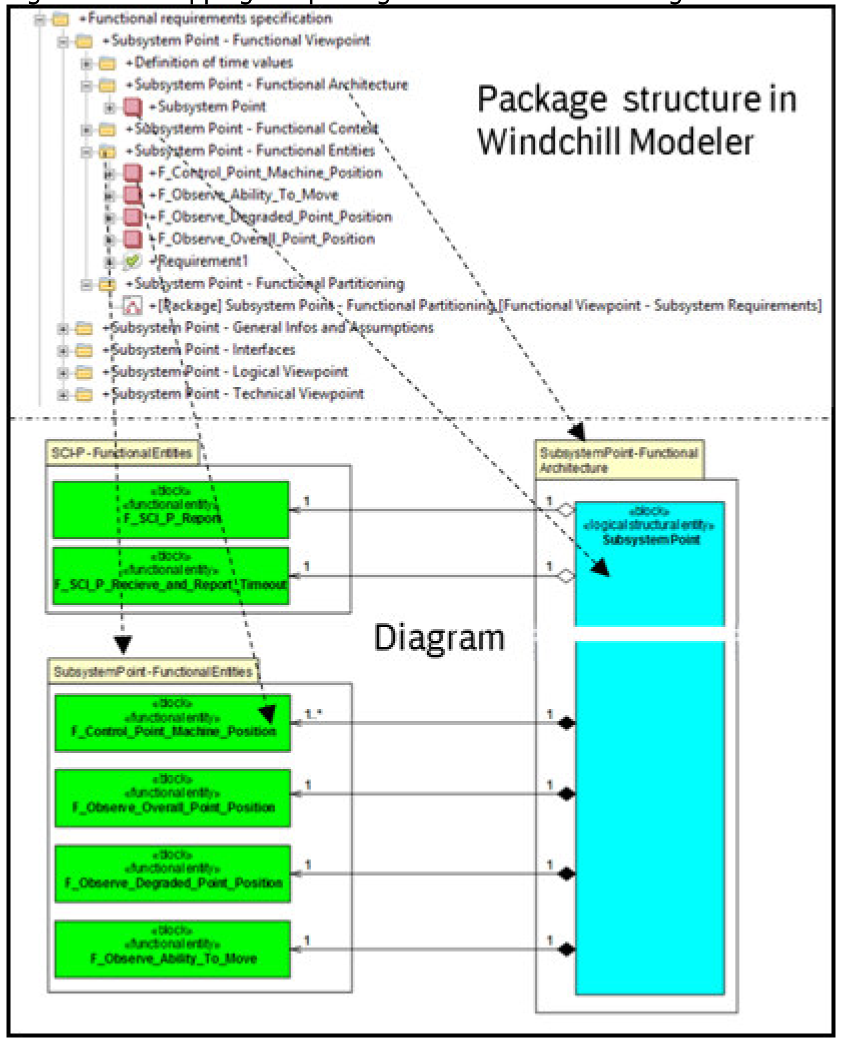
ID	Type	Requirements
Eu.ModSt.1558	Info	Figure 1558 Model view "Technical Functional Architecture" of a SUS 
Eu.ModSt.1652	Info	**Task (10a): creation of model view "Technical Functional Entity" of a SUS** Based on technical requirements, the model view "Technical Functional Entity" as shown in *Figure 1578* is created at the Technical Viewpoint on abstraction level AL2.
Eu.ModSt.7464	Info	TFEs represent technology-dependent control system functions such as "F_Control_And_Observe_4W_PM" (see *Figure 1578*). As well as FEs, TFEs also have executable SysML state machines and SysML block operations to describe behaviour. SysML state machines enable the specification of finite discrete event dynamic behaviour. SysML block operations are used to perform logical or algebraic transformations.
Eu.ModSt.1578	Info	Figure 1578 Model view "Technical Functional Entity" of SUS 
Eu.ModSt.341	Head	**8.1.3.2 Engineering path SIUS**
Eu.ModSt.1649	Info	**Task (6b): creation of model view "Functional Architecture" of a SIUS** Starting from the model view "Functional Partitioning" of the involved SIUS, the engineering path continues with the generation of the further model views of the SIUS at the Functional Viewpoint at abstraction level AL2.

ID	Type	Requirements
Eu.ModSt.7465	Info	First, the model view "Functional Architecture" of the SIUS as depicted in *Figure 1648* is created. It defines the global behaviour of the application protocol. As described in *chapter 8.2.4* the global behaviour is described by connecting the local behavioural components referenced by a communication partner with the corresponding ones of the neighbour via communication channels.
Eu.ModSt.7466	Info	The description of the global behaviour of the application protocol is done by the internal structuring of the association block defined in model view "Functional Partitioning" of the involved SIUS. In this process, the communication partners, which in turn reference the local behavioural parts of the protocol represented by FEs, are referenced in the form of SysML participant properties and connected via their interfaces with connectors.
Eu.ModSt.1648	Info	Figure 1648 Model view "Functional Architecture" of a SIUS 
Eu.ModSt.1641	Info	**Task (7b): creation of model view "Information Flow" of a SIUS** Based on the defined interfaces in model view "Functional Architecture" of a SIUS the model view "Information Flow" is created. The model view "Information Flow" as shown in *Figure 1567* describes the information objects to be exchanged via an interface.
Eu.ModSt.7467	Info	The information objects are represented by SysML signals such as "Cd_Move_Point". These signals can in turn have typed attributes such as "CommandedPointPositionState" that represent parameters of the information objects. For example, the attribute "CommandedPointPositionState" is typed with the enumeration "PointPositionControlableState" with the available values "Left" and "Right".
Eu.ModSt.7468	Info	The information objects are further refined into telegrams on AL3 of the AM MBSE. However, the telegrams are currently not yet implemented in a model-based way.

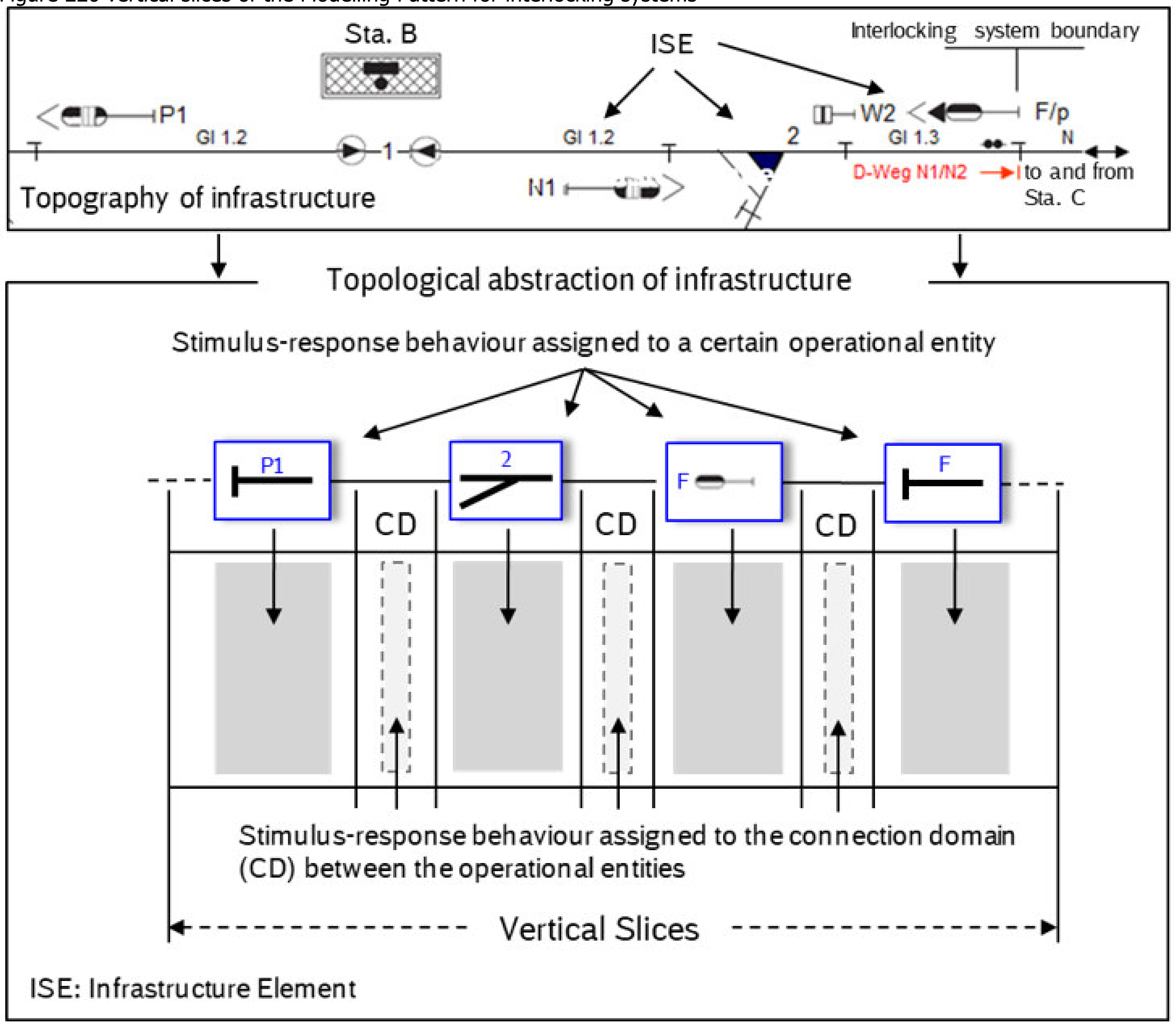
ID	Type	Requirements
Eu.ModSt.1567	Info	Figure 1567 Model view "Information Flow" of a SIUS 
Eu.ModSt.1642	Info	**Task (8b): creation of model view "Functional Entity" of a SIUS** After the information objects are defined, the model views "Functional Entity" are created for the FEs defined in the model view "Functional Partitioning" of a SIUS. These FEs such as "F_SCI_P_Report" (see *Figure 1579*) represent the local behaviours of the RCP of the respective interface. They have executable SysML state machines and SysML block operations to describe behaviour. SysML state machines enable the specification of finite discrete event dynamic behaviour. SysML block operations are used to perform logical or algebraic transformations.
Eu.ModSt.1579	Info	Figure 1579 Model view "Functional Entity" of a SIUS 
Eu.ModSt.2121	Info	The following chapters describe general modelling rules (*chapter 8.2*) and the rules for creating the model views used to specify EULYNX SUS (*chapter 8.3*) and the ones used to define EULYNX SIUS (*chapter 8.4*). As the model views "Functional Entity" and "Technical Functional Entity" are used for the specification of EULYNX SUS as well as for the specification of EULYNX SIUS they are described in the separate *chapters 8.5 and 8.6*.
Eu.ModSt.363	Head	**8.2 Model views - General modelling rules**

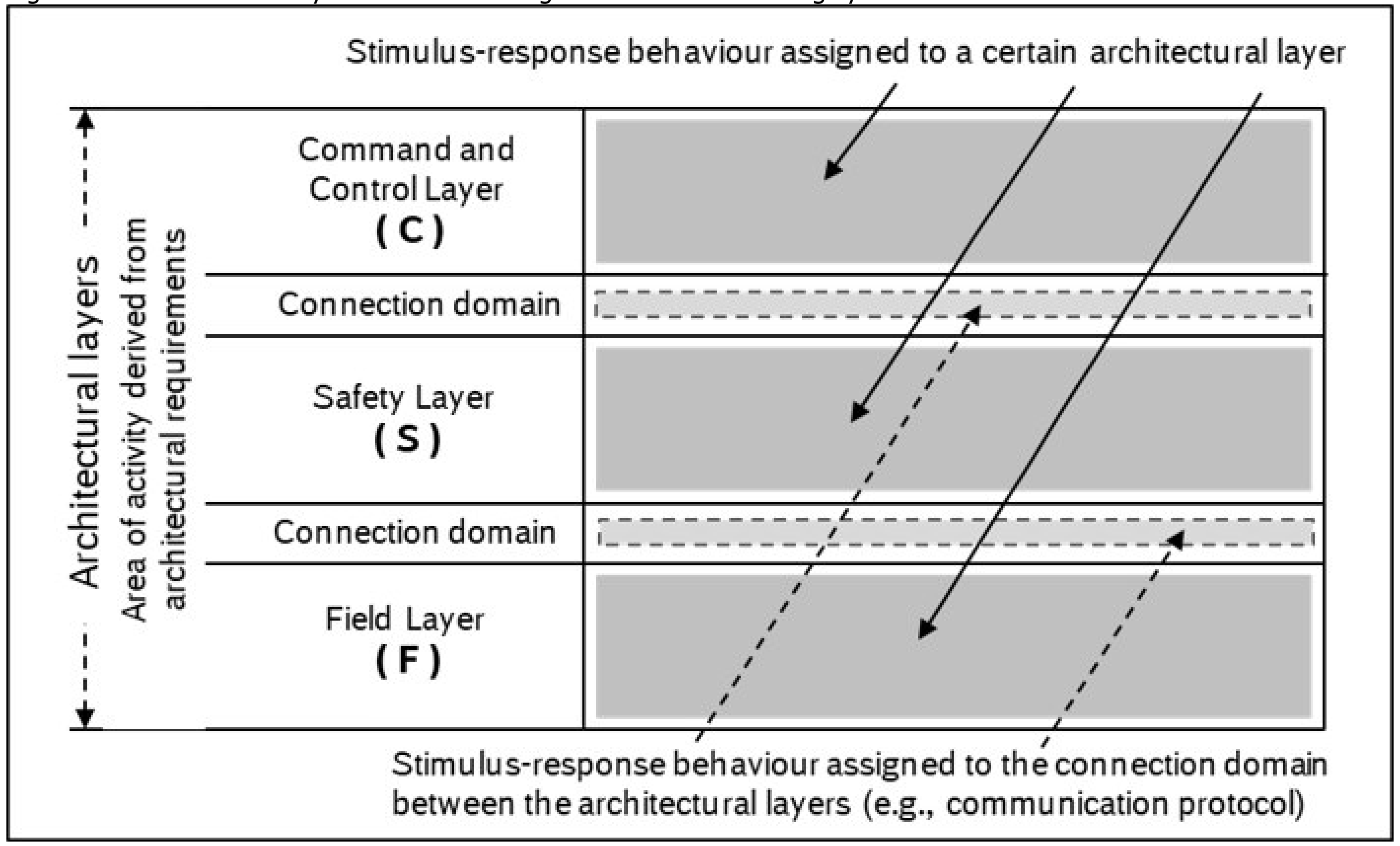
ID	Type	Requirements
Eu.ModSt.58	Info	The system requirements of a specification model (abstraction levels AL2 Subsystem Requirements and AL2 Interface Requirements) of the AM MBSE must be executable and provide a graphical user interface enabling model simulation.
Eu.ModSt.60	Info	Before delivering derived specifications to the signalling system supplier, quality assurance must be completed by carrying out the verification and validation activities defined in the MBSE process.
Eu.ModSt.63	Info	Links to model elements embedded blue-coloured in model descriptions formulated in prose must not be put in quotation marks.
Eu.ModSt.1160	Info	The related information, which is required to convoy the complete meaning of a model element, must be documented for each used model element in the modelling tool (e.g. Properties ->Text->Description).
Eu.ModSt.1161	Info	Unless there are project-specific commitments, stereotypes such as <<block>>, <<ProxiPort>> and so forth may be shown on the diagrams if the modeller regards it as beneficial.
Eu.ModSt.1162	Info	Unless there are project-specific commitments, data types such as Boolean, Integer, PulsedIn, PulsedOut and so forth may be shown on the diagrams if the modeller regards it as beneficial.
Eu.ModSt.1239	Info	Shapes and colours of model elements presented in this modelling standard can be adapted according to project-specific commitments, unless explicitly required. Example: An actor basically is depicted as a stickman. It might be project-specifically determined to use the image of a cube if the actor represents a system and a "stickman" if the actor represents a person.
Eu.ModSt.1456	Info	Project-specific requirements transcending the requirements of Modelling Standard are to be documented separately.
Eu.ModSt.7847	Info	As shown in principle in *Figure 7847*, the AM MBSE is to be represented by the package structure in the modelling tool.
Eu.ModSt.7844	Info	Figure 7844 Representation of the AM MBSE through the package structure 
Eu.ModSt.2027	Info	Viewpoint, abstraction level and model view of the AM MBSE name are made evident in the header of the diagram representing a certain model view.
Eu.ModSt.2028	Info	Examples: • The view "Functional Context" depicted in *Figure 2029* describing a certain aspect of system element Subsystem Light Signal by a SysML use case diagram (uc) belongs to the "Functional Viewpoint" and has the granularity of abstraction level AL1 (Subsystem Definition). • The view "Functional Architecture" depicted in *Figure 2029* describing a certain aspect of system element Subsystem Light Signal by a SysML internal block diagram (ibd) belongs to the "Functional Viewpoint" and has the granularity of abstraction level AL2 (Subsystem Requirements).

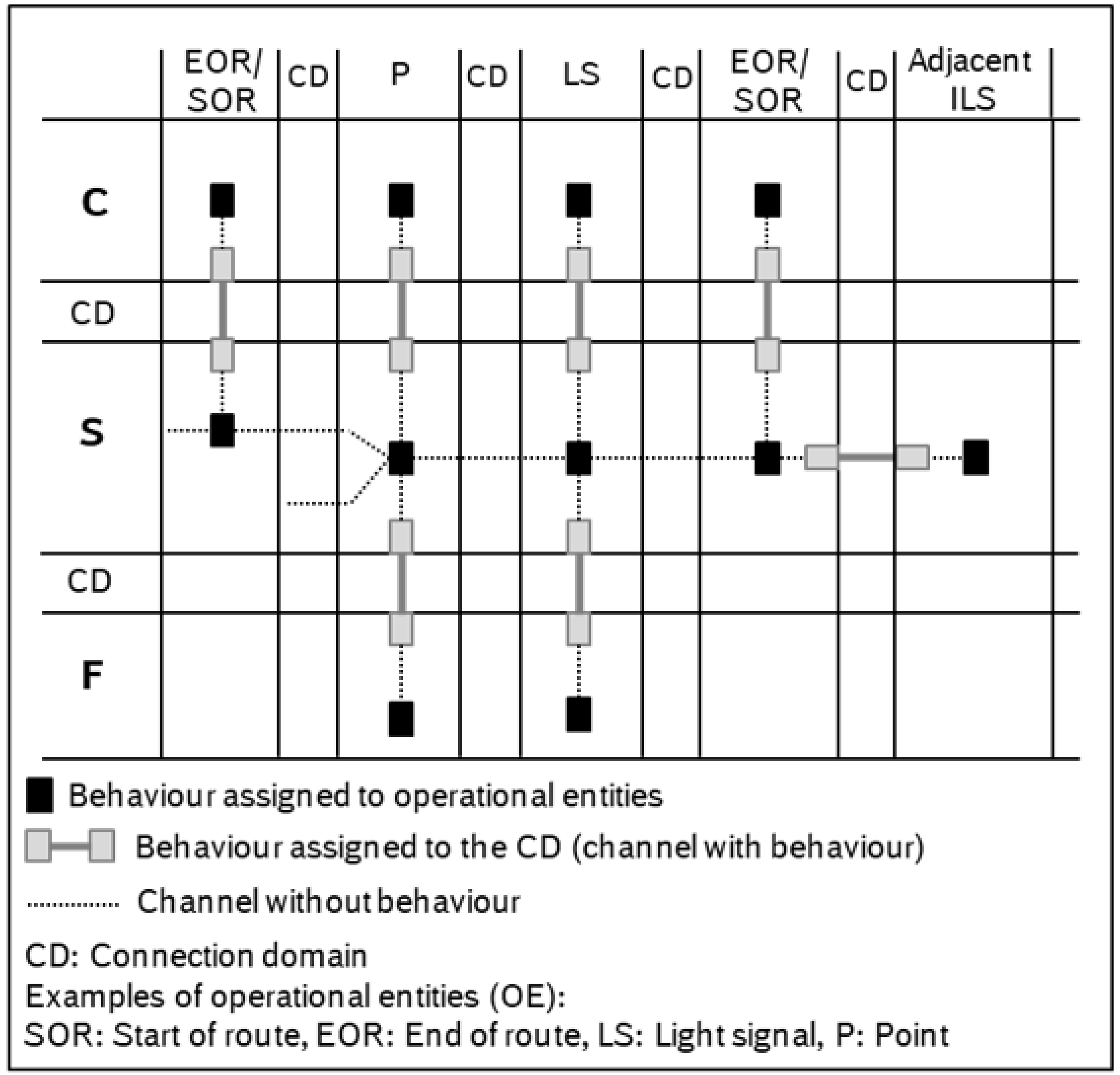
ID	Type	Requirements
Eu.ModSt.2029	Info	Figure 2029 Structure of the diagram headings 
Eu.ModSt.7845	Info	As shown in Figure 7846 as an example, the packages in which the respective model elements are stored are to be displayed on the diagrams.

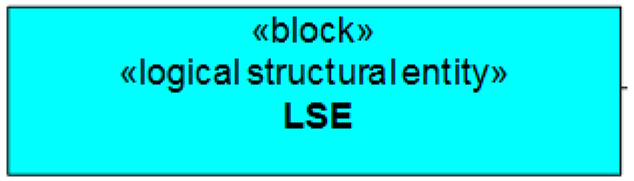
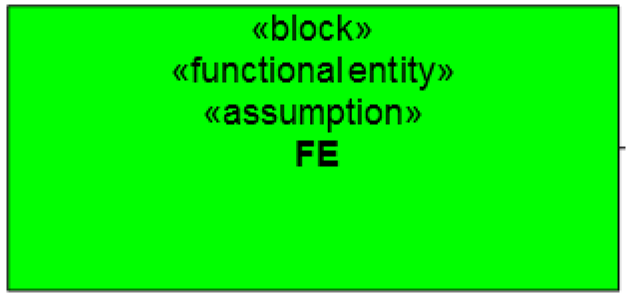
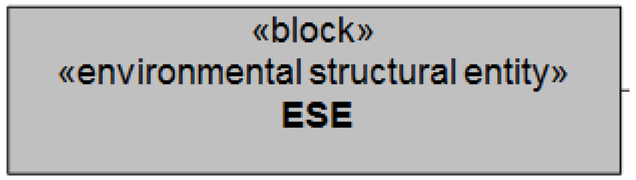
ID	Type	Requirements
Eu.ModSt.7846	Info	Figure 7846 Mapping the package structure onto the diagrams 
Eu.ModSt.7707	Info	In the following *subsections 8.2.1, 8.2.2 and 8.2.3*, the binding of requirements, the modelling pattern for interlocking systems supporting the EULYNX methodology and the basic structural model elements used are introduced.
Eu.ModSt.7065	Head	**8.2.1 Binding nature of the requirements and their structuring**
Eu.ModSt.2030	Info	The SUS and SIUS SysML specification models are stored in the repository of the modelling tool. Relevant artefacts of them are depicted in a traceable manner as surrogates in the requirement specification documents in the form of atomic referenceable functional SUS or SUIS requirements.
Eu.ModSt.7060	Info	Each of these atomised requirements is assigned a liability in the form of an object type. A distinction is made between the object types "Req", "Def", "Info" and "Head".
Eu.ModSt.7061	Info	• "**Req**": This denotes a mandatory requirement.
Eu.ModSt.7062	Info	• "**Def**": This denotes referenceable model elements that are used in the model-based creation of requirements
Eu.ModSt.7063	Info	• "**Info**": This denotes additional information to help understand the specification. These objects do not specify any additional requirements.
Eu.ModSt.7064	Info	• "**Head**": This denotes chapter headings.
Eu.ModSt.7937	Info	**Please note:** State machines or several state machines linked together in a Functional Architecture define the totality of all functional requirements of an SUS or an SIUS in a coherent and consistent manner. State diagrams of a corresponding state machine are marked with the object type "**Req**". For the later design and implementation, it is not the description language SysML that is binding, but the domain-specific meaning expressed by it. The specified behaviour can be converted into a vendor specific language but must retain the domain specific meaning describing the functional requirements. The specific model elements are additionally specified and defined by object type "**Def**" to allow for traceability to supplier designs or test cases. The compliance of products to the specifications must be demonstrated by testing against EULYNX test cases, which are derived from the functionality specified by the models.
Eu.ModSt.7896	Info	**Please note:** The bindings assigned to each model view in this document can be adjusted on a project-specific basis. Thus, the bindings assigned in the specifications always apply.

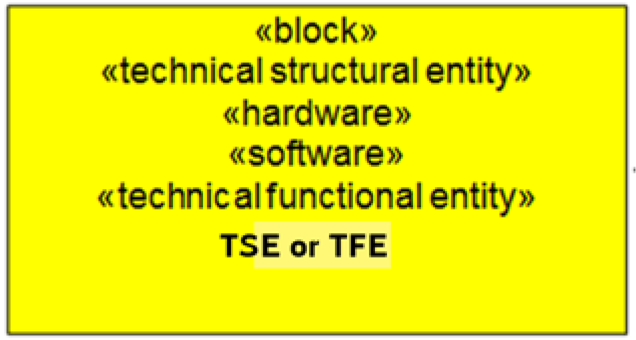
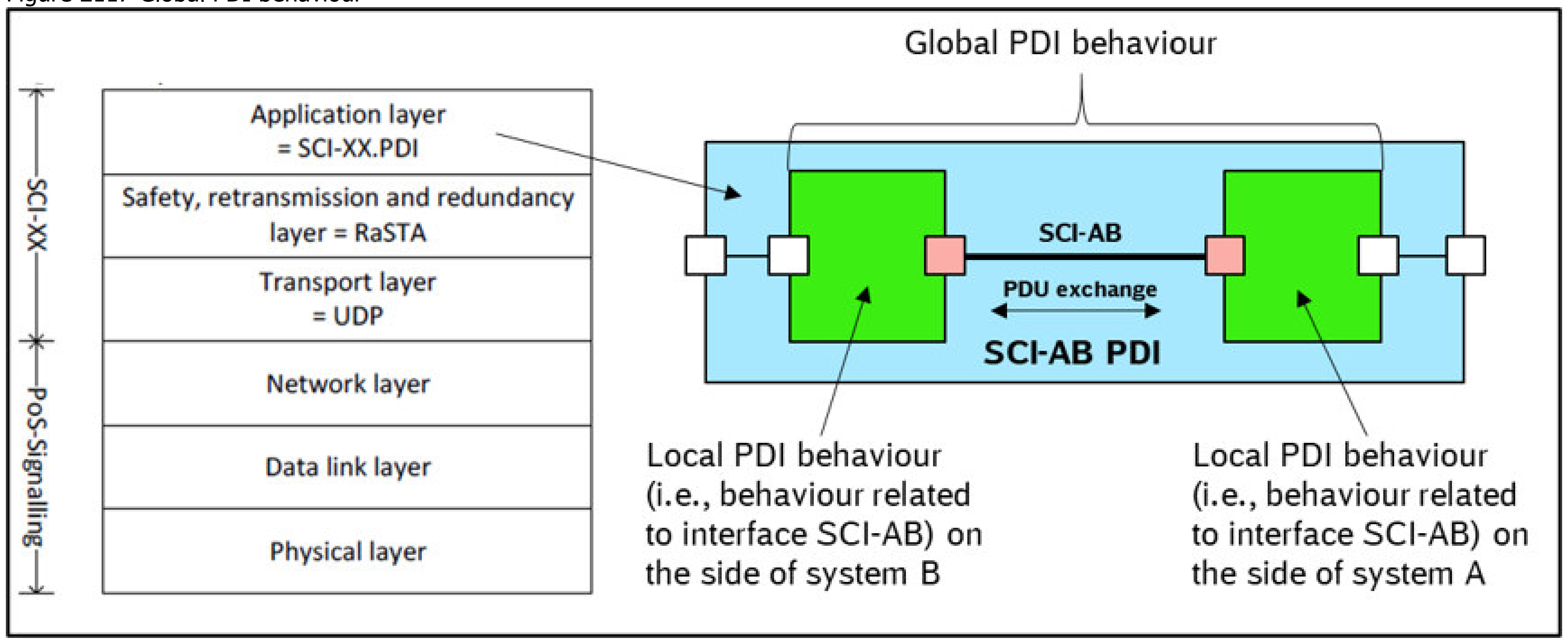
ID	Type	Requirements
Eu.ModSt.2031	Info	A functional requirement consists of the respective SysML model element, for instance a SysML diagram, and if necessary, an additional extension of it.
Eu.ModSt.2032	Info	For this reason, functional requirements have two attributes "**Requirement Part 1**" and "**Requirement Part 2**", which are shown in adjacent columns (see Figure 2).
Eu.ModSt.2033	Info	In "Requirement Part 1" the respective SysML model element is listed and in "Requirement Part 2" the corresponding extension is shown. Column 'Type' defines the bindingness of the requirement and applies normally both to "Requirement Part 1" and "Requirement Part 2".
Eu.ModSt.2034	Info	In the case of requirements with a binding character "**Req**", in which the "Requirement Part 2" is provided with the heading "**Information**", the defined binding character "**Req**" only applies to "Requirement Part 1".
Eu.ModSt.2035	Info	Figure 2: "Requirement Part 1" and "Requirement Part 2" as shown in the requirement specifications. **ID** / **Type** / **Requirement Part 1** / **Requirement Part 2** Eu.LS.4687 / Req / Cd_Indicate_Signal_Aspect / Command (Cd) from the Subsystem - Electronic Interlocking to the Subsystem - Light Signal to indicate the transmitted Signal Aspect.
Eu.ModSt.2036	Info	Just this partition of requirements is applied throughout the entire requirement specification document regardless of whether a requirement has its origins in the SUS or SIUS model or it is for example a text-based nonfunctional requirement manually added.
Eu.ModSt.7704	Head	**8.2.2 Modelling Pattern for interlocking systems**
Eu.ModSt.220	Info	Assuming that the stimulus-response behaviour of an overall interlocking system is immanently allocated to the infrastructure elements and encapsulated in each, the vertical slices of a Modelling Pattern for an overall interlocking system as depicted in *Figure 226*, may be derived in form of a generic topological abstraction of the signalling infrastructure, i.e. following the geographical principle.
Eu.ModSt.221	Info	This assumption has already been verified by the implementation of the all-relay interlocking in which the logic of routes is designed following the geographical principle (e.g. the Sp DRS 60 interlocking of Siemens AG as described in [18]).
Eu.ModSt.222	Info	The geographical principle considers the interconnection of distinct pieces of functionality, immanently encapsulated in the infrastructure elements (ISE), in the form of modules according to the signal layout plan (topological abstraction of infrastructure).
Eu.ModSt.223	Info	Hence, the functional structure within each vertical slice of the Modelling Pattern for an overall interlocking system may be derived from ISE specific behaviour and interconnected according to the signal layout plan (see *Figure 226*).
Eu.ModSt.224	Info	Each of the vertical slices, i.e. each OE, represents the stimulus-response behaviour of a corresponding ISE.
Eu.ModSt.1237	Info	The goal is to define the stimulus-response behaviour assigned to a vertical slice in a way that it fits into all valid variants of signal layout plans.
Eu.ModSt.1163	Info	The OEs communicate as appropriate with one another, i.e. they exchange information.
Eu.ModSt.1164	Info	Each information is sent out by a sender and received by one or multiple receivers. One of these is an OE; the other is an adjacent OE.
Eu.ModSt.1165	Info	During its transmission, an information passes through a communication channel, which is the path through which the information travels from the sender to the receiver. This communication channel is assigned to the connection domain (CD).
Eu.ModSt.1166	Info	If the information is given directly by the sender to the receiver a communication channel may be abstracted without specifying any behaviour.
Eu.ModSt.1167	Info	In other cases, the communication channel is significant because in it information may be delayed, lost, transformed into a format more convenient for the receiver or ordered in time. In these cases, the behaviour of the communication channel is to be modelled explicitly.

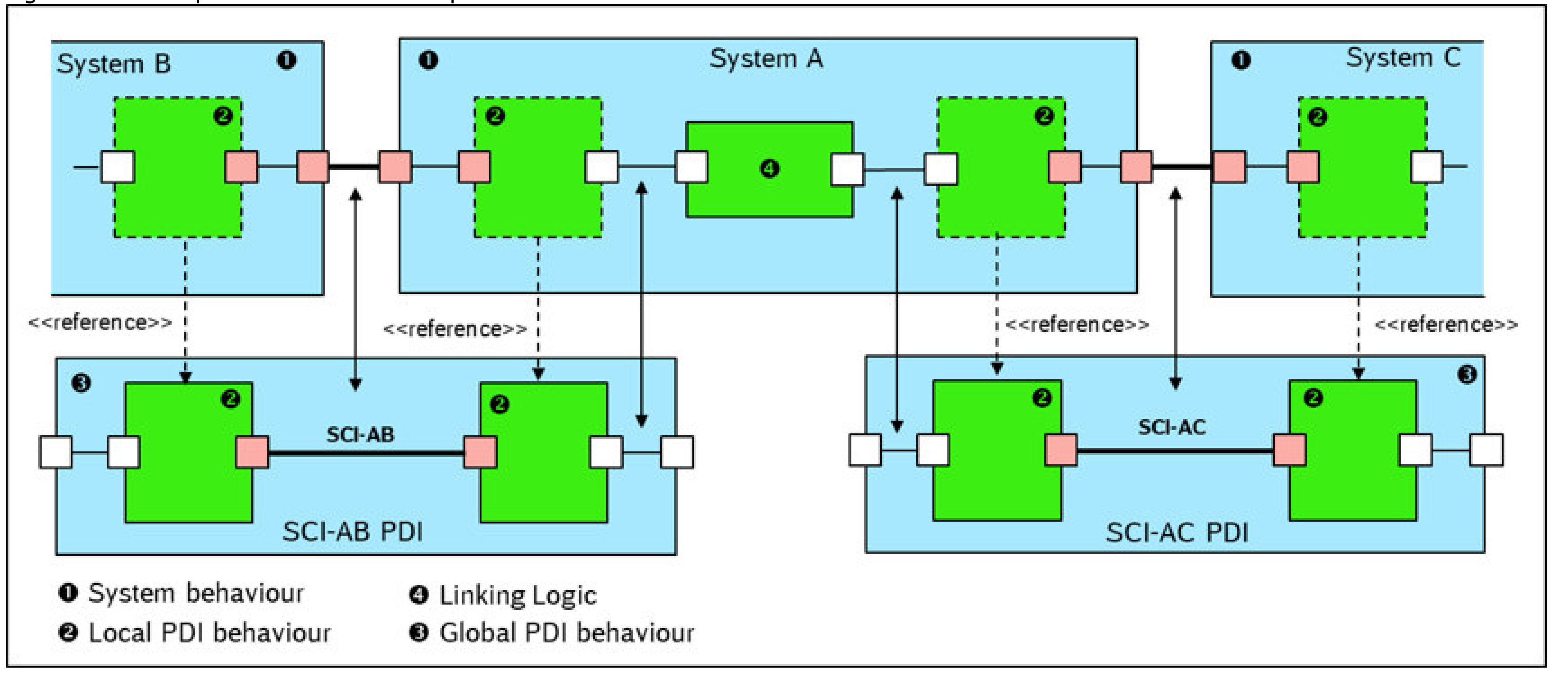
ID	Type	Requirements
Eu.ModSt.226	Info	Figure 226 vertical slices of the Modelling Pattern for interlocking systems 
Eu.ModSt.227	Info	The layers of a Modelling Pattern for an overall interlocking system may be derived from architectural requirements based on the present architecture of an interlocking system [12] (see *Figure 228*): • **Command Control Layer** (acronym: **C**), • **Safety Layer** (acronym: **S**), • **Field Layer** (acronym: **F**).
Eu.ModSt.1168	Info	The OEs exchange information between the different architectural layers as appropriate.
Eu.ModSt.1169	Info	Each information has a sender and one or multiple receivers. One of these is a certain architectural layer of an OE; the other is the underlying or overlying architectural layer of this OE.
Eu.ModSt.1170	Info	In the same way as between the vertical slices described above each information passes through a communication channel assigned to the CD. It connects sender and receiver and may have a behaviour or not.

ID	Type	Requirements
Eu.ModSt.228	Info	Figure 228 Architectural layers of the Modelling Pattern for interlocking systems 
Eu.ModSt.231	Info	The Modelling Pattern for interlocking systems, as depicted in principle in *Figure 230*, consists of vertical slices representing the required stimulus-response behaviour of corresponding OEs such as "Light Signal" or "Point" and adjacent vertical slices in which the behaviour of the CD is to be specified.
Eu.ModSt.1172	Info	At the architectural layers **C**, **S** and **F**, the stimulus-response behaviour of the operational entities is put into the perspective of architectural requirements. The CD is to be specified at the underlying or overlying layer of the architectural layer **S**, respectively.
Eu.ModSt.232	Info	Each cell of the so-defined matrix represents a piece of required stimulus-response behaviour of the corresponding OE, put into the perspective of architectural requirements inherent in the respective architectural layer.
Eu.ModSt.1292	Info	This aforementioned behaviour is described in each cell by a FE or a number of FEs that are interconnected in a Functional Architecture.
Eu.ModSt.7705	Info	A Functional Architecture divides the behaviour into Functional Entities, which communicate with each other via internal interfaces and with the environment via external interfaces.
Eu.ModSt.1294	Info	A distinction is made between cells containing the behaviour assigned to OEs and those containing the behaviour of the CD.
Eu.ModSt.1293	Info	The behaviour assigned to the CD specifies the **c**ommunication channel (i.e. the global behaviour of the application protocol RCP) between cells containing the behaviour of adjacent OEs (*see chapter 8.2.4 Interface centric specification*).
Eu.ModSt.7706	Info	Channels without behaviour are represented by SysML connectors that connect the ports of the respective FEs.

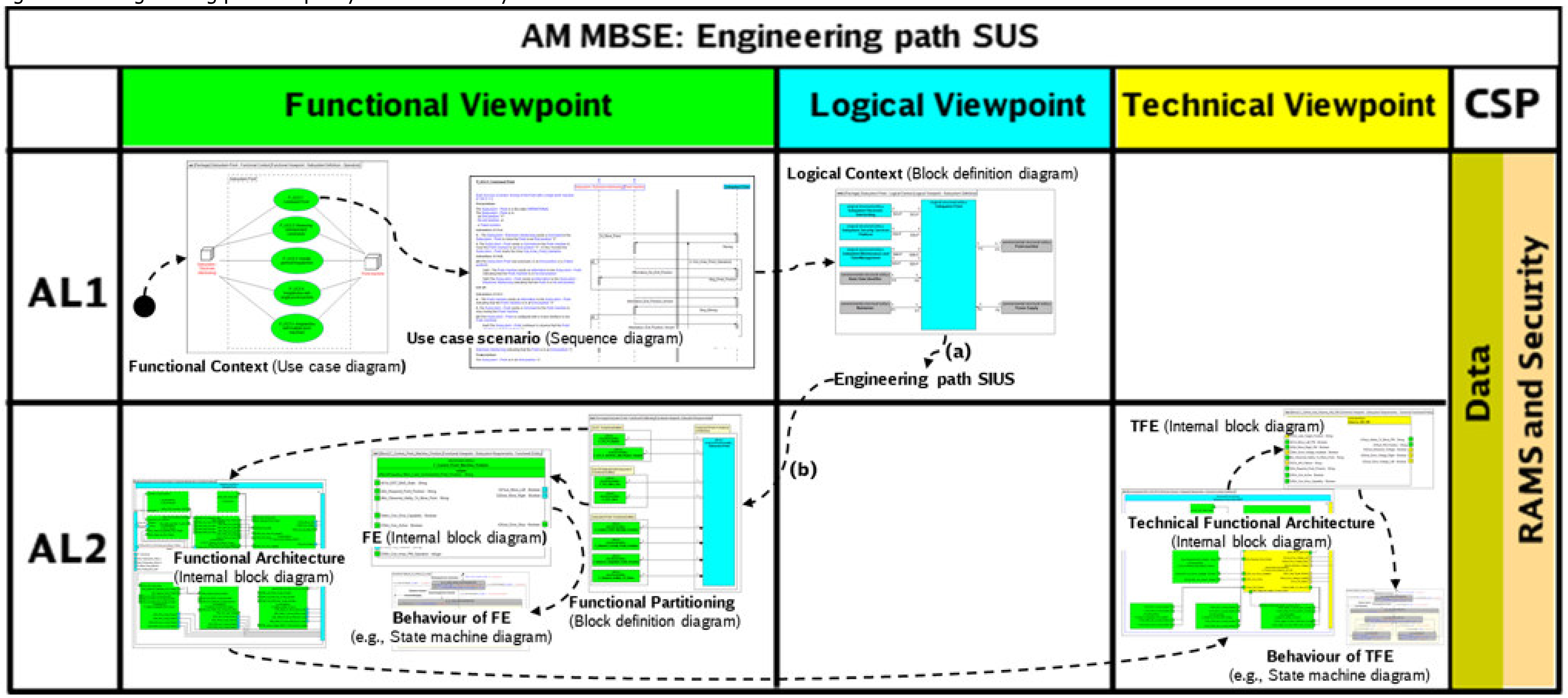
ID	Type	Requirements
Eu.ModSt.230	Info	Figure 230 Principle of a Modelling Pattern for interlocking systems (simplified) 
Eu.ModSt.2091	Head	**8.2.3 Introduction of the basic structural model elements**
Eu.ModSt.2092	Head	**8.2.3.1 Logical Structural Entity (LSE)**
Eu.ModSt.2093	Info	A Logical Structural Entity (block in turquoise, stereotyped as <<logical structural entity>>) represents a system element from a logical point of view. It encapsulates either one or more LSEs interconnected in the form of a Logical Architecture or one or more FEs interconnected in the form of a Functional Architecture.
Eu.ModSt.1243	Info	LSEs representing architectural entities are applied in order to structure a SUS according to architectural aspects aiming at a logical system architecture solution independent from any technological constraints. This kind of partitioning results in a glass box view of the SUS.
Eu.ModSt.355	Info	In a glass box specification the SUS is described as a collection of subsystems.
Eu.ModSt.205	Info	LSEs that are not required to be further decomposed by other LSEs are referred to as atomic LSEs.
Eu.ModSt.1101	Info	The stimulus-response behaviour of a non-atomic LSE is represented by the interactions between its decomposed subcomponents and the interactions of those subcomponents with the interfaces of the SUS. These interactions are described by use case scenarios.
Eu.ModSt.203	Info	Each atomic LSE encapsulates a piece of the "total" external visible stimulus-response behaviour of a SUS. This behaviour may be modularised by Functional Entities (black box view of a SUS).
Eu.ModSt.354	Info	In a black box specification only the black box behaviour of the system to be specified is considered, i.e. only the external properties of the system are defined (externally visible input/output behaviour).

ID	Type	Requirements
Eu.ModSt.2094	Info	Figure 9 Logical Structural Entity 
Eu.ModSt.2095	Head	**8.2.3.2 Functional Entity (FE)**
Eu.ModSt.2096	Info	A functional entity (green block, stereotyped with <<functional entity>>) encapsulates a certain portion of technology-independent system behaviour of a system element.
Eu.ModSt.1247	Info	FEs representing behavioural entities are applied to modularise the stimulus-response behaviour of an atomic LSE aiming at reusability and mastering the complexity. This kind of partitioning does not have any impact on system architectural aspects i.e. the atomic LSE remains a black box. A FE is not further decomposable.
Eu.ModSt.1102	Info	The syntactic interface of a FE defines primarily the signatures of the in ports and the out ports and as appropriate the signatures of block properties and block operations. The semantic interface specifies the stimulus-response behaviour, i.e. the chronological order of stimuli and responses using a state machine. The syntactic interface as well as the semantic interface of a FE are explained in detail in the *chapters 8.5 and 8.6*.
Eu.ModSt.2097	Info	A functional entity additionally stereotyped with <<assumption>>represents a set of assumptions which are not functional requirements. Assumptions are mainly used to restrict the environment of a FE.
Eu.ModSt.2098	Info	Figure 10 Functional Entity 
Eu.ModSt.2099	Head	**8.2.3.3 Environmental Structural Entity (ESE)**
Eu.ModSt.2100	Info	In the environment of a SUS, there may be other system elements belonging to the same overall system (subsystems) with which the SUS in question has a communication relationship. These system elements are described by logical structural entities. However, the SUS can also have a relationship with system elements that are outside the associated overall system. These system elements are described by environmental structural entities (grey block, stereotyped with <<environmental structural entity>>).
Eu.ModSt.2101	Info	Figure 11 Environmental Structural Entity 
Eu.ModSt.2102	Head	**8.2.3.4 Technical Structural Entity (TSE) or Technical Functional Entity (TFE)**
Eu.ModSt.2103	Info	**Technical Structural Entity:** A Technical Structural Entity (yellow-coloured SysML block stereotyped with <<technical structural entity>>) encapsulates one or more TSEs in the form of a Technical Architecture or one or more TFEs interconnected in the form of a Technical Functional Architecture based on technical requirements (<<hardware>>: TSE representing a hardware artefact, <<software>>**:** TSE representing a software artefact).
Eu.ModSt.2104	Info	**Technical Functional Entity:** A Technical Functional Entity (yellow-coloured SysML block stereotyped with <<technical functional entity>>) represents a certain piece of technology-dependent behaviour based on technical requirements in a Technical Functional Architecture supplementing or substituting the technology-independent behaviour defined by FEs.

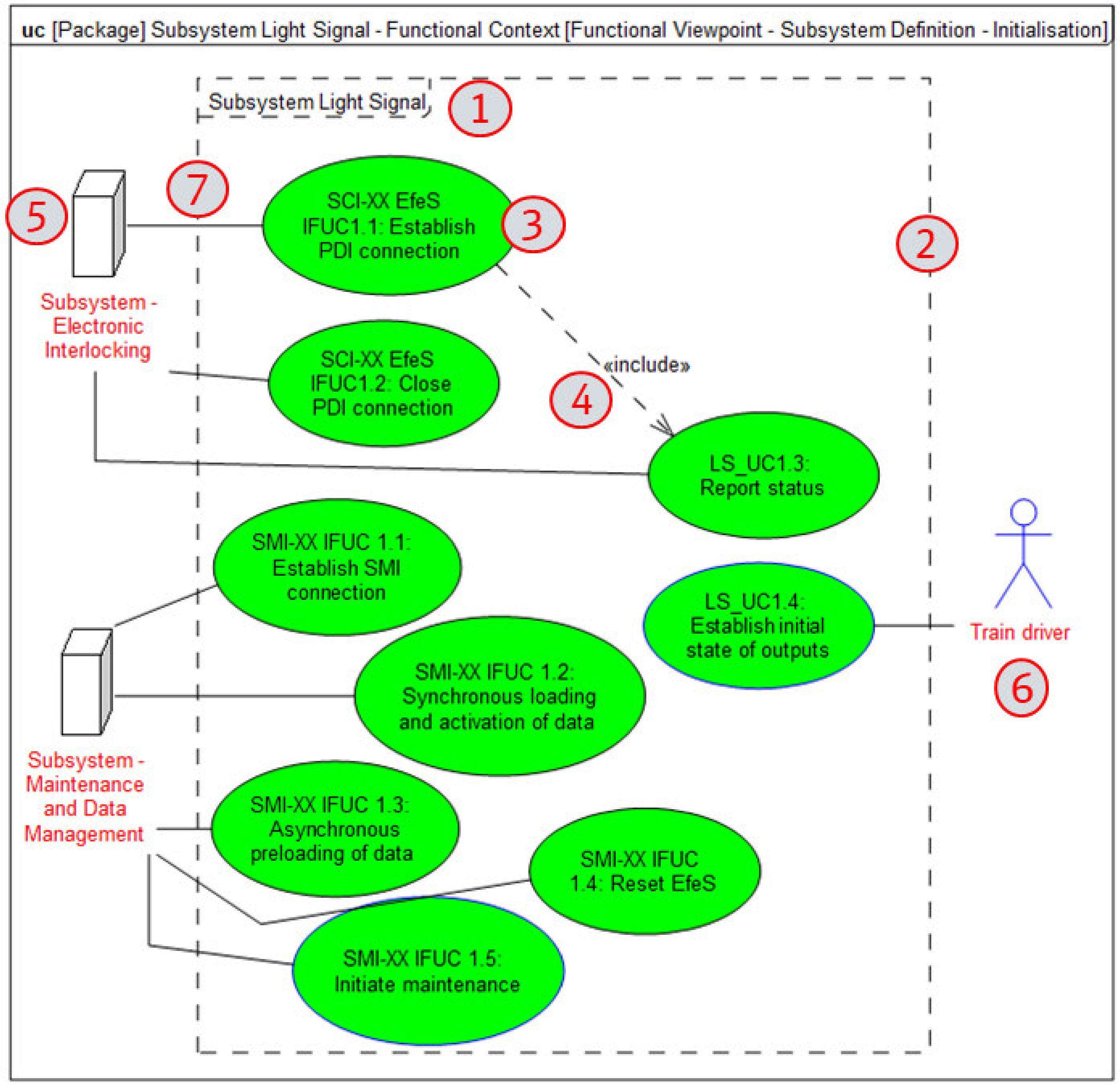
ID	Type	Requirements
Eu.ModSt.2105	Info	Figure 12 Technical Structural Entity or Technical Functional Entity 
Eu.ModSt.2106	Head	**8.2.3.5 Information objects**
Eu.ModSt.2107	Info	Information objects are the objects that are exchanged between the respective communication partners via a communication relationship. They are formed from signals and values of the signals, the so-called attributes and are made available or received at ports.
Eu.ModSt.2108	Info	Ports are represented by small squares at the edge of a Functional Entity and represent the connections to the interfaces to other internal or external Functional Entities to which a communication relationship exists, or to external interfaces. The port also indicates the arbitrary port name and interface type in the format "port name:interface type". Communication relationships between functional entities are assigned a reading direction. In the case of ports, this is represented by the interface type being shown in conjugated form, i.e. by the symbol "~", on one side of the communication relationship.
Eu.ModSt.2109	Head	**8.2.4 Interface centric specification**
Eu.ModSt.2112	Info	By an interface centric approach**,** it is understood that the external visible stimulus-response behaviour (usage behaviour) of a SUS is largely described by the behaviours related to its interfaces. These behaviours are linked together and supplemented by behaviour relevant for more than one interface by means of linking behaviour.
Eu.ModSt.2113	Info	As depicted in *Figure 2117*, the models of the protocol stacks assigned to the communication interfaces are downscaled to the Process Data Interface protocols (PDI) defining the global PDI behaviours of the application layers (e.g., SCI-AB PDI).
Eu.ModSt.2114	Info	**Global behaviour** specifies the dependencies between the local PDI behaviours of the communication partners, that is the exchange of Process Data Units (PDU) between them in a chronological order.
Eu.ModSt.2115	Info	The **local PDI behaviours** represent the behaviours of the communicating systems related to a certain interface.
Eu.ModSt.2116	Info	The relation between local PDI behaviour and global PDI behaviour can be illustrated by a telephone call. The dialling is a local PDI behaviour at the initiator side, the ringing the associated local PDI behaviour at the partner side. Only the global PDI behaviour defines that the dialling must precede the ringing (i.e., the chronological order).
Eu.ModSt.2117	Info	Figure 2117 Global PDI behaviour 

ID	Type	Requirements
Eu.ModSt.2118	Info	As the local PDI behaviours represent the interface behaviours of the communicating systems they may be specified in the model of the PDI.
Eu.ModSt.2119	Info	As depicted in *Figure 2120*, in the model of a SUS such as System A, these local PDI behaviours are referenced and linked together (Linking Logic).
Eu.ModSt.2120	Info	Figure 2120 Principle of interface centric specification 
Eu.ModSt.7952	Head	**8.2.5 Functional packaches**
Eu.ModSt.7953	Info	The EULYNX specifications are to be divided into functional packages in the requirements management tool used. This is intended to enable Infrastructure Managers (IM) involved to select requirements in a targeted manner and thus apply the specifications to the desired capabilities of their products.
Eu.ModSt.7954	Info	There are two types of packages that relate to product capabilities: • 'Basic packages', i.e. one or more packes, at least one of them must be implemented. It is allowed to combine and implement more than one 'basic package' in a product. • 'Optional package', i.e. one or more packages that can be optionally implemented in addition to one or more basic packages.
Eu.ModSt.7955	Info	For the evaluation if a requirement is valid or not depending on the selected functional packages of an IM, the basic packages have an "or" relation and optional packages have an "and" relation to everything else. I.e. from mathematical point of view: ("Basic P1" or "Basic P2" or "Basic Pn") and "Option P1".
Eu.ModSt.7956	Info	The functional packages are to be allocated to the requirements in the requirements management tool used. The practical implementation of the allocation depends on the capabilities of the tool.
Eu.ModSt.7957	Info	The SysML specification model must be structured in such a way that the required functional packages can be separated from the overall functionality in order to enable clear allocation as described above.
Eu.ModSt.7958	Info	For example, functional packages can be formed by encapsulating certain behaviours in functional entities, which are then used or not in the corresponding functional architecture as required.
Eu.ModSt.1509	Head	**8.3 Model views used to specify EULYNX subsystems**
Eu.ModSt.2124	Info	**Model view "Functional Context": Use case Diagram (uc)** The model view "Functional Context" defines the services to be provided by the SUS in the form of use cases. Relationships are used to represent which actors interact with which SUS use case.
Eu.ModSt.2125	Info	**Model view "Use case scenario": Sequence Diagram (sd)** The model view "Use case scenario" describes the behaviour of the use cases defined in the model view "Functional Context" at the upper level of abstraction by means of one or more use case scenarios.
Eu.ModSt.2123	Info	**Model view "Logical Context": Block Definition Diagram (bdd)** The model view "Logical Context" describes at the top level • the system/subsystem under specification (SUS), • the actors in the environment interacting with the SUS and their quantity structure (multiplicities) as well as the logical interfaces between the SUS and the actors.

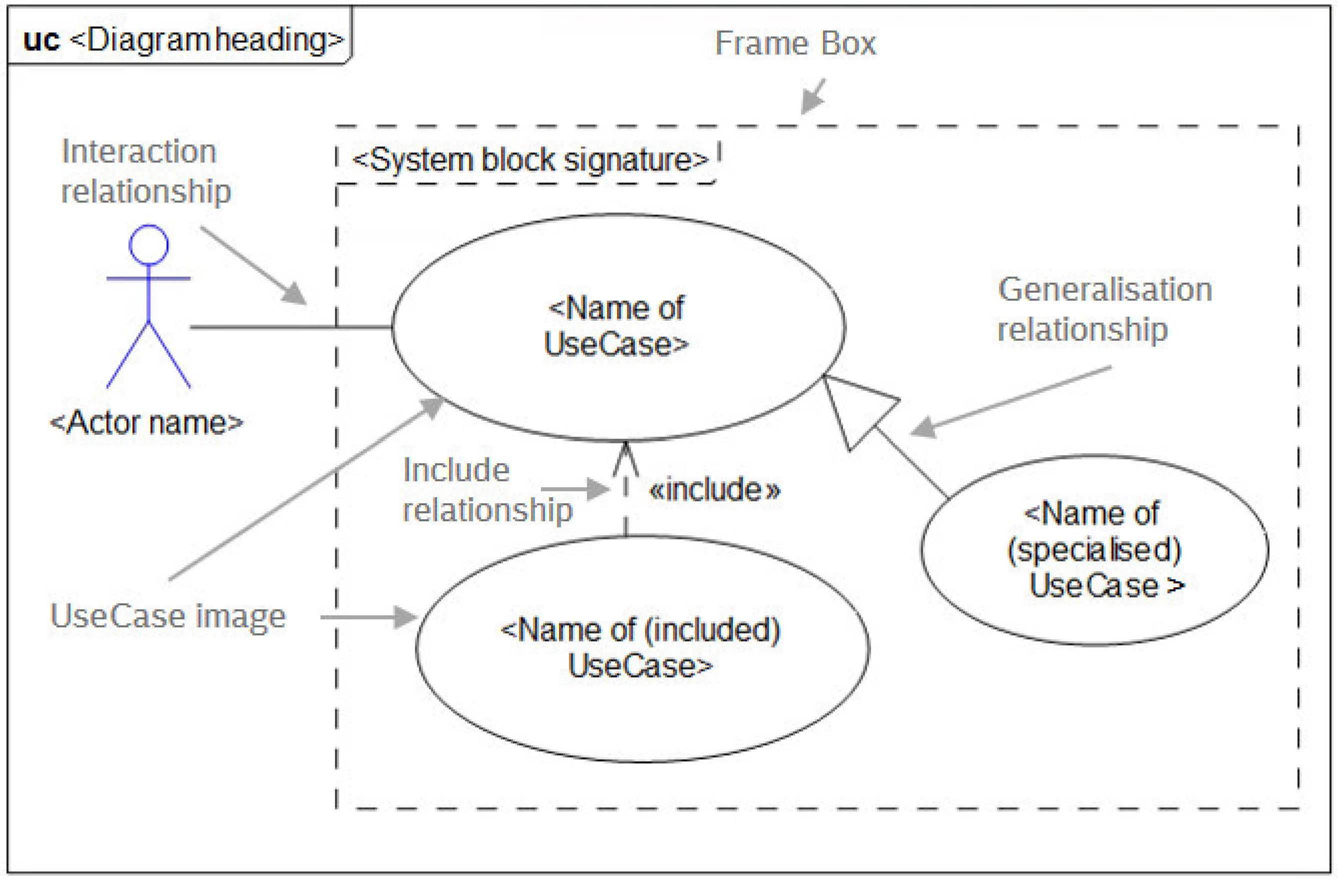
ID	Type	Requirements
Eu.ModSt.7708	Info	**Model view "Functional Partitioning": Block Definition Diagram (bdd)** The model view "Functional Partitioning" describes the refinement of the SUS by means of the FEs defined in the SIUS model view "Functional Partitioning", which represent the local behaviours of the PDI, as well as the FEs specific to the SUS (linking behaviour according to *chapter 8.2.4*).
Eu.ModSt.2126	Info	**Model view "Functional Architecture": Internal Block Diagram (ibd)** The model view "Functional Architecture" refines or completes the behaviour of an SUS defined in the model view "Use case scenarios". The behaviour of the SUS is divided into Functional Entities" (FE), which communicate with each other via internal interfaces and with the environment via external interfaces. The FEs are defined in model view "Functional Partitioning".
Eu.ModSt.7720	Info	**Model view "Technical Functional Architecture": Internal Block Diagram (ibd)** The model view "Technical Functional Architecture" supplements the behaviour described in the model view "Functional Architecture", which is independent of technology, with behavioural components derived from technical requirements. Either the entire behaviour can be described in a technical context or a mixture of functional and technical aspects.
Eu.ModSt.2127	Info	**Model views "Functional Entity" and "Technical Functional Entity": Internal Block Diagram (ibd) and State Machine (stm)** The model view "Functional Entity" encapsulates a subset of technology-independent functional requirements and the model view "Technical Functional Entity" a subset of technology-dependent functional requirements of a SUS in the form of a function module. It delimits the function module from its environment and defines the inputs and outputs. In the discrete case, the behaviour of the FE is described by means of state machines. In this, the binding functional requirements are specified in the form of state transitions. Both model views are described in the separate *chapters 8.5 and 8.6*.
Eu.ModSt.2128	Info	*Figure 2129* shows the engineering path of the model views used to specify a SUS considering the Functional Viewpoint, the Logical Viewpoint and the Technical Viewpoint. It describes the context of the model views, with the arrows indicating which model views are developed from which. During the development of the model, the model views "Functional Context" (the Use Cases), "Use case scenarios" and "Logical Context" are created. These model views form the basis for the description of the model views "Functional Partitioning", "Functional Architecture" and "Functional Entity". For the creation of the model view "Functional Partitioning", the FEs defined in the model view "Functional Partitioning" of the SIUS are required (b: see *Figure 2244* in *chapter 8.4*). In case technical requirements are to be considered, the model views "Technical Functional Architecture" and "Technical Functional Entity" are created based on the model view "Functional Architecture".
Eu.ModSt.2129	Info	Figure 2129 Engineering path to specify a EULYNX subsystem



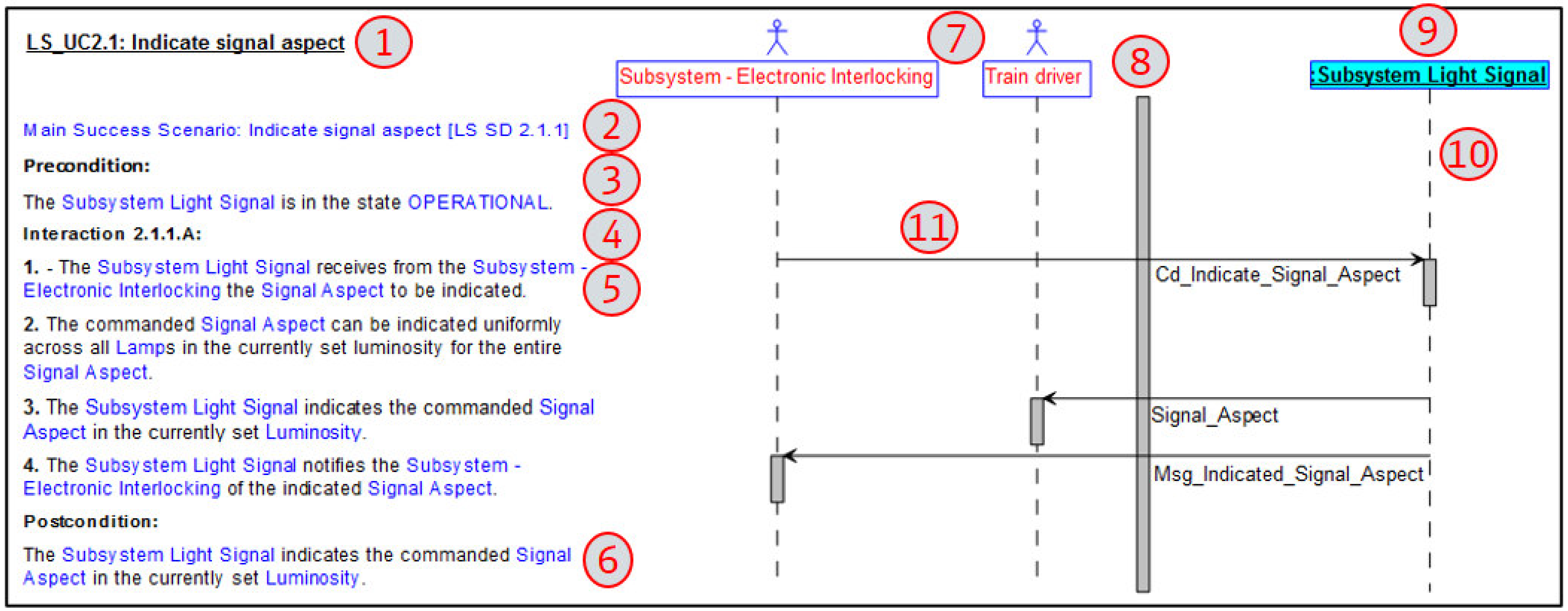
Eu.ModSt.3550	Head	**8.3.1 Model View "Functional Context" of a SUS (AL1) - Description**
Eu.ModSt.3495	Info	The model view "Functional Context" as shown in *Figure 3496* defines the services to be provided by the SUS in the form of use cases. On one or more SysML use case diagrams all subsystem use cases and their relationships to the SUS environment and between the subsystem use cases themselves are depicted.

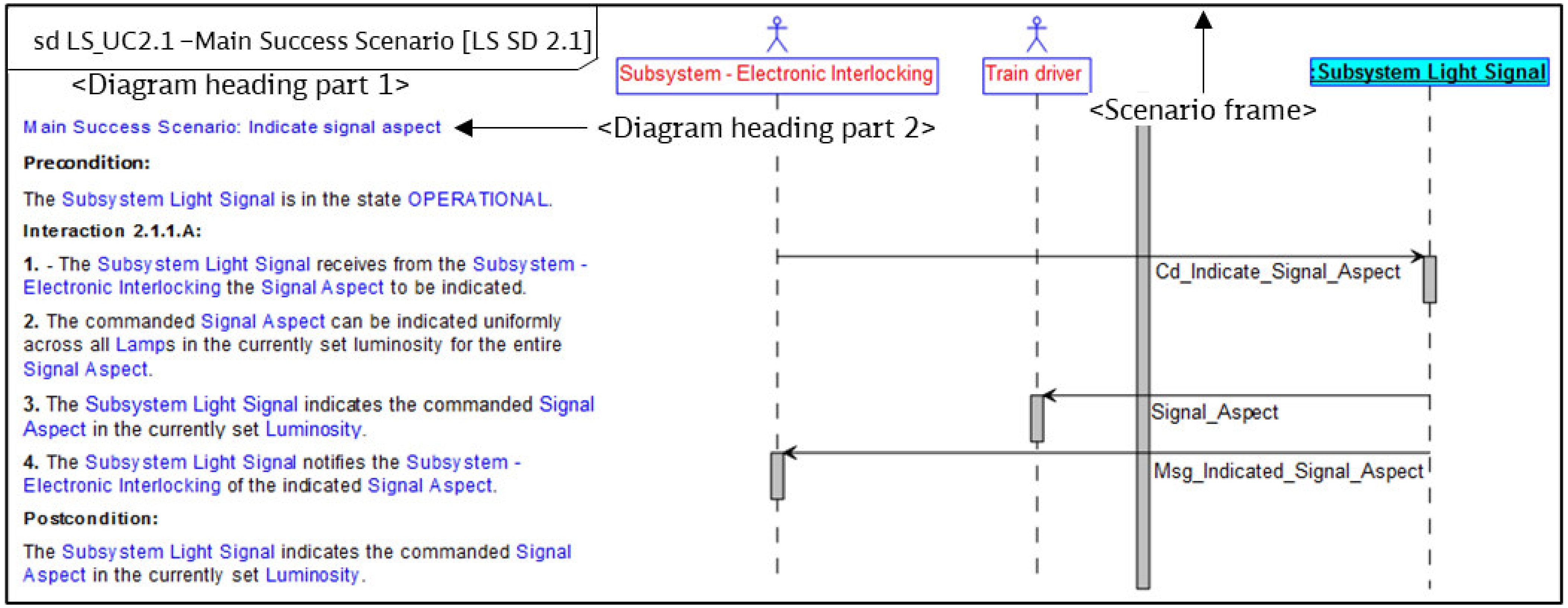
ID	Type	Requirements
Eu.ModSt.3497	Info	In the use case diagrams, the boundary **(2)** of the SUS **(1)** is shown as a frame with a dotted line.
Eu.ModSt.3498	Info	The use cases of the SUS are shown as ellipses within the frame and have the name of the respective use case **(3)**.
Eu.ModSt.3499	Info	A use case describes a service a SUS provides to its environment and is specified by one or more interaction scenarios (model view "Use case scenario").
Eu.ModSt.3500	Info	Use cases are connected by interaction connectors **(7)** to those actors in the SUS environment with whom they interact. An actor may represent another system **(5)** or a person **(6)**.
Eu.ModSt.3501	Info	Use cases may be connected to each other through include relationships **(4)**, which are represented by arrows with a dashed line stereotyped with <<include>>. Such a relationship indicates that the interaction scenarios of the use case at the arrowhead are included in the use case at the other end of the arrow. These included use cases encapsulate services that occur more than once, for example, and can also be included in other use cases.
Eu.ModSt.3496	Info	Figure 3496 Example of SUS model view "Functional Context" 
Eu.ModSt.7711	Head	**8.3.2 Model View "Functional Context" of a SUS (AL1) - Modelling rules**
Eu.ModSt.7713	Head	**8.3.2.1 SysML Diagram**

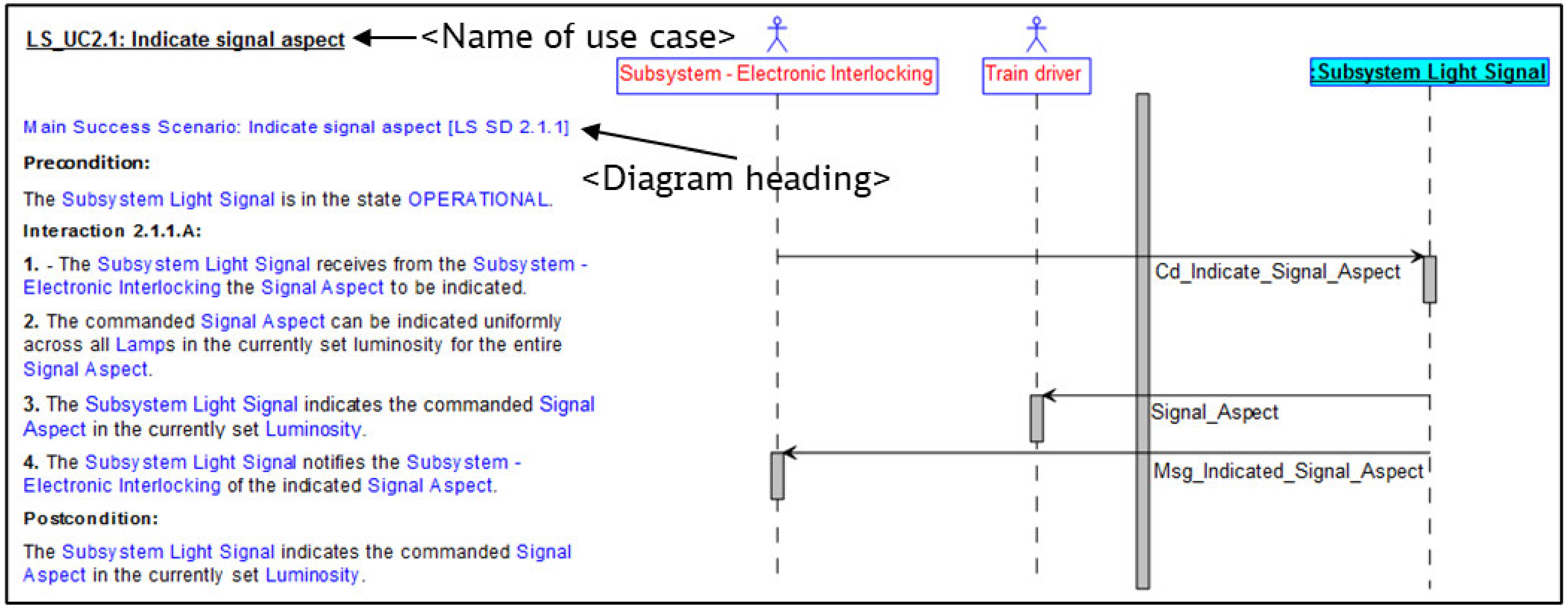
ID	Type	Requirements
Eu.ModSt.7715	Info	**UseCase diagram (uc)**: depicts the model view "Functional Context" (one or more use case diagrams classified by domain motivated use case groups such as Start-up, Operation, Maintenance and so on).
Eu.ModSt.7716	Info	**Name of the Diagram:** *uc[Package]<><System Name><>-<>Functional Context<>[Functional Viewpoint<>-<>Subsystem Definition<>-<><Use case group><>DiaNo]*.
Eu.ModSt.7717	Info	**Example:** uc[Package] Subsystem Light signal - Functional Context [Functional Viewpoint - Subsystem Definition - Initialization]
Eu.ModSt.1197	Info	<Use case group> := <Main use case group><>-<><Sub use case group>
Eu.ModSt.1949	Info	<Main use case group> := Broader term of the domain motivated group of services defined on the use case diagram
Eu.ModSt.1950	Info	<Sub use case group> := Broader term of the subdomain motivated group of services defined on the use case diagram
Eu.ModSt.1199	Info	**Examples:** Operation Operation - Direction
Eu.ModSt.1198	Info	<DiaNo> := Number of use case diagram (Natural number starting with 1); optional to use
Eu.ModSt.1200	Info	<Name of Frame Box> := <System block signature>
Eu.ModSt.1201	Info	<Name of use case> **:=** <UC designator>:<><Service to be described>
Eu.ModSt.1952	Info	<UC designator> **:=** <UC type>UC<DiaNo of uc>.<UCNo>
Eu.ModSt.1763	Info	<UC type> := <Abbr. System type>
Eu.ModSt.1202	Info	<UCNo> := Number of UseCase (Natural number).
Eu.ModSt.1203	Info	<Service to be described> := The name of the service required by the system environment.
Eu.ModSt.1204	Info	**Example:** LS_UC1.4: Establish initial state of outputs
Eu.ModSt.1205	Info	<Name of UseCase> (generic UseCase) := <Gen UC designator>:<><Service to be described>
Eu.ModSt.1953	Info	<Gen UC designator> := <Gen UC type>UC<DiaNo of uc>.<UCNo>
Eu.ModSt.1951	Info	<Gen UC type> := Gen | <Abbr. System group>
Eu.ModSt.1955	Info	<Abbr. System group> := Freely selectable designator such as EfeS (EULYNX field element system) or AdjS (adjacent system)
Eu.ModSt.1206	Info	**Example:** EfeSUC1.2: Establish PDI connection GenUC1.4: Establish PDI connection
Eu.ModSt.728	Head	**8.3.2.2 Model elements**
Eu.ModSt.926	Info	The model elements basically used to describe the model view "Functional Context" are depicted in *Figure 746*.

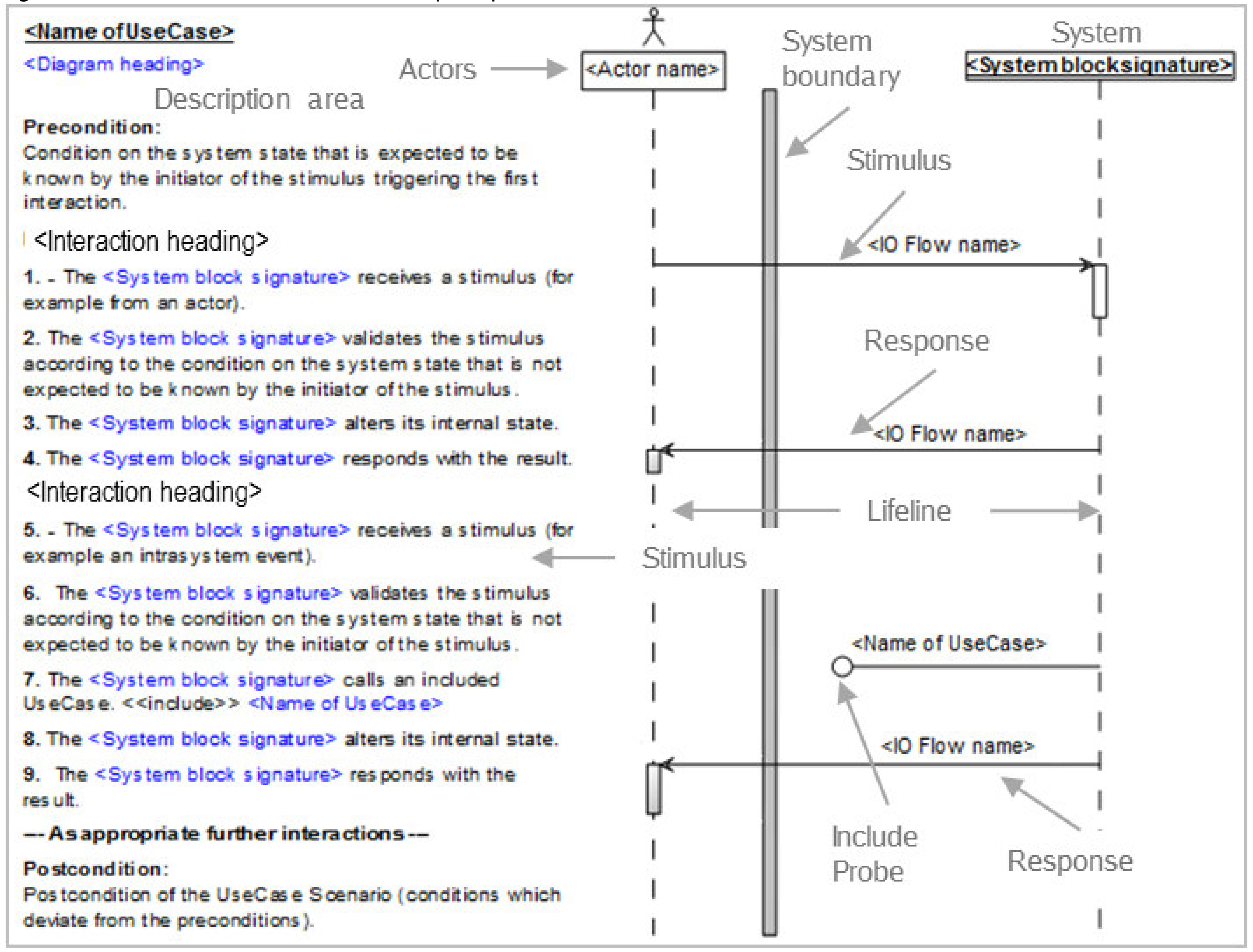
ID	Type	Requirements
Eu.ModSt.746	Info	Figure 746 Basically used model elements of model view "Functional Context" 
Eu.ModSt.729	Info	**Frame Box:** Represents the boundary of the SUS the use cases are allocated to.
Eu.ModSt.731	Info	**UseCase image:** Depicts a UseCase on the use case diagram.
Eu.ModSt.1714	Info	It may be project-specifically determined that for each use case one constraint may be added for each of the following definitions: • the Purpose, • the Primary Actor and • the Secondary Actor.
Eu.ModSt.1715	Info	It may be project-specifically determined that the purpose of the UseCase is to be written in accordance with the following pattern: This UseCase describes the <><UseCase Action><>of<><UseCase Object><>by<><UC Actor/s><><to do/ for doing><><summary of UseCase content>. <Optional free text description to add details about UseCase content>.
Eu.ModSt.1709	Info	**Actor:** As stated earlier, an actor specifies a role played by user or any other system that interacts with the system. Cockburn [22] distinguishes between primary and secondary actors.
Eu.ModSt.1710	Info	**Primary Actor:** The primary actor of a use case is the stakeholder that calls on the system to deliver one of its services. It has a goal with respect to the system – one that can be satisfied by its operation. The primary actor is often, but not always, the actor who triggers the use case.
Eu.ModSt.1711	Info	**Secondary Actor:** The secondary actor of a use case is a stakeholder that the system needs assistance from to achieve the primary actor's goal.
Eu.ModSt.1712	Info	In other words, secondary actors may or may not have goals that they expect to be satisfied by the use case, the primary actor always has a goal, and the use case exists to satisfy the primary actor.
Eu.ModSt.744	Info	**Interaction relationship:** Connects the actors participating in the system use cases to the use case images (see *Figure 746*).
Eu.ModSt.745	Info	The interaction relationship is an abstract representation of the exchange of messages temporally ordered (information flow from and to the system) within the scope of the corresponding SUS use case.
Eu.ModSt.1713	Info	It may be project-specifically determined that only the primary actors participating in the SUS use cases are connected to the use case images. Secondary actors may not be connected for the benefit of the diagram´s readability.

ID	Type	Requirements
Eu.ModSt.1207	Info	**Generalisation relationship:** use cases can be classified using the standard SysML generalisation relationship. The meaning of classification is similar to that for other classifiable model elements. One implication, for example, is that the use case scenarios for the general use case are also use case scenarios of the specialised use case. It also means that the actors associated with a specialised use case can also participate in use case scenarios described by a general use case. Classification of use cases is shown using the standard SysML generalisation symbol (see Fig. 746).
Eu.ModSt.747	Info	**Include relationship:** An include relationship between two UseCases means that the sequence of behaviour described in the included use case is included in the sequence of the base (including) use case.
Eu.ModSt.748	Info	**Please note:** Include relationships are only to be used if absolutely necessary, whereas extends relationships are not to be used at all.
Eu.ModSt.749	Info	The included use case may be a primary use case as well as a secondary use case.
Eu.ModSt.861	Info	When including a use case, this use case shall be named in the description of the sequence.
Eu.ModSt.750	Info	A primary use case is a complete UseCase having a domain trigger, a result, and a primary actor.
Eu.ModSt.751	Info	A secondary use case is an incomplete use case fragment. This is a "piece" of use case that doesn't fulfil at least one of the criteria of a primary use case. It is modelled for example if its flow is part of several (primary) use cases. This allows to avoid redundant descriptions or enables the structured merge of specific behaviour and generic behaviour. "Include" creates a relationship between primary and secondary use cases.
Eu.ModSt.752	Info	In the example depicted in *Figure 3496*, the system-specific use case "LS_UC1.3:Report status" is included in the generic UseCase " EfeSUC1.2: Establish PDI connection".
Eu.ModSt.7075	Head	**8.3.2.3 Binding** (see *chapter 8.2.1*)
Eu.ModSt.7754	Info	**Diagram of model view "Functional Context"** has an "**Info**" binding.
Eu.ModSt.7077	Info	**Use Case** has an "**Info**' binding if it is further specified in a refined model view.
Eu.ModSt.7894	Info	**Use Case** has a "**Req**" binding if it is not further specified in a refined model view.
Eu.ModSt.364	Head	**8.3.3 Model View "Use case scenario" of a SUS (AL1) - Description**
Eu.ModSt.3503	Info	The model view "Use case scenario" as shown in *Figure 3504* defines the behaviour of the use cases defined in the model view "Functional Context" by means of one or more use case scenarios at the upper level of abstraction. These use case scenarios describe the interaction between the SUS and the actors in the SUS environment using SysML sequence diagrams.
Eu.ModSt.3506	Info	**Use case name (1)** Name of the use case to which the interaction scenario belongs (e.g., LS_UC2.1: Indicate signal aspect).
Eu.ModSt.3508	Info	**Use case scenario name (2)** The use case scenario name is the name of a possible information flow (shown as a sequence diagram) within a use case (Main Success Scenario or Alternative Scenario).
Eu.ModSt.3510	Info	**Preconditions (3)** Preconditions are conditions that must be met and known to the actor triggering the stimulus for the scenario to start (see *chapter 8.1.2.1.3*).
Eu.ModSt.3512	Info	**Interaction (4)** An interaction consists of a sequence of steps, starting with a stimulus (prefixed by a dash "-"), a validation, possibly a state change and a reaction. In addition, combined fragments may be included. A use case scenario can consist of one or more interactions. The structure of an interaction follows the principle of the Action Block Scheme as described in *chapter 8.1.2.1.2*.
Eu.ModSt.3514	Info	**Sequences and information flows (5)** Sequences consist of a text part describing the sequence and, in the case of an information flow, a graphical representation of the information flow in the form of arrows between the lifelines **(11)**. In the text part, elements of the model are shown in blue and explanatory text in black. In the graphical part, the corresponding exchange of information objects is shown accordingly. Here in the example (sequence 1), the information object "Cd_Indicate_Signal_Aspect" is sent from the "Subsystem Electronic Interlocking" to "Subsystem Light_Signal". As it is a stimulus it is prefixed by a dash "-" in the text part of the sequence. In sequence 2, the validation of the information object in the "Subsystem Light Signal" is described in the text part, without representation in the graphical part.
Eu.ModSt.3516	Info	**Postconditions (6)** Postconditions are conditions for which changes have resulted from the sequence diagram. Conditions that have already been mentioned in the preconditions are not listed here.
Eu.ModSt.3518	Info	**Actors (7)** Actors are systems (e.g., Subsystem Electronic Interlocking) or persons that interact with the SUS, i.e. trigger a stimulus and/or receive a response.
Eu.ModSt.3520	Info	**System under specification and System boundary (8)** The boundary between the system under specification (SUS) and the actors is symbolised by a thick grey bar. The SUS **(9)** is located to the right of the grey bar and the actors to the left.
Eu.ModSt.3522	Info	**Lifelines (10)** Lifelines represent the time axis of the SUS and the actors, with the time running from top to bottom.

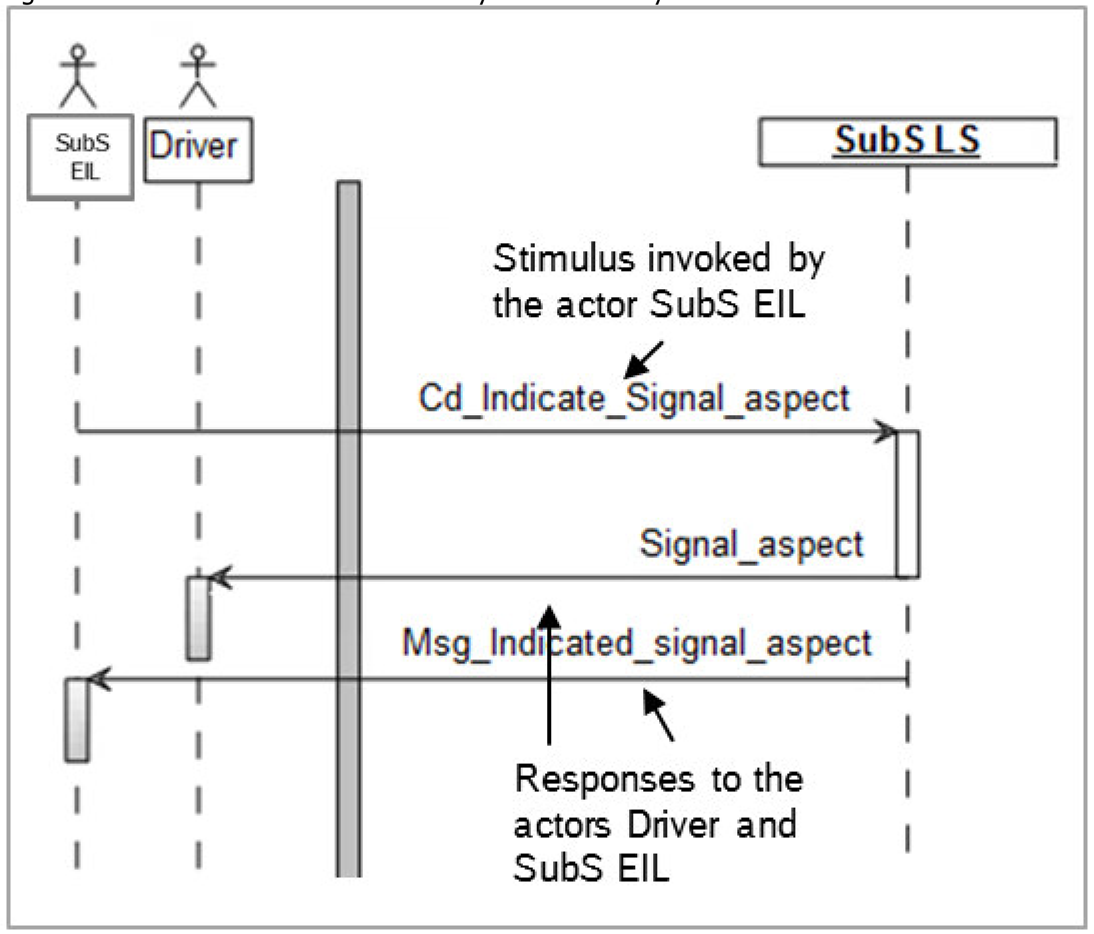
ID	Type	Requirements
Eu.ModSt.3504	Info	Figure 3504 Example of SUS model view "Use case scenario" 
Eu.ModSt.756	Head	**8.3.4 Model View "Use case scenario" of a SUS (AL1) - Modelling rules**
Eu.ModSt.757	Head	**8.3.4.1 SysML diagram**
Eu.ModSt.758	Info	**Sequence Diagram:** A sequence diagram generally shows a stimulus-response behaviour, focusing on the temporal sequence of messages.
Eu.ModSt.759	Info	A sequence diagram depicting a use case scenario shows a specific sequence of messages, i.e. it represents a possible variant of a SUS use case.
Eu.ModSt.760	Info	**In contrast to the complete stimulus-response behaviour of a SUS use case, described using a state machine, a use case scenario only represents a "flash light" view of this behaviour.**
Eu.ModSt.761	Info	There are two variants of use case scenario layouts: • Variant 1: Use case scenario with frame (*Figure 1690*) and • Variant 2: Use case scenario without frame (*Figure 6976*).
Eu.ModSt.1693	Info	It has to be project-specifically determined which variant to apply. The example scenarios in this document are depicted according to variant 2.

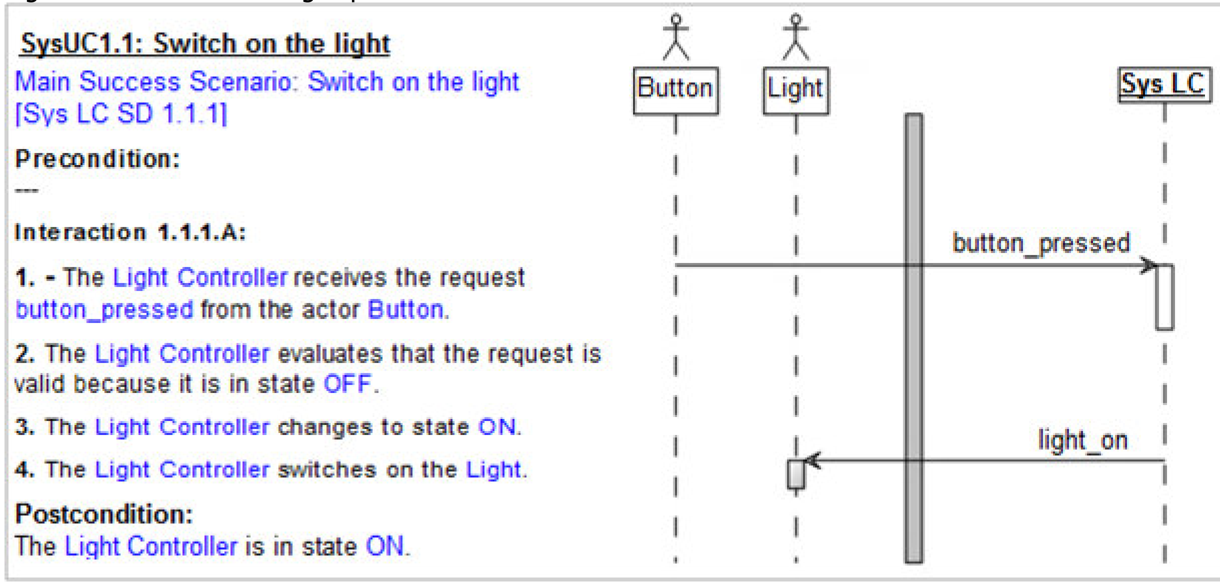
ID	Type	Requirements
Eu.ModSt.1690	Info	Figure 1690 Variant 1: Use case scenario with frame 
Eu.ModSt.1691	Info	**Variant 1: Diagram heading part 1** *sd<><Abbr. System type>UC<DiaNo of UCD>.<UCNo>-<Scenario type><> [<Abbr. System ID><>SD<><DiaNo of UCD>.<UCNo>.<DiaNo of SD>]*
Eu.ModSt.1695	Info	**Variant 1: Diagram heading part 2** ***<Scenario type>:<> <Scenario name>***
Eu.ModSt.766	Info	A use case may be defined by one or more use case scenarios in the following compositions: - one Main Success Scenario and any number of Alternative Scenarios, - only one Main Success Scenario, - any number of Alternative Scenarios without a Main Success Scenario.
Eu.ModSt.1698	Info	**Examples:** sd SubSUC2.1-Main Success Scenario [SubS LS SD 2.1.1] Main Success Scenario: Indicate signal aspect sd SubSUC2.2-Alternative Scenario [SubS LS SD 2.2.2] Alternative Scenario: Illuminant failure
Eu.ModSt.1696	Info	**Variant 1: Diagram heading part 1 (generic UseCase Scenario)** *sd<><Gen UC type>UC<DiaNo of UCD>.<UCNo>-<Scenario type><>[<Gen UC type><>SD<> <DiaNo of UCD>.<UCNo>.<DiaNo of SD>]*
Eu.ModSt.1697	Info	**Variant 1: Diagram heading part 2 (generic UseCase Scenario)** *<Scenario type>:<> <Scenario name>*
Eu.ModSt.1699	Info	**Example:** sd GenUC1.2-Main Success Scenario [Gen SD 1.2.1] Main Success Scenario: Establish PDI connection sd EfeSUC1.2-Main Success Scenario [EfeS SD 1.2.1] Main Success Scenario: Establish PDI connection

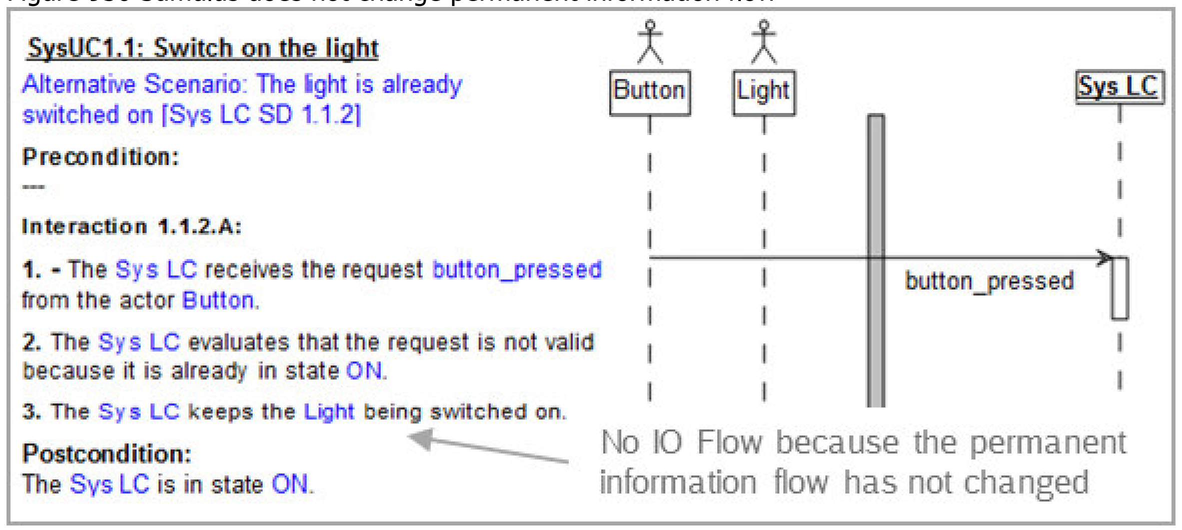
ID	Type	Requirements
Eu.ModSt.6976	Info	Figure 6976 Variant 2: Use case scenario without frame 
Eu.ModSt.6977	Info	**Variant 2: Diagram heading** ***<Scenario type>:<><Scenario name><> [<Abbr. System ID><>SD<> <DiaNo of UCD>.<UCNo>.<DiaNo of SD>]***
Eu.ModSt.6978	Info	**Examples:** Main Success Scenario: Indicate signal aspect [SubS LS SD 2.1.1] Alternative Scenario: Illuminant failure [SubS LS SD 2.1.2]
Eu.ModSt.5269	Info	**Variant 2: Diagram heading (generic UseCase Scenario)** ***<Scenario type>:<><Scenario name><> [<Gen UC type><>SD<> <DiaNo of UCD>.<UCNo>.<DiaNo of SD>]***
Eu.ModSt.3562	Info	**Example:** Main Success Scenario: Establish PDI connection [Gen SD 1.2.1] Main Success Scenario: Establish PDI connection [AdjS SD 1.2.1]
Eu.ModSt.765	Info	**<Scenario type>** := "Main Success Scenario" | "Alternative Scenario" where the Main Success Scenario specifies the service to be provided when nothing goes wrong, and the Alternative Scenario describes deviations from the Main Success Scenario.
Eu.ModSt.1211	Info	**<Scenario name>** := Unique designation of the scenario
Eu.ModSt.1210	Info	**<DiaNo of SD> :=** Number of sequence diagram (Natural number starting with 1).
Eu.ModSt.1220	Info	**<Interaction heading**> := Interaction <Name of interaction>:
Eu.ModSt.791	Info	**<Name of Interaction>** := **<DiaNo of UCD>.<UCNo>.<DiaNo of SD>.<IId>**
Eu.ModSt.792	Info	**<IId> :=** Id of an Interaction (Capital letters starting with "A"; if there are more than one Interactions on a scenario, the letter rises along the alphabet)

ID	Type	Requirements
Eu.ModSt.793	Info	**Example:** Interaction 2.1.1.A: 1. - ... 2. ... Interaction 2.1.1.B: 3. - ... 4. ...
Eu.ModSt.772	Head	**8.3.4.2 SysML model elements**
Eu.ModSt.762	Info	The model elements used to describe the model view "Use case scenario" and the structural principle are depicted in *Figure 763*.
Eu.ModSt.763	Info	Figure 763 Model elements and structural principle of a use case scenario 
Eu.ModSt.773	Info	As depicted in Fig. 763, a sequence diagram describing a UseCase scenario consists of the following vertical segments: **- Description area,** **- Lifelines of actors,** **- System boundary,** **- Lifeline of the system.**
Eu.ModSt.927	Info	**Description area:** In the vertical segment "Description area" the action steps of the scenario are to be described.
Eu.ModSt.1278	Info	**Lifelines:** The principal structural feature a of a scenario is the lifeline. A lifeline represents the relevant lifetime of a property of the scenario's owning block, which will be either a SysMl part or a SysML reference property. A part can be typed by an actor, which enables actors to participate in scenarios as well.

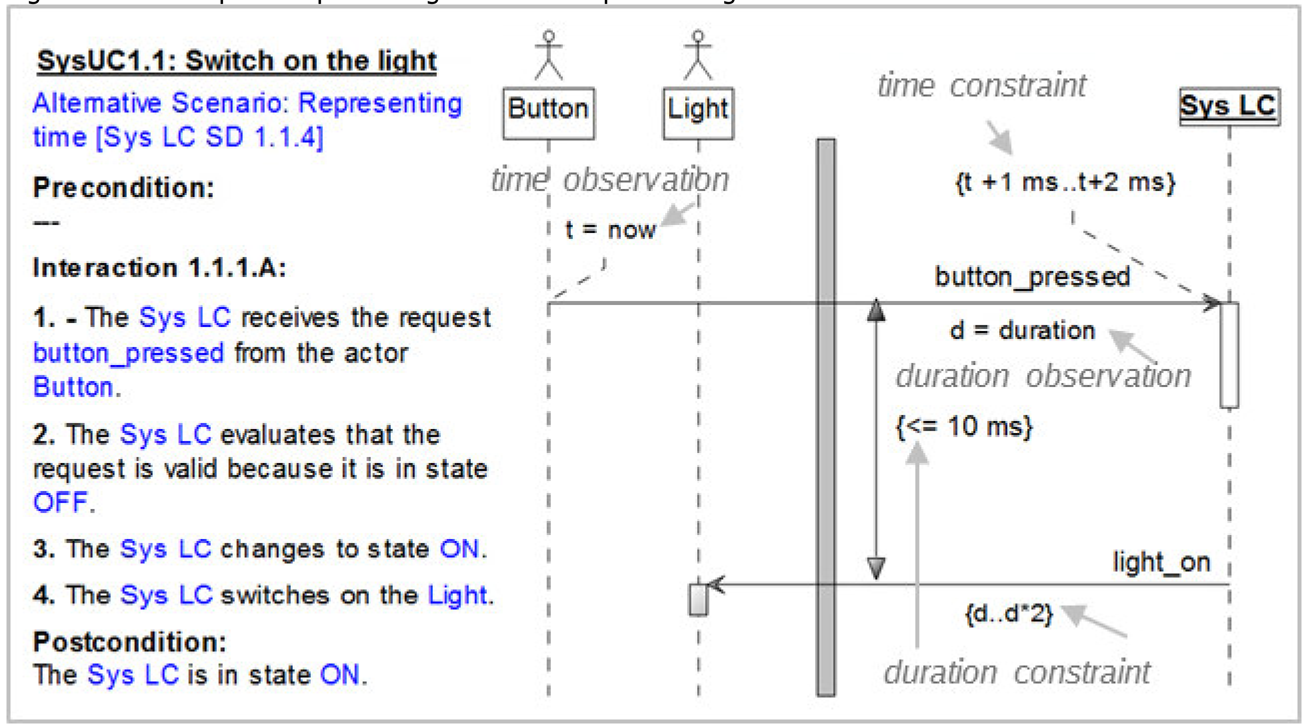
ID	Type	Requirements
Eu.ModSt.928	Info	**Lifelines of actors:** In the vertical segment Lifelines of actors, the actors of the system are to be arranged. This section may be empty.
Eu.ModSt.774	Info	**Lifeline of the system:** The vertical segment Lifeline of the system is represented by an instance of the block describing the structure of the system such as "Subsystem Light Signal".
Eu.ModSt.775	Info	**Please note:** The instance of the block has to be created once and used in all corresponding sequence diagrams.
Eu.ModSt.776	Info	**Architectural boundary:** The architectural boundary (dashed vertical line depicted as default at any sequence diagram) is to be arranged to the right of the vertical segment "System" and overlaid by a white-coloured note.
Eu.ModSt.777	Info	A Use case scenario of a primary Use Case is to be structured horizontally as depicted in Fig. 763.
Eu.ModSt.778	Info	**Precondition:** After the declaration of the diagram heading, the preconditions are to be stated.
Eu.ModSt.1705	Info	**General rules for pre- and postconditions:** Pre-and postconditions are to be defined in the following order: 1. States (if defined) of objects involved in the sequence, 2. States of timers (e.g. The Subsystem – Point monitors the Timevalue "Con_tmax_Point_Operation") involved in the sequence, 3. All other conditions of objects, which are required before proceeding the sequence (in case of preconditions) or which are achieved after completing the sequence.
Eu.ModSt.1706	Info	When objects are named in pre-or postconditions, the following order is to be followed: 1. Itinerary 2. Train Unit / Infrastructure Element 3. Vehicle
Eu.ModSt.1707	Info	When nested states of objects (refer to ABB.4.250) are named in pre-or postconditions, all nested and parent states are to be named.
Eu.ModSt.1708	Info	With the aforementioned rules, the pre-and postconditions are to be structured as follows: **<Pre/Post>conditions** <Object 1 is in state 1>. ... <Object 1 is in state n>. ... <Object 2 is in state 1>. ... <Object 2 is in state n>. ... <Object m is in state n>. ... <Conditions 1>. ... <Conditions n>.
Eu.ModSt.779	Info	Preconditions denote what must be true before the UseCase runs. The preconditions are stated at this place if they are expected to be known by the initiator of the stimulus of the first interaction of the UseCase.
Eu.ModSt.780	Info	The preconditions are to be structured as follows: **Precondition:** ***<Precondition 1>.*** ***...*** ***<Precondition n>.***
Eu.ModSt.782	Info	If there are no preconditions to be stated, three hyphens are to be depicted instead of them: **Precondition:** **---**
Eu.ModSt.786	Info	There may be cases when a precondition is not expected to be known by the initiator of the stimulus. In those cases, the precondition is to be described as validation condition at action step 2 within the first interaction according to the action block schema (see *chapter 8.1.2.1.2*).
Eu.ModSt.787	Info	If stated at this place, alternative scenarios may be derived from that precondition.

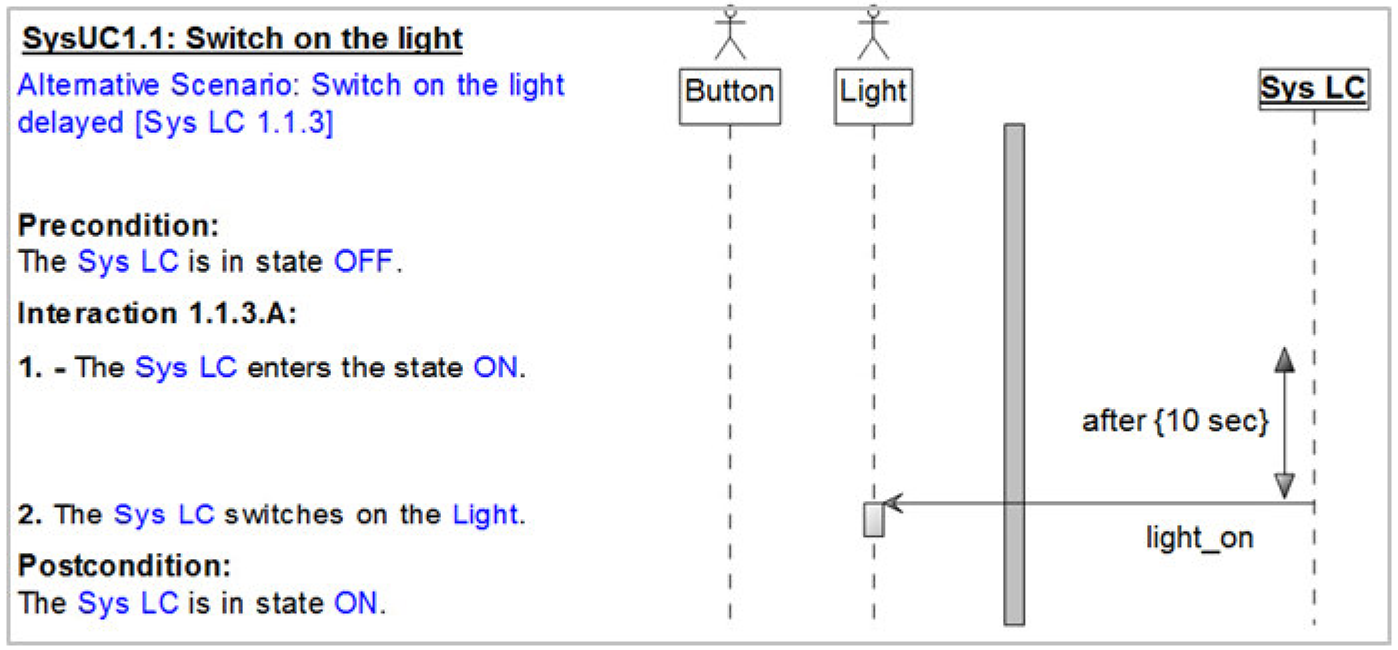
ID	Type	Requirements
Eu.ModSt.789	Info	The preconditions are followed by the occurrence specifications. A lifeline is related to an ordered list of occurrence specifications that describe what can happen to the instance (e.g. Subsystem Light Signal) represented by the lifeline during the execution of the scenario.
Eu.ModSt.1279	Info	Those occurrences are specified by action steps structured by one or more interactions according to the structure depicted in *Figure 763*.
Eu.ModSt.790	Info	**Interaction:** An interaction represents a functional system requirement structured according to the action block schema as described in *chapter 8.1.2.1.2*. It is understood as an interaction contract as introduced in *chapter 8.1.2.1.3*.
Eu.ModSt.794	Info	An interaction is to be invoked at its first action step - **by a stimulus from an actor of the system**, - **by a timed trigger**, - **by an intrasystem event** (that is, an event that occurs in the system) or - **when entering or leaving a system state**.
Eu.ModSt.795	Info	The invoking of an interaction by a stimulus from an actor of the system is to be described as an information flow from the actor in the system environment to the system as depicted in *Figure 796*.
Eu.ModSt.797	Info	The response of the system to an actor (primary actor or secondary actor) is to be described as an information flow from the system to the actor in the system environment as depicted in *Figure 796*.
Eu.ModSt.796	Info	Figure 796 Information flow across the system boundary 
Eu.ModSt.799	Info	The information flows are to be defined using SysML Item Flows or SysML signal events (in the following referred to as IO Flows) .
Eu.ModSt.800	Info	The data types of the SysML Item Flows are to be hidden on the sequence diagram unless there is a project-specific commitment.
Eu.ModSt.7941	Info	When using SysML signal events as IO Flows, the parameter values can also be displayed. **Example:** Msg_TVPS_Occupancy_Status(Vacant, Unable to be forced to clear, Command from EIL).
Eu.ModSt.888	Info	An IO Flow which represents a permanent information flow is only to be depicted on the diagram as demonstrated in *Figure 932* if this information flow has changed.

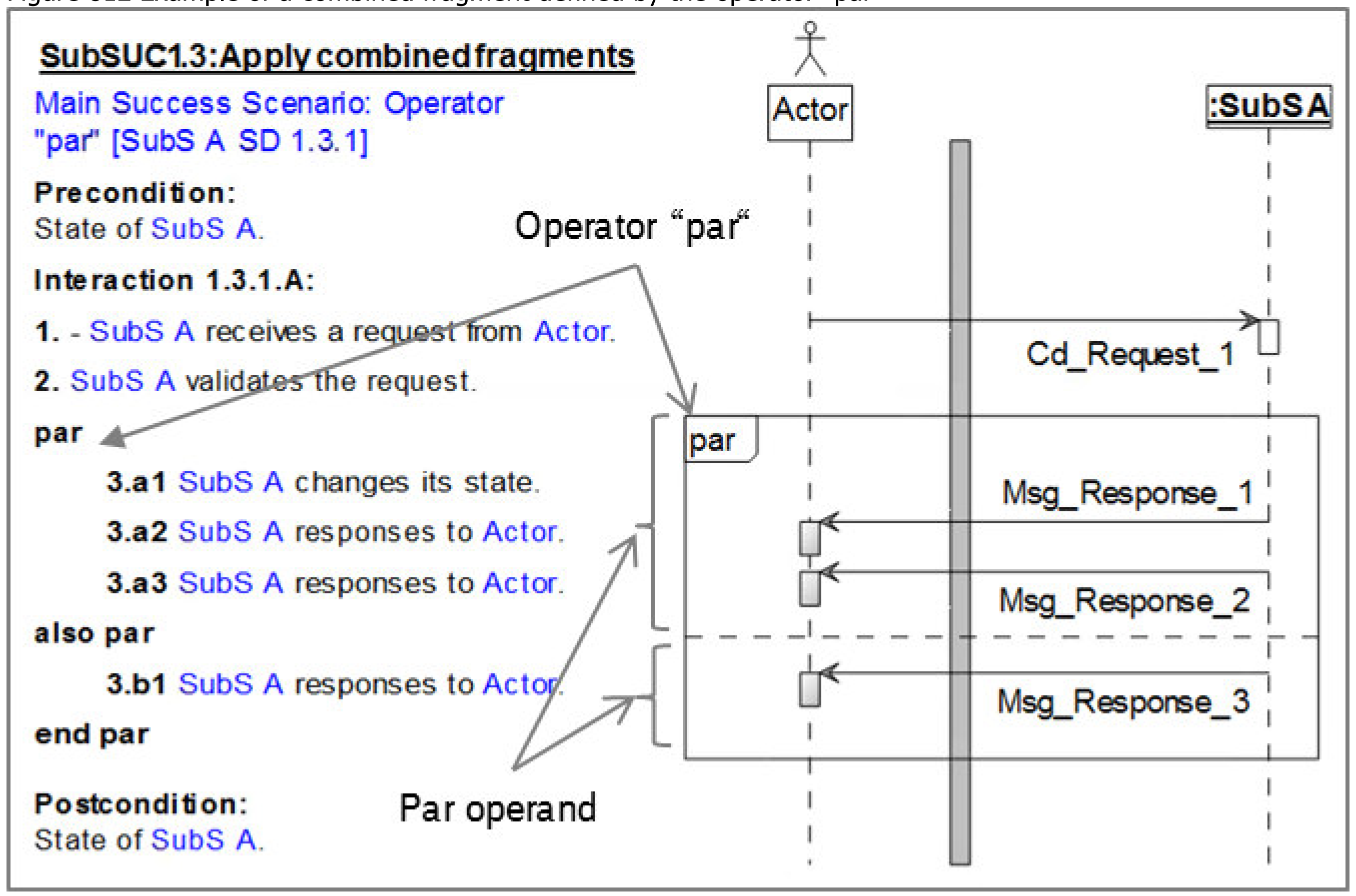
<table>
<tr><th>ID</th><th>Type</th><th>Requirements</th></tr>
<tr><td>Eu.ModSt.932</td><td>Info</td><td>
Figure 932 Stimulus changes permanent information flow


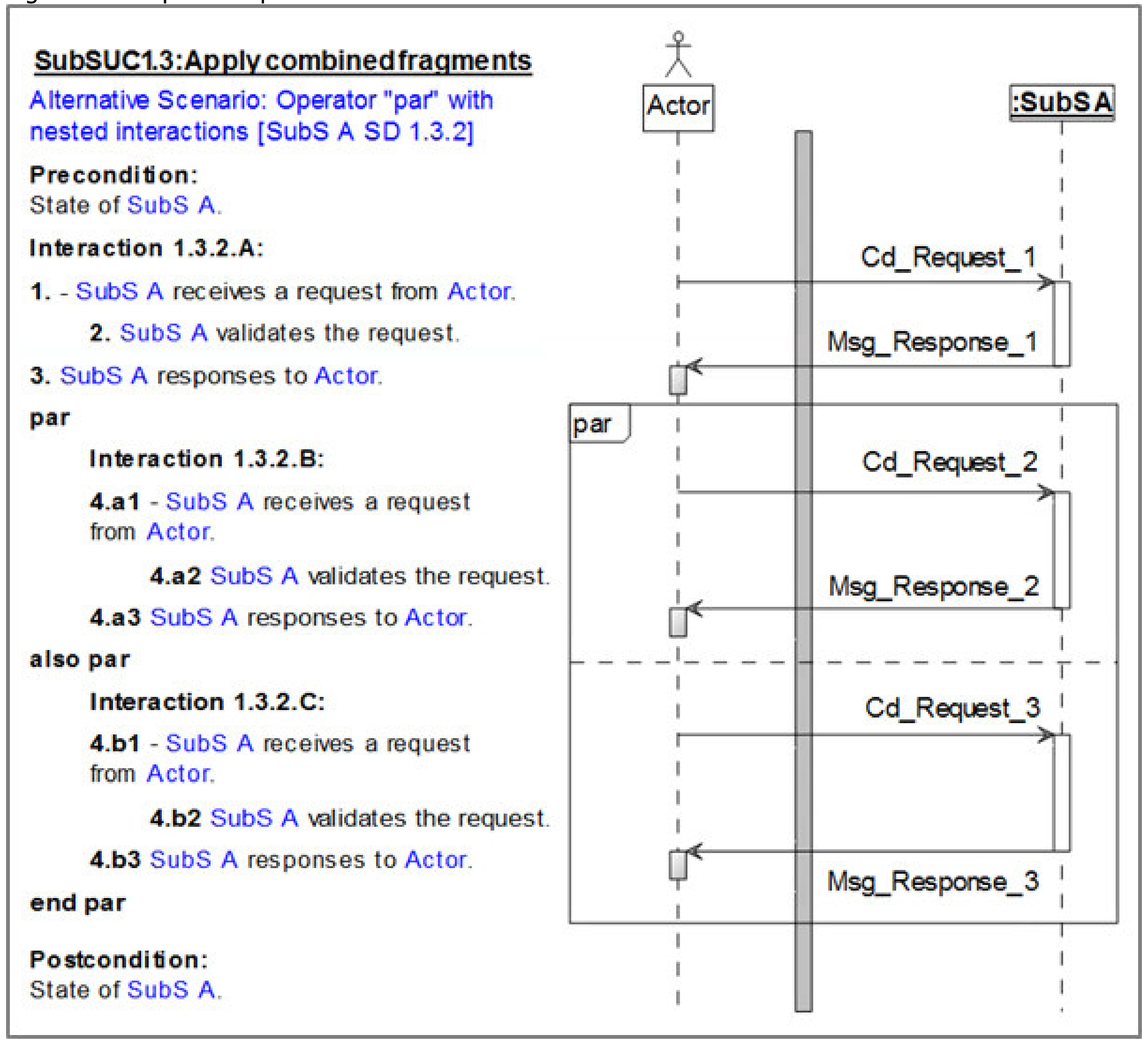
</td></tr>
<tr><td>Eu.ModSt.931</td><td>Info</td><td>In the example depicted in Figure 930, the stimulus "button_pressed" does not change the permanent information flow "light_on". Thus, the IO Flow "light_on" is not depicted on the diagram.</td></tr>
<tr><td>Eu.ModSt.930</td><td>Info</td><td>
Figure 930 Stimulus does not change permanent information flow


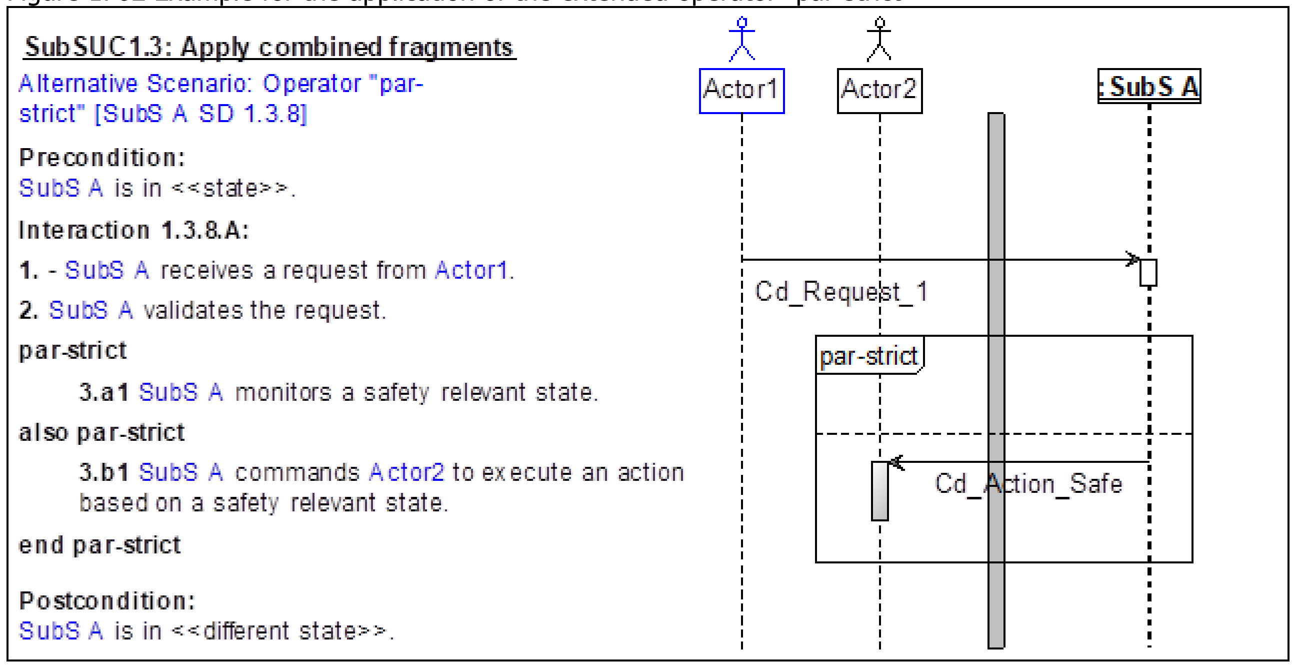
</td></tr>
<tr><td>Eu.ModSt.1267</td><td>Info</td><td>Representing time on a sequence diagram:
In a sequence diagram, time progresses vertically down the diagram and occurrences on a lifeline are correspondingly ordered in time. In addition, the send occurrence and receive occurrence for a single message are also ordered in time.</td></tr>
<tr><td>Eu.ModSt.1274</td><td>Info</td><td>Time observation and duration observation:
In addition to relative ordering in time, time can be represented explicitly on sequence diagrams. A time observation refers to an instant in time corresponding to the occurrence of some event during the execution of the scenario, and a duration observation refers to the time taken between two instants during the execution of the scenario.</td></tr>
<tr><td>Eu.ModSt.1268</td><td>Info</td><td>Time constraint and duration constraint:
A time constraint and a duration constraint can use observations to express constraints involving the values of those observations. A time constraint identifies a constraint that applies to a single occurrence on the sequence diagram. A duration constraint identifies two occurrences, called start and end occurrences, and expresses a constraint on the duration between them. A duration constraint can apply to any element deemed to have duration, such as a message or an execution, in which case the constraint applies between the occurrences that bracket the element's duration.</td></tr>
<tr><td>Eu.ModSt.1269</td><td>Info</td><td>A time constraint is shown using a standard constraint expression in braces attached by a dashed line to the constrained occurrence.</td></tr>
<tr><td>Eu.ModSt.1270</td><td>Info</td><td>A duration constraint is shown by a double-headed arrow between the two constrained occurrences with the constraint floating near it, also expressed in standard constraint notation (i.e. in braces). A duration constraint may also be shown as a standard constraint floating close to an element such as a message.</td></tr>
</table>

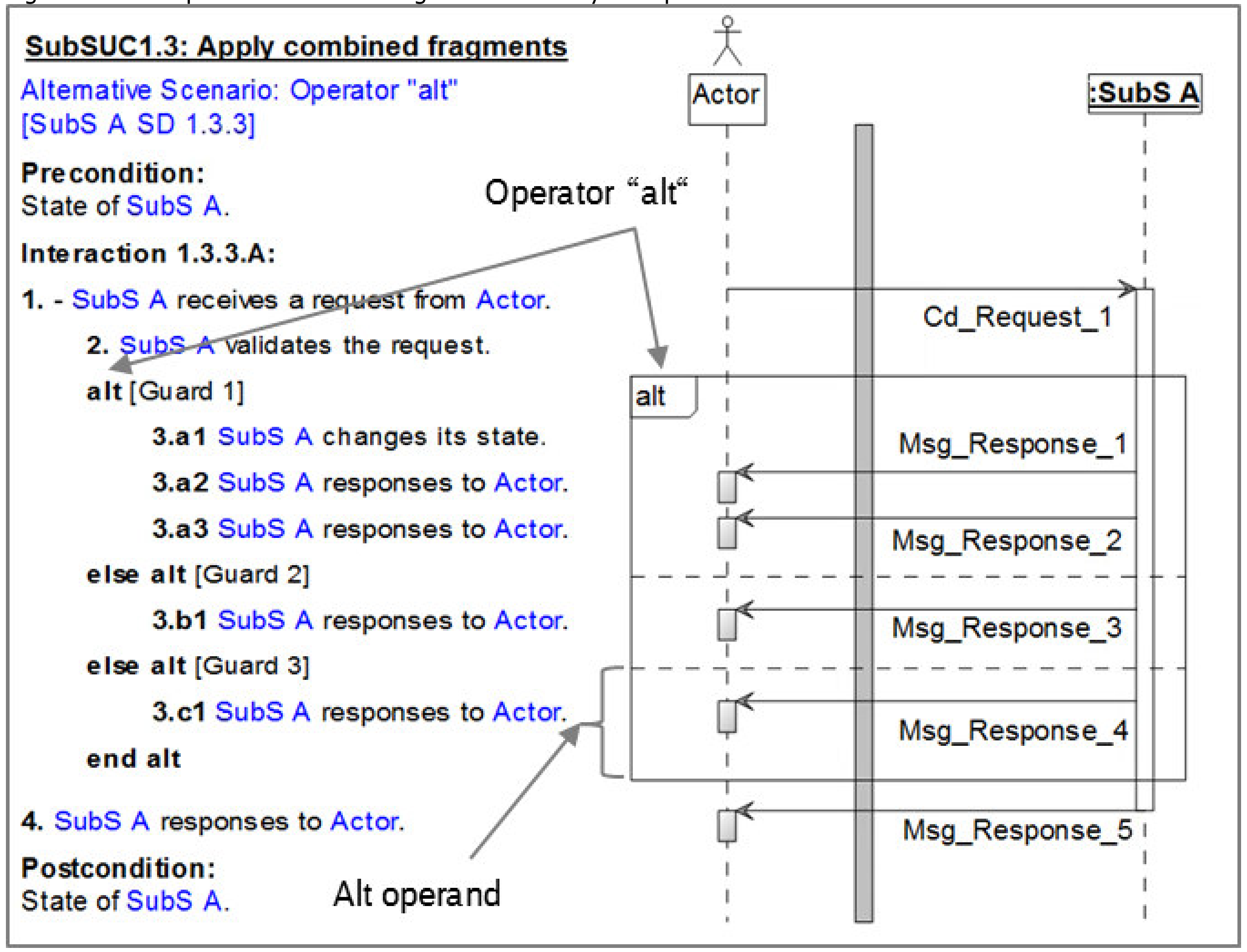
ID	Type	Requirements
Eu.ModSt.1277	Info	Observations are shown in a way similar to constraints, but instead of an expression in braces, an observation has the name of the observation followed by an equal sign and then an expression indicating how the value for the observation is obtained.
Eu.ModSt.1275	Info	An example of representing time on a sequence diagram is shown in the scenario depicted in *Figure 1272*. A time observation, t, is taken at the point when the button is pressed using the expression "t = now". The time constraint {t + 1 ms..t + 2 ms} indicates that the message receipt must occur between 1 ms and 2 ms after t. The total time taken between pressing the button and switching on the light should be not more than 10 ms, as indicated by the duration constraint between action step 1 and action step 4. The duration between pressing the button and receiving the corresponding message is observed via a duration observation d, and there is a constraint ({d..d*2}) on the response "light_on" to not exceed 2 times the duration d.
Eu.ModSt.7940	Info	**Please note:** always use "<=" instead of "<".
Eu.ModSt.1272	Info	Figure 1272 Example of representing time on a sequence diagram 
Eu.ModSt.804	Info	**Timed trigger (timer):** A timed trigger indicates that a given time interval has passed since the occurrence of some event, such as entering a state (intrasystem event) or receiving a request during the execution of the scenario.
Eu.ModSt.1221	Info	The term "after**"** followed by the time such as "after {10 sec}", or "after{t_con_t_max}" indicates that the time is relative to the moment of an occurrence.
Eu.ModSt.1276	Info	An example of a timed trigger is shown in the scenario depicted in *Figure 805*. The system responses with "light_on" 10 sec after the state ON has been entered.

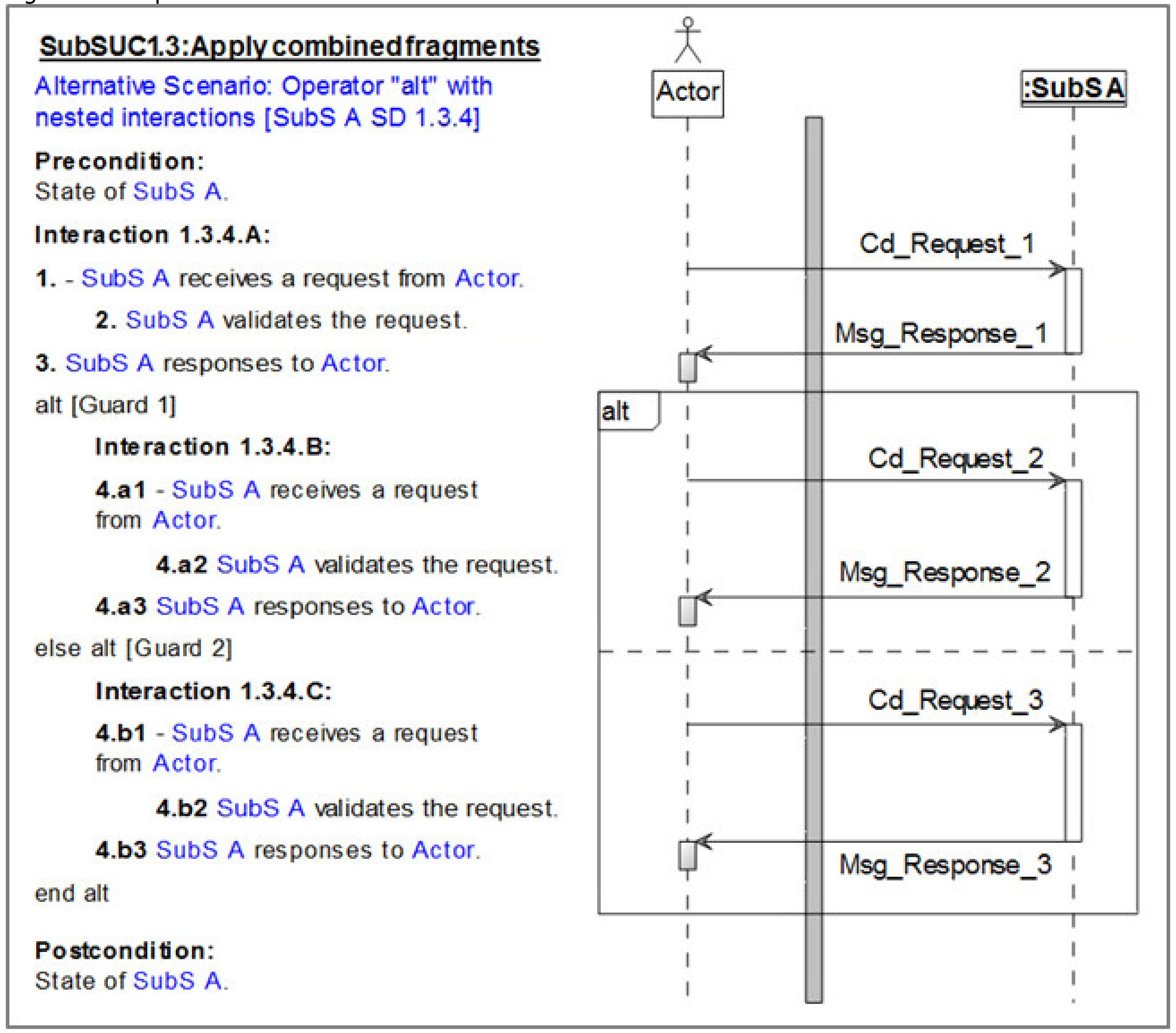
ID	Type	Requirements
Eu.ModSt.805	Info	Figure 805 Example of a timed trigger 
Eu.ModSt.806	Info	**Intrasystem event:** An intrasystem event is described as demonstrated in the following example: 1. -The SubS LS detects a change of the indicated signal aspect.
Eu.ModSt.807	Info	A stimulus created by entering or leaving a system state is to be described as demonstrated in the following examples. 1. - SubS LS enters the state OPERATING. 1. - SubS LS exits the state OPERATING.
Eu.ModSt.7939	Info	The graphical representation of the time behaviour as shown in figure 1272 and figure 805 can be supplemented by a description in the description area of the sequences. "t_con_t_max" represents the defined time period (duration): • Start of timer should be mentioned within the corresponding step (trigger). • "Subsystem X starts to monitor the time period "t_con_t_max"." • Reaction for timer that shall be waited for --> where possible combine within corresponding step otherwise keep it separate. • "Subsystem X detects that time period "t_con_t_max" has expired." • Reaction for timer that has been exceeded (unintended case) --> where possible combine within corresponding step otherwise keep it separate. • "Subsystem X detects that time period "t_con_t_max" has exceeded." • Restart of a timer within the corresponding step (trigger). • "Subsystem X stops to monitor time period "t_con_t_max" caused by first command and starts to monitor the time period ""t_con_t_max" caused by second command." • Reset of a timer within the corresponding step (trigger). • "Subsystem X stops to monitor time period "t_con_t_max"."
Eu.ModSt.7943	Info	**Time periods** shall be defined using block properties without further specification of the values. The values to be used shall be specified separately in the requirements management tool (chapter 5.3 Configuration and engineering data) as binding requirements and linked to the corresponding definitions.
Eu.ModSt.808	Info	**Combined fragments:** In order to parallelize interactions as well as action steps of an interaction or define alternatives or loops, combined fragments defined by the Operators **"par"**, **"alt"** or **"loop"** may be used.
Eu.ModSt.809	Info	In sequence diagrams, combined fragments are logical groupings, represented by a rectangle, which contain the conditional structures that affect the flow of messages. A combined fragment contains operands and is defined by operators (see *Figure 812* and *Figure 935*).
Eu.ModSt.855	Info	Operands are separated by dashed lines.
Eu.ModSt.856	Info	Depending on the operator, there is a guard containing a constraint expression that indicates the conditions under which it is valid for the operand to begin execution. Guards appear at the beginning of the combined fragment following the corresponding operator (example: alt [Guard]).
Eu.ModSt.810	Info	The operator identifies the type of logic or conditional statement that defines the behaviour of the combined fragment.

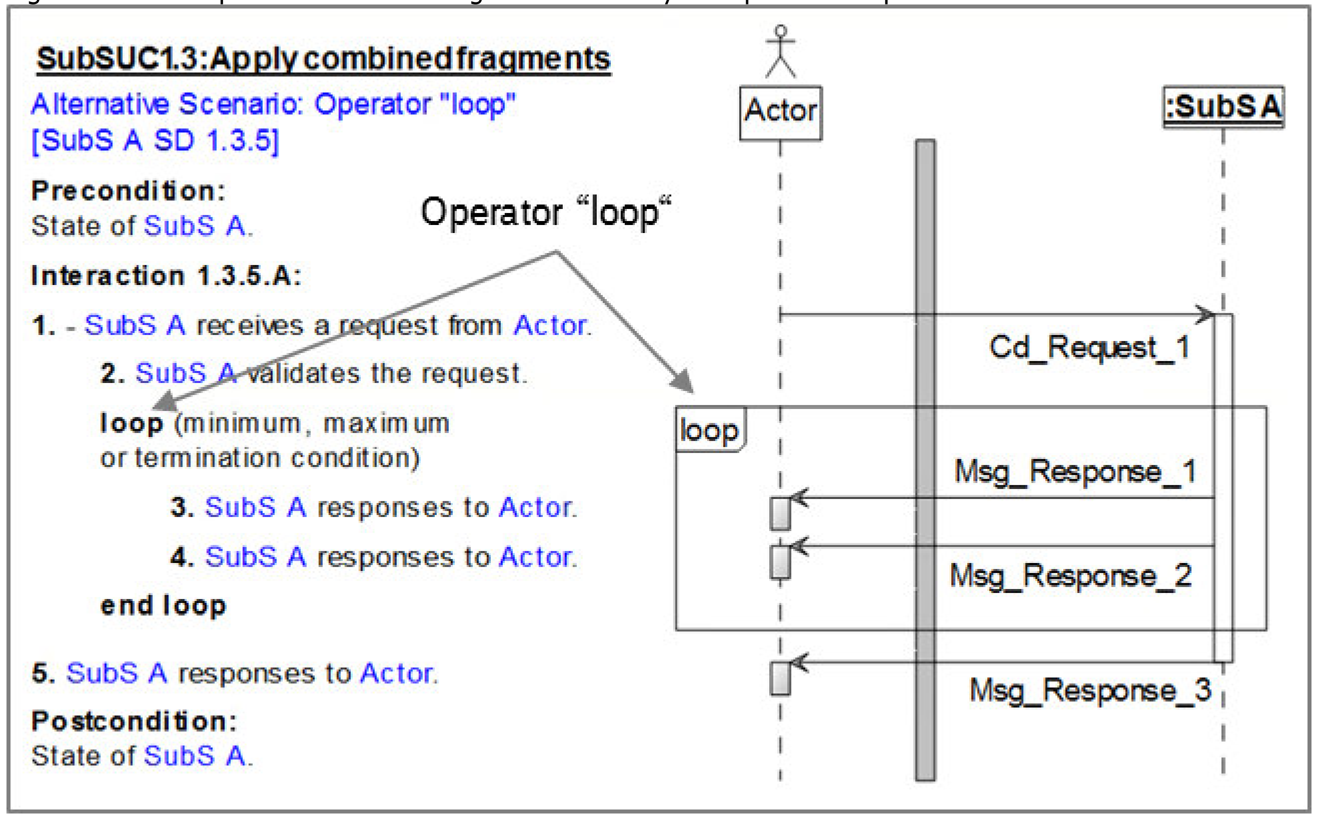
ID	Type	Requirements
Eu.ModSt.811	Info	**Operator "par"** In the example depicted in *Figure 812*, the usage of the operator "par" is demonstrated. The message *Msg_Response_3* is parallelized to *Msg_Response_1* followed by *Msg_Response_2* using two par operands.
Eu.ModSt.857	Info	If a par operand consists of more than one action step, the action steps are structured according the following schema (see also *Figure 812*): **par** 3.a1 action step. 3.a2 action step. 3.ax ... **also par** 3.b1 action step. 3.b2 action step. 3.bx ... **also par** 3.c1 action step. 3.cx... **end par**
Eu.ModSt.812	Info	Figure 812 Example of a combined fragment defined by the operator "par" 

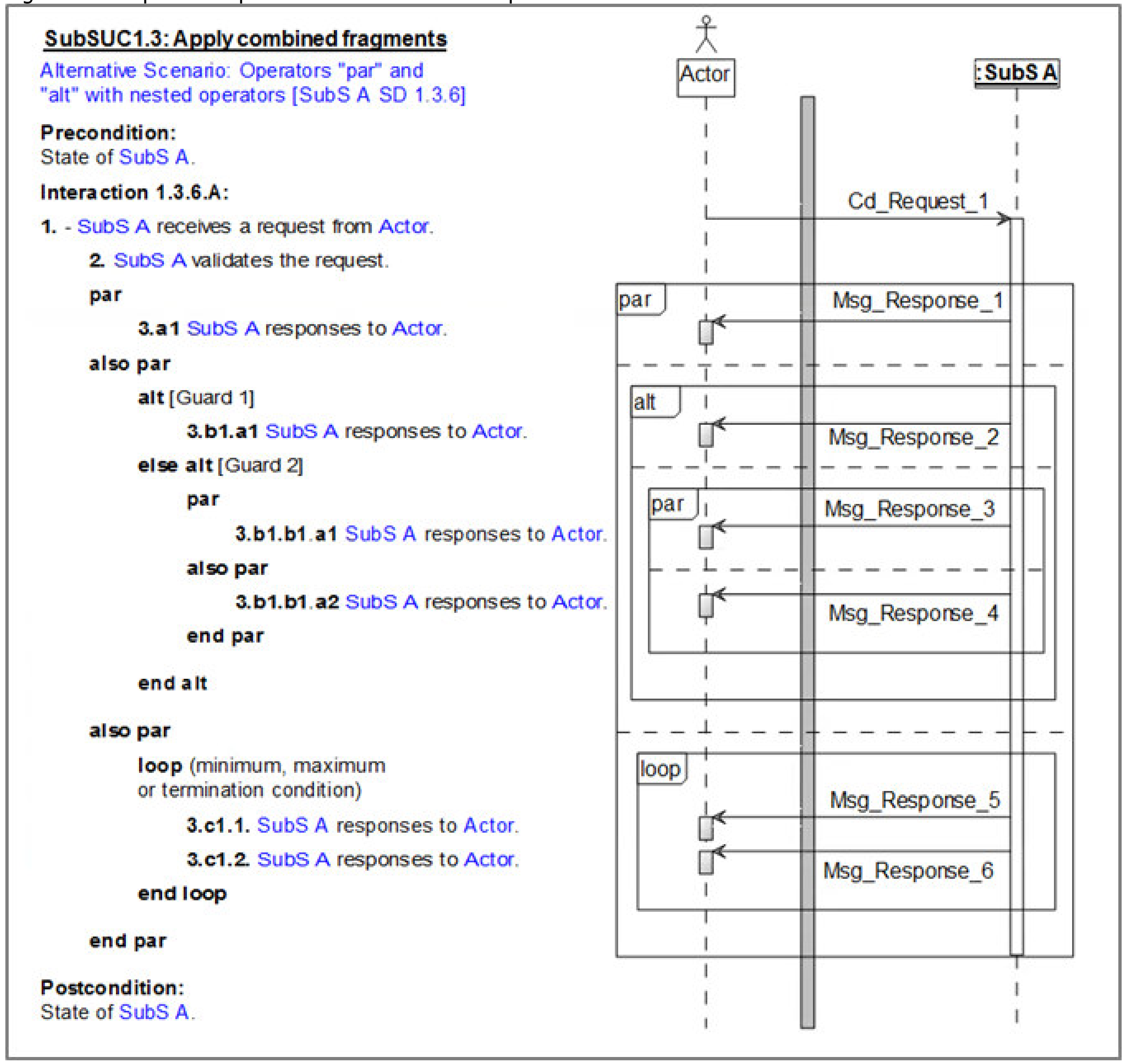
ID	Type	Requirements
Eu.ModSt.813	Info	<u>Interactions are to be parallelized according to the following schema</u> **(**see also Fig. 1255**):** **par** Interaction <Name of the interaction> 4.a1 - action step. 4.a2 action step. Interaction <Name of the interaction> 4.a3 - action step. 4.a4 action step. 4.ax ... **also par** Interaction <Name of the interaction> 4.b1 - action step. 4.b2 action step. 4.bx ... **end par**
Eu.ModSt.1255	Info	Figure 1255 Operator "par" with nested interactions 
Eu.ModSt.1700	Info	**Operator "par-strict"** The keyword "strict" is defined as extension to the operator "par": • <u>Semantics:</u> If the "par" operator of a combined fragment is extended by the keyword "strict", all operands must be executed strictly parallel. This means that IOFlows are sent at the exact same time and included or extended UseCases are invoked at the same time and terminated at the same time. • <u>Syntax:</u> Extend keyword "par" in sequence text as well as in graphical frame box by "-strict"
Eu.ModSt.1701	Info	In the example in Fig.1702, the usage of the extension "strict" of the operator "par" is shown.

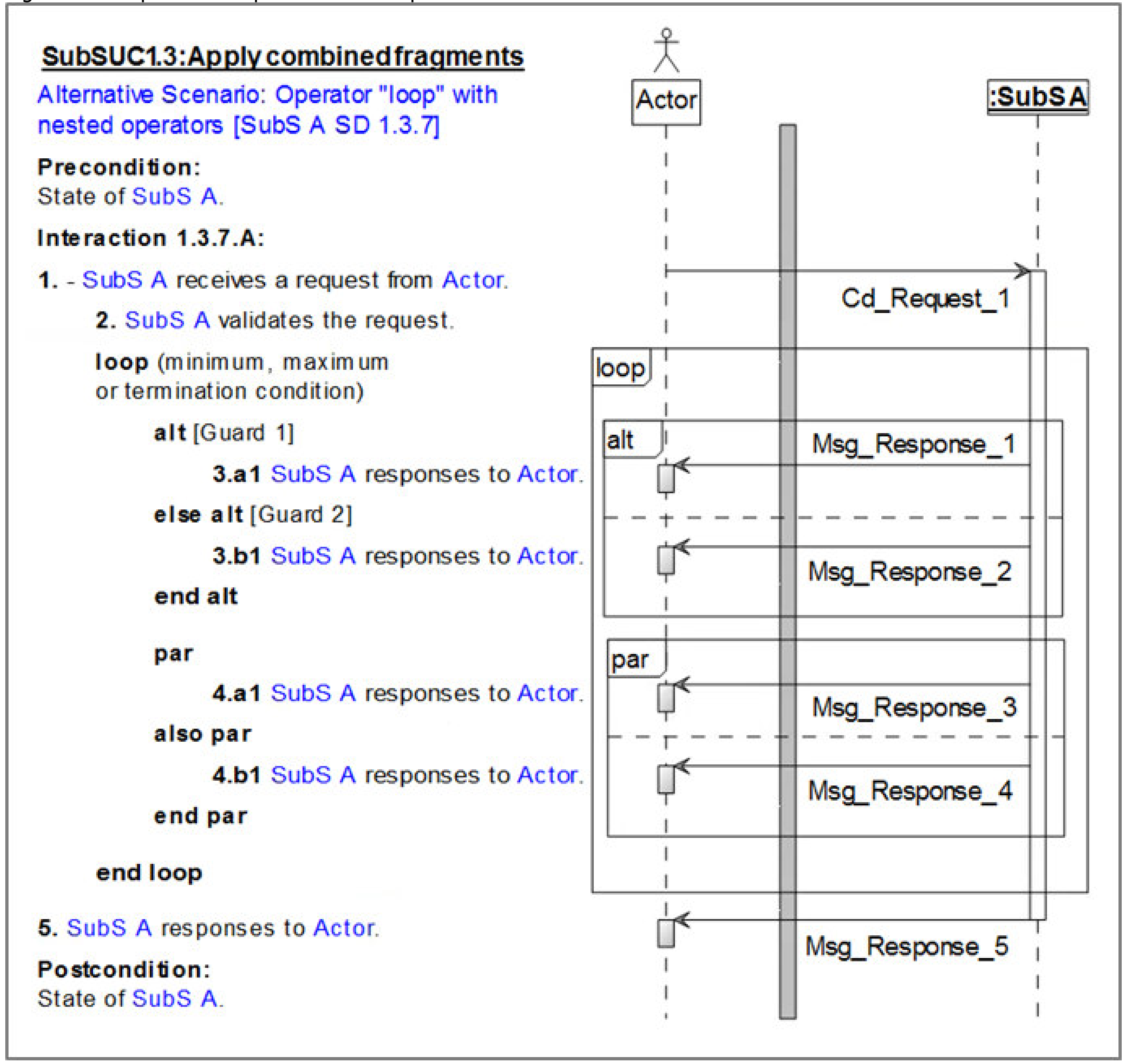
ID	Type	Requirements
Eu.ModSt.1702	Info	Figure 1702 Example for the application of the extended operator "par-strict" 
Eu.ModSt.1703	Info	If a "par-strict" operand consists of more then one action step, the action steps are structured according the following schema: **par-strict** 3.a1 action step. 3.a2 action step. 3.ax ... **also par-strict** 3.b1 action step. 3.b2 action step. 3.bx ... **also par-strict** 3.c1 action step. 3.cx... **end par-strict**
Eu.ModSt.936	Info	**Operator "alt"** In the example depicted in *Figure 935*, the utilisation of the operator "alt" is demonstrated in the way that exactly one of its operands is selected based on the value of its guard. The guard on each operand is evaluated before selection, and if the guard on one of the operands is valid, that one is selected. If more than one operand has a valid guard, the selection is nondeterministic. An optional else fragment (else fragment without guard) is valid only if none of the guards on the other operands are valid.
Eu.ModSt.1704	Info	In case no guard of an alt operand is valid then no operand is executed, unless an optional else fragment without a guard is defined, in which case that operand is selected.
Eu.ModSt.814	Info	If an alt operand consists of more then one action step, the action steps are structured according the following schema (see also *Figure 935*)**:** **alt** [Guard 1] 3.a1 action step. 3.a2 action step. 3.ax... **else alt** [Guard 2] 3.b1 action step. 3.b2 action step. 3.bx... **end alt**

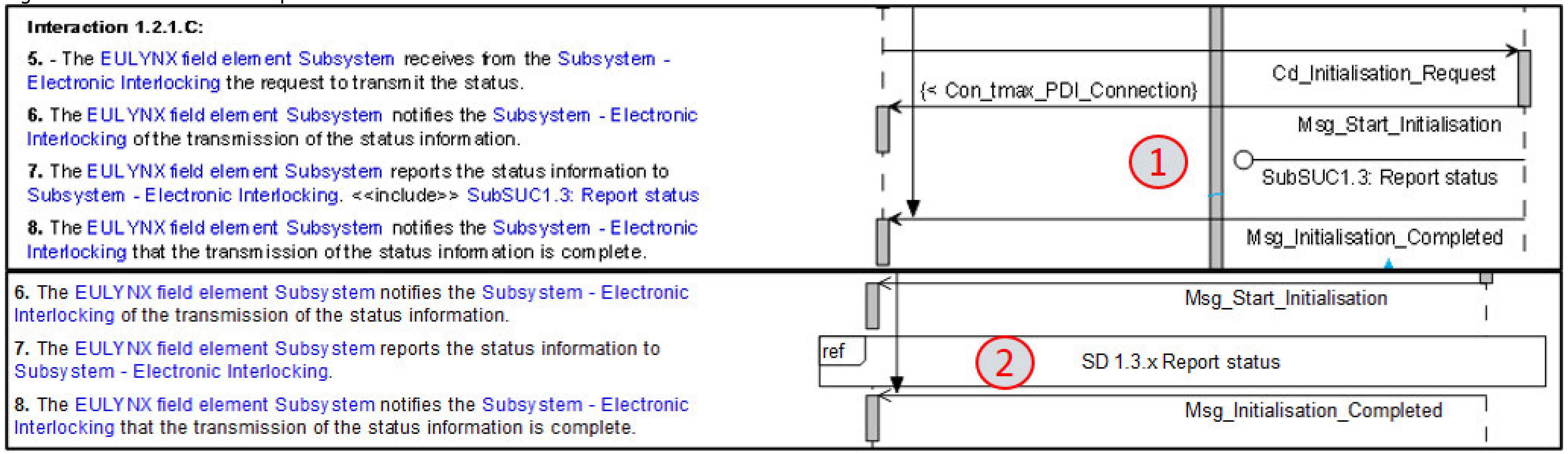
ID	Type	Requirements
Eu.ModSt.935	Info	Figure 935 Example of a combined fragment defined by the operator "alt" 
Eu.ModSt.937	Info	Interactions are to be used in alt operands according to the following schema (see also Figure 1256)**:** **alt** [Guard 1] Interaction <Name of the interaction> 4.a1 - action step. 4.a2 action step. Interaction <Name of the interaction> 4.a3 - action step. 4.a4 action step. 4.ax ... **else alt** [Guard 2] Interaction <Name of the interaction> 4.b1 - action step. 4.b2 action step. 4.bx ... **end alt**

ID	Type	Requirements
Eu.ModSt.1256	Info	Figure 1256 Operator "alt" with nested interactions 
Eu.ModSt.854	Info	Please note: the guards of the alt operands are not to be depicted inside the combined fragment but only in the textual description of it.
Eu.ModSt.1983	Info	**Operator "opt":** The operator **"opt"** (optional sequence) is equivalent to the operator **"alt"** with only one **operand**. This implies that the operand is either executed or skipped depending on the validity of the **guard** (condition).
Eu.ModSt.858	Info	**Operator "loop"**: A loop is specified by the interaction operator "loop" in which the trace represented by its operand repeats until its termination constraint is met. It may define lower and upper bounds on the number of iterations as well as the guard expression. As shown in *Figure 1257*, these bounds are documented in brackets after the loop keyword as (minimum, maximum or termination condition), where the maximum (upper bound) may have the value * indicating an unlimited upper bound.
Eu.ModSt.859	Info	A combined fragment describing a loop is to be structured according to the following schema (see also *Figure 1257*)**:** **loop** (minimum, maximum or termination condition) 1. action step. 2. action step. 3. action step. 4. ...

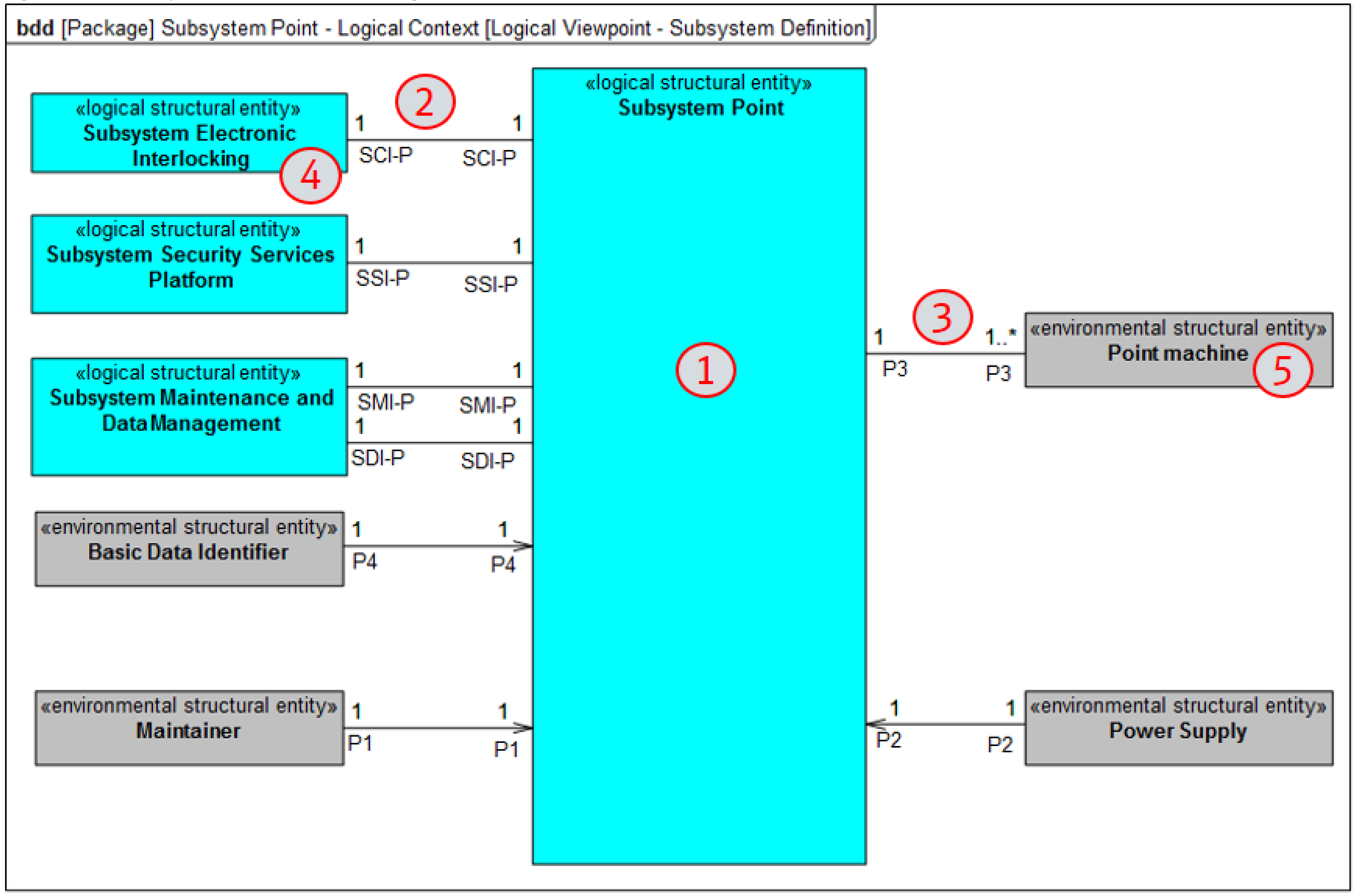
ID	Type	Requirements
Eu.ModSt.1257	Info	Figure 1257 Example of a combined fragment defined by the operator "loop" 
Eu.ModSt.860	Info	Note: the (minimum, maximum or termination condition) of the loop operand is not to be depicted inside the combined fragment but only in the textual description of it.
Eu.ModSt.1261	Info	As shown in *Figure 1258* and *Figure 1259* the operands of combined fragments may themselves contain combined fragments, and thus can be composed into a tree hierarchy.

ID	Type	Requirements
Eu.ModSt.1258	Info	Figure 1258 Operators "par" and "alt" with nested operators 

ID	Type	Requirements
Eu.ModSt.1259	Info	Figure 1259 Operator "loop" with nested operators 
Eu.ModSt.815	Info	**Postcondition:** The postconditions positioned after the last interaction of a scenario representing the results of a UseCase are to be structured as follows: **Postcondition:** ***<Postcondition 1>.*** ***...*** ***<Postcondition n>***.
Eu.ModSt.816	Info	**Example** (see Fig. 715): **Postcondition:** SubS LS indicates the commanded signal aspect.
Eu.ModSt.1222	Info	Postconditions which equal preconditions are not to be stated.
Eu.ModSt.938	Info	If there are no postconditions to be stated, three hyphens are to be depicted instead of them: **Postcondition:** **---**

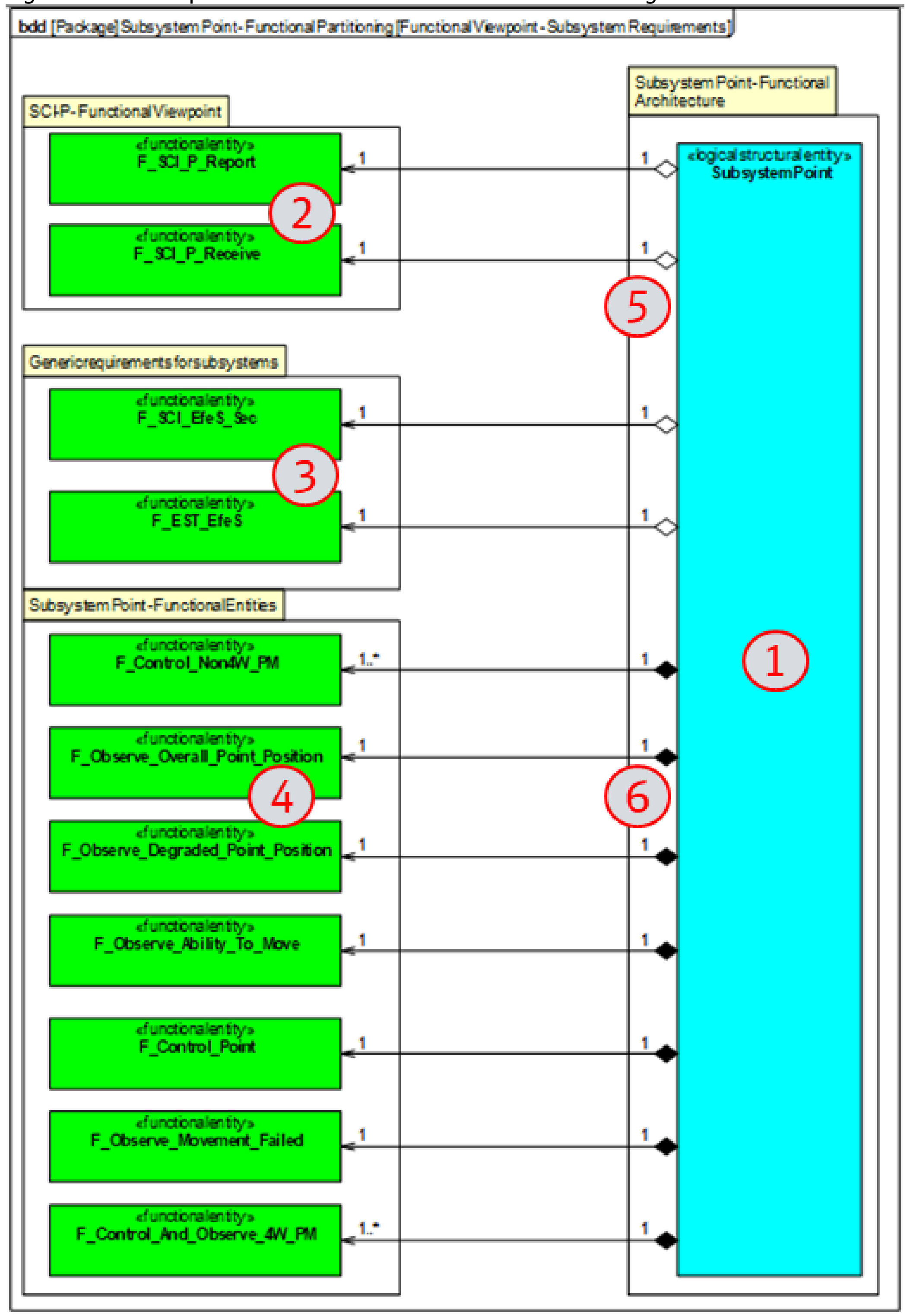
ID	Type	Requirements
Eu.ModSt.3547	Info	**Include relationship** As shown in *Figure 3549* an <<include>> relationship can be used to jump from an interaction scenario to the interaction scenario of an included use case (e.g., SubSUC1.3: Report status). The text part and the include symbol **(1)** indicate which use case is to be accessed. After processing the included interaction scenario, the original interaction scenario is continued.
Eu.ModSt.3548	Info	Alternatively to the include symbol **(1)** an "interaction use" **(2)** may be used to indicate which included interaction scenario is to be accessed. "Interaction uses" are shown as frames with the keyword "ref" in the frame label. The body of the frame contains the name of the referenced interaction scenario.
Eu.ModSt.7949	Info	For each SD that is referenced in another SD, a notice must be inserted in the modelling tool (e.g. Properties ->Text->Description) that corresponds to a defined schema: • This SD is part of [referred SD].
Eu.ModSt.7950	Info	The notice is to be transferred to "Requirements Part 2" of the specification document generated in the requirements management tool.
Eu.ModSt.3549	Info	Figure 3549 Include relationship in interaction scenarios 
Eu.ModSt.7084	Head	**8.3.4.3 Binding** (see *chapter 8.2.1*)
Eu.ModSt.7753	Info	**Diagram of model view "Use case scenario"** has an "**Info**" binding if it is further specified in a refined model view (e.g. through a state machine).
Eu.ModSt.7938	Info	**Diagram of model view "Use case scenario"** has a "**Req**" binding if it is not further specified in a refined model view.
Eu.ModSt.7942	Info	The definitions of **time periodes** (e.g. Con_tmax_PDI_Connection) represented by block properties have "**Def**" bindings.
Eu.ModSt.7944	Info	The **values of the defined time periods**, which are specified and linked separately in the requirements management tool, have "**Req**" bindings.
Eu.ModSt.2131	Head	**8.3.5 Model View "Logical Context" of a SUS (AL1) - Description**
Eu.ModSt.2132	Info	The model view "Logical Context" as shown in *Figure 2134* represents the environment of the SUS and provides initial information about the SUS boundaries and the relationships to the interaction partners. This diagram contains the following definitions relevant to implementation: • **Interaction partners:** the representation of the interaction partners as actors with whom the SUS concerned must be able to interact, • **Logical SUS interfaces:** - number of required logical interfaces represented by associations to interaction partners in the SUS environment defined by means of multiplicities at the association ends - possible directions of the interaction (uni- or bidirectional). - kinds of interfaces such as SCI-P, SMI-P and so on defined by means of roles at the association ends.
Eu.ModSt.2136	Info	**Interaction partners** Interaction partners **(4, 5)** of the SUS **(1)** are represented by actors. An actor describes a person (for example "Maintainer") or another system (for example the "Subsystem - Electronic Interlocking) in the role of a user of services offered by the SUS concerned (here "Subsystem Point"). At the logical viewpoint actors are represented by logical structural entities if they are in the context of a system element belonging to the same overall system. If an actor in the context of a system element is outside of the overall system of this system element (adjacent system) it is represented by an environmental structural entity.
Eu.ModSt.7880	Info	*Figure 2134* therefore includes for example the following related definitions: • system element "Subsystem Electronic Interlocking" represented by a logical structural entity (LSE) assumes the role of an actor in the environment of "Subsystem Point" belonging to the same overall system **(4)**. • system element "Point machine" represented by an environmental structural entity (ESE) assumes the role of an actor in the environment of "Subsystem Light Signal" not belonging to the same overall system **(5)**.

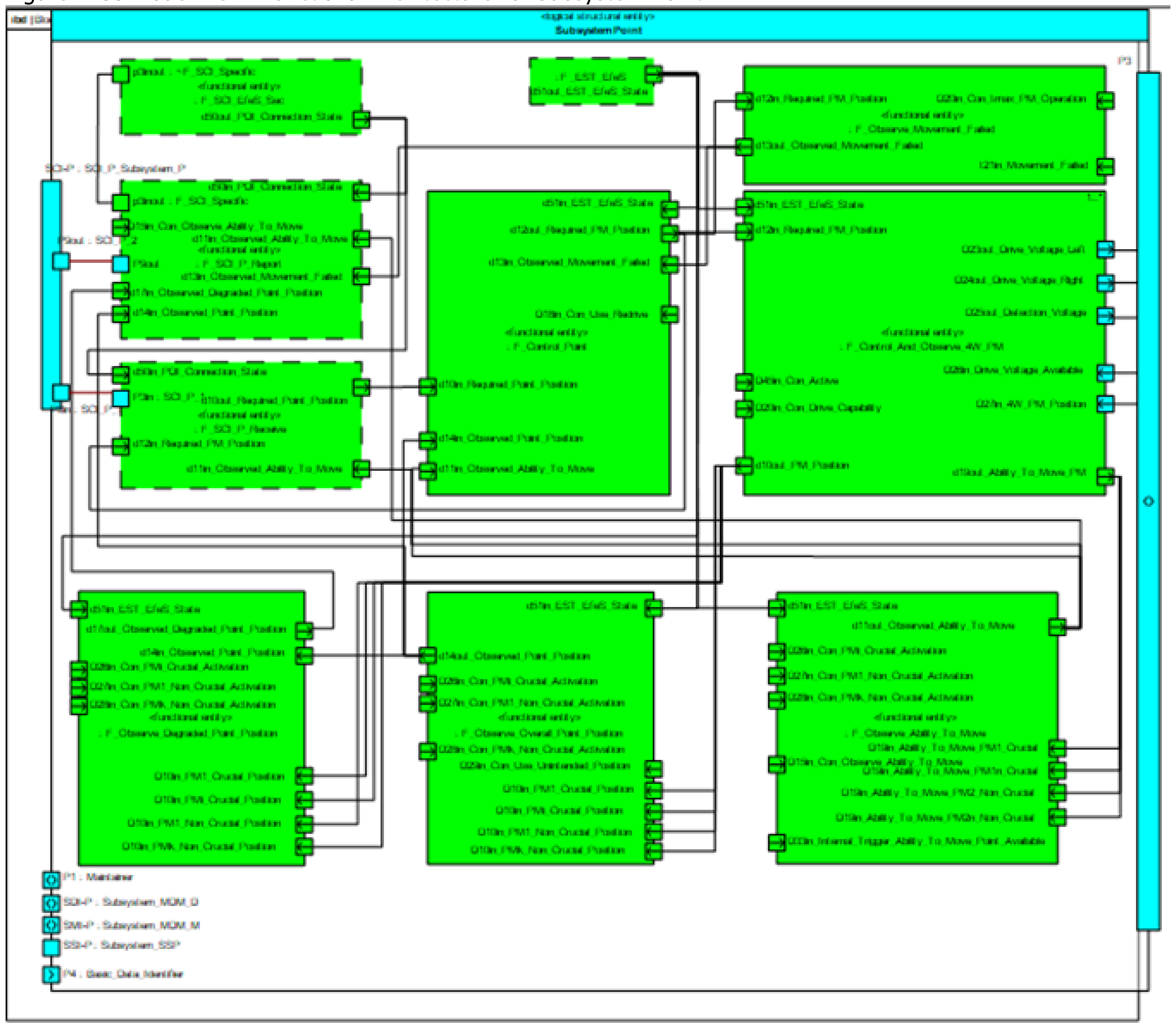
ID	Type	Requirements
Eu.ModSt.2139	Info	**Logical SUS Interfaces** The connection between the SUS (represented by a logical structural entity) and an actor represents a logical interface **(2, 3)**. It is depicted as an association that is a continuous line between the actor and the SUS. It represents the definition that the SUS must be able to interact with the connected actor through a corresponding logical interfaces.
Eu.ModSt.2140	Info	The association also represents the possible interaction directions of the interface. No arrow heads means that the interaction is bidirectional. An arrow head on the other hand indicates that an interaction is only possible in the direction of the arrow.
Eu.ModSt.2141	Info	On the side of the actor of the association, a multiplicity indication describes in more detail with how many of the respective actors the SUS concerned must be able to interact i.e., how many logical interfaces are required.
Eu.ModSt.2142	Info	The definition of the quantity of each actor by means of multiplicities represents an important requirement regarding system development. It is obvious that it makes a difference, for example, whether the system depicted in *Figure 2134* requires an interface to one "Subsystem Electronic Interlocking" or to several.
Eu.ModSt.2143	Info	The multiplicity "1" is defined at the SUS side of the association. The reason for this is that only requirements for the SUS concerned may be phrased in the respective requirements specification. However, according to the SysML syntax, a multiplicity indication at the SUS side would represent a statement for the actor.
Eu.ModSt.2144	Info	Some examples for the representation of multiplicities and their meaning: 1 or blank exactly one 0..1 none or one * none or several 1..* one or several 2..4 at least two and at most four
Eu.ModSt.7881	Info	*Figure 2134* therefore includes for example the following related definitions: • the "Subsystem Point" must be able to interact with exactly one "Subsystem Electronic Interlocking" as an actor, with the interaction possible in two directions. • the "Subsystem Point" must be able to interact with one or more actors "Point machine", with the interaction possible in two directions. • the "Subsystem Point" must be able to interact with exactly one "Basic Data Identifier" as an actor, with an interaction only possible from "Basic Data Identifier" to the "Subsystem Point".
Eu.ModSt.7745	Info	Roles at the association ends represent the used "**Interface kind**" such as SCI-LS, SMI-LS and so on. In Figure 2134 "Subsystem Point" sees for example "Subsystem Electronic Interlocking" in the role of "SCI-P" and vice versa.
Eu.ModSt.7882	Info	*Figure 2134* therefore includes for example the following related definitions: • the interface between "Subsystem Point" and "Subsystem Electronic Interlocking" must be implemented according to the specification of "SCI-P". • the interface between "Subsystem Point" and "Subsystem Maintenance and Data Management" must be implemented according to the specification of "SMI-P". • the interface between "Subsystem Point" and "Subsystem Maintenance and Data Management" must be implemented according to the specification of "SDI-P". • the interface between "Subsystem Point" and "Subsystem Security Services Platform" must be implemented according to the specification of "SSI-P".

ID	Type	Requirements
Eu.ModSt.2134	Info	Figure 2134 Example of SUS model view "Logical Context" 
Eu.ModSt.377	Head	**8.3.6 Model view "Logical Context" of a SUS (AL1) - Modelling rules**
Eu.ModSt.378	Head	**8.3.6.1 SysML diagram**
Eu.ModSt.379	Info	**Block definition diagram (BDD):** depicts the view "Logical System Context".
Eu.ModSt.3560	Info	**Name of the Diagram:** *bdd[Package]<><System block signature><>-<>Logical Context<>[Logical Viewpoint<>-<>Subsystem Definition]*.
Eu.ModSt.383	Info	**Example:** bdd [Package] Subsystem Light Signal - Logical Context [Logical Viewpoint - Subsystem Definition]
Eu.ModSt.385	Head	**8.3.6.2 Model elements**
Eu.ModSt.890	Info	The model elements basically used to describe the model view "Logical Context" are depicted in *Figure 2134*.
Eu.ModSt.386	Info	**Block:** Modular unit of structure in SysML that is used to define the Logical Structural Entity (LSE) or Environmental Structural Entity (ESE) representing the logical view of the SUS or the actors at the uppermost level of abstraction.
Eu.ModSt.1184	Info	**Naming conventions for blocks representing LSEs:** **<System block signature>** := <Abbr. System ID> | <System ID>
Eu.ModSt.1186	Info	**<Abbr. System ID> :=** <Abbr. System type><><Abbr. System name>

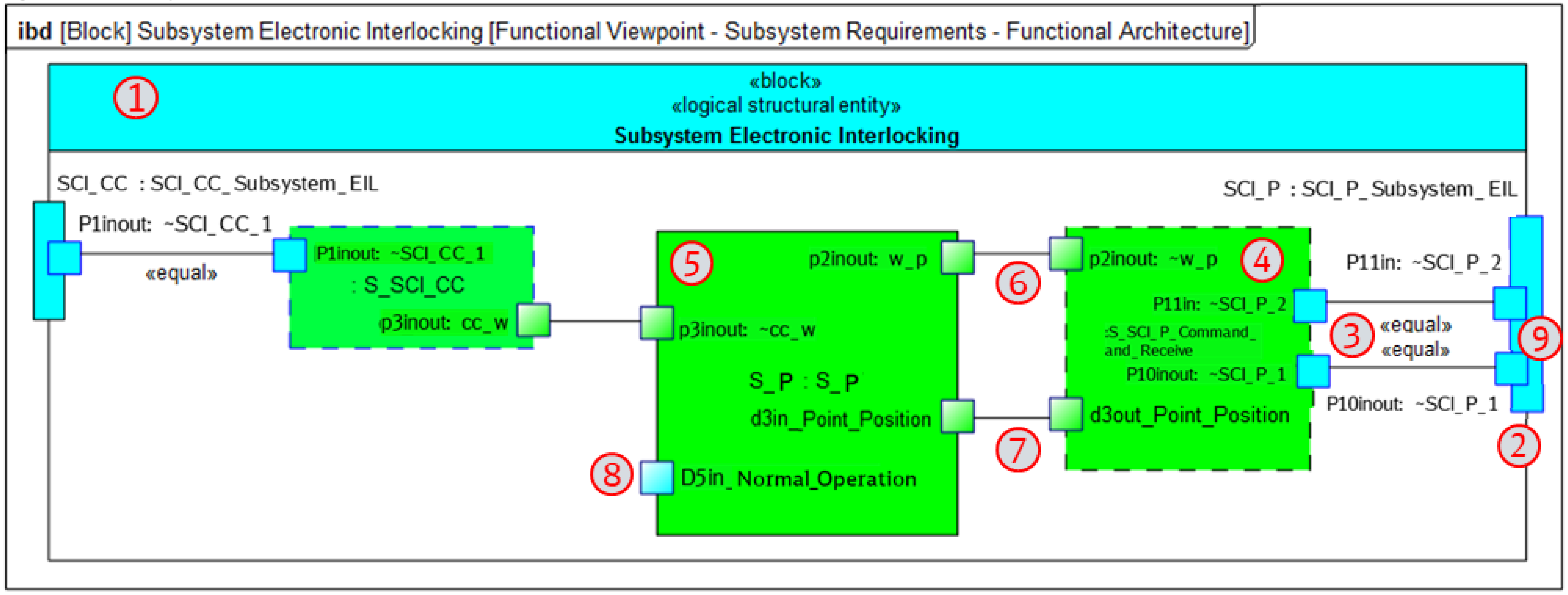
ID	Type	Requirements
Eu.ModSt.1212	Info	**<Abbr. System type**> := "Sys" | "SubS" | "SysElem"
Eu.ModSt.1213	Info	**<Abbr. System name**> := freely selectable
Eu.ModSt.1188	Info	Examples: Sys ABB SubS LS SysElem 1
Eu.ModSt.1185	Info	**<System ID> :=** <System type><><System name>
Eu.ModSt.1214	Info	**<System type>** := "System" | "Subsystem" | "System Element"
Eu.ModSt.1215	Info	**<System name**> := freely selectable
Eu.ModSt.1187	Info	Example: System ABB Subsystem Light Signal System Element 1
Eu.ModSt.1252	Info	If there are project-specific commitments, a deviating designation of **<System block signature>** may be used.
Eu.ModSt.1189	Info	The modeller must ensure that the descriptions of the functional (Functional Viewpoint) and logical (Logical Viewpoint) representations of actors and SUS match.
Eu.ModSt.391	Info	**Actor:** At the Functional Viewpoint (model view "Functional Context"), an actor may be a class of users, roles users can play, or other systems. Cockburn [22] distinguishes between primary and secondary actors.
Eu.ModSt.740	Info	A primary actor is one having a goal requiring the assistance of the system.
Eu.ModSt.741	Info	A secondary actor is one from which the system needs assistance.
Eu.ModSt.392	Info	**Depiction of an actor:** At the logical viewpoint, however, the actors defined in the model view "Functional Context" are represented as parts of the logical overall system architecture. They are represented by logical structural entities if they are in the context of a system element belonging to the same overall system. If an actor in the context of a SUS is outside of the overall system of this SUS (adjacent system) it is represented by an environmental structural entity.
Eu.ModSt.394	Info	**Association:** specifies the structural relationship between a block, i.e. the SUS and an actor. It represents a logical interface (see also *chapter 8.3.5*)
Eu.ModSt.395	Info	Depending on the direction of the information flow, the association has to be stated bi-directional or uni-directional.
Eu.ModSt.396	Info	At the actor's side of an association, the multiplicity that defines the required quantity of each actor and the name of the logical interface has to be stated.
Eu.ModSt.397	Info	At the block's side of an association, the multiplicity "1" and the name of the logical interface has to be stated.
Eu.ModSt.1191	Info	**Naming conventions for interfaces:** **<Interface kind>** := <Abbr. Type of interface>-<Interface ID>
Eu.ModSt.1192	Info	**<Abbr. Type of interface>** := S*)CI | S*)Freely selectable | Freely selectable S*)CI: Communication interface S*)Freely selectable: Standardised Interface except SCI Freely selectable: any non-standardised interface *) "S" indicates that the interface is standardised
Eu.ModSt.1193	Info	**<Interface ID> :=** Freely selectable designator (as far as a generic interface is concerned, “Gen” or "XX"is to be used as Interface ID)
Eu.ModSt.1194	Info	Examples: SCI-P, SMI-LS, SDI-LS, SCI-Gen, SCI-XX
Eu.ModSt.1286	Info	If the interface kind is used within the executable part of the model, where hyphens <-> are forbidden, an underscore <_> is to be used between <Abbr. Type of interface> and <Interface ID>.
Eu.ModSt.1287	Info	Examples: SCI_P, SMI_LS, SDI_LS, SCI_Gen, SCI_XX
Eu.ModSt.1896	Info	If there are project-specific commitments, a deviating designation of **<Interface kind>** may be used.

ID	Type	Requirements
Eu.ModSt.7746	Head	**8.3.6.3 Binding** (see *chapter 8.2.1*)
Eu.ModSt.7752	Info	**Diagram of model view "Logical Context"** has a "**Def**" binding.
Eu.ModSt.7718	Head	**8.3.7 Model view "Functional Partitioning" of a SUS (AL2) - Description**
Eu.ModSt.7721	Info	The model view "Functional Partitioning" shown in *Figure 7723* describes the refinement of the SUS **(1)** by FEs.
Eu.ModSt.7849	Info	The FEs **(2)** defined in the SIUS model view "Functional Partitioning" (see *chapter 8.4.3*), which represent the local behaviours of the PDI (see *chapter 8.2.4*), and the generic FEs **(3)** are referenced by the SUS through reference associations **(5)**. FEs which are assigned to the subsystem via reference associations (marked with a white diamond) are not part of the subsystem, but are only used there. They represent the local behaviour of the PDI of the corresponding SIUS and are part of it.
Eu.ModSt.7850	Info	The SUS-specific FEs **(4)** are part of the SUS which is represented by composite associations **(6)**. FEs which are assigned to the subsystem via composite associations, i.e. so-called whole-part relationships (marked with a black diamond) are part of the subsystem. They represent the specific behaviour of the subsystem that influences more than one interface. This so-called "linking behaviour" is also used to link the behaviour assigned to the interfaces.
Eu.ModSt.7851	Info	The model view "Functional Partitioning" forms the basis for the model view "Functional Architecture" (see *chapter 8.3.9*). It defines the FEs in their maximum quantity structure in the form of multiplicities. Within the framework of this quantity structure, the FE configurations required for the definition of the functional requirements are then created in the model view "Functional Architecture".

ID	Type	Requirements
Eu.ModSt.7723	Info	Figure 7723 Example of SUS model view "Functional Partitioning" 
Eu.ModSt.7719	Head	**8.3.8 Model view "Functional Partitioning" of a SUS (AL2) - Modelling rules**
Eu.ModSt.7780	Head	**8.3.8.1 SysML diagram**
Eu.ModSt.7781	Info	**Block Definition Diagram (bdd):** depicts the model view "Functional Partitioning".
Eu.ModSt.7782	Info	**Diagram heading:** *bdd[Package]<><System block signature> <>->Functional Partitioning<> [Functional Viewpoint - Subsystem Requirements]*

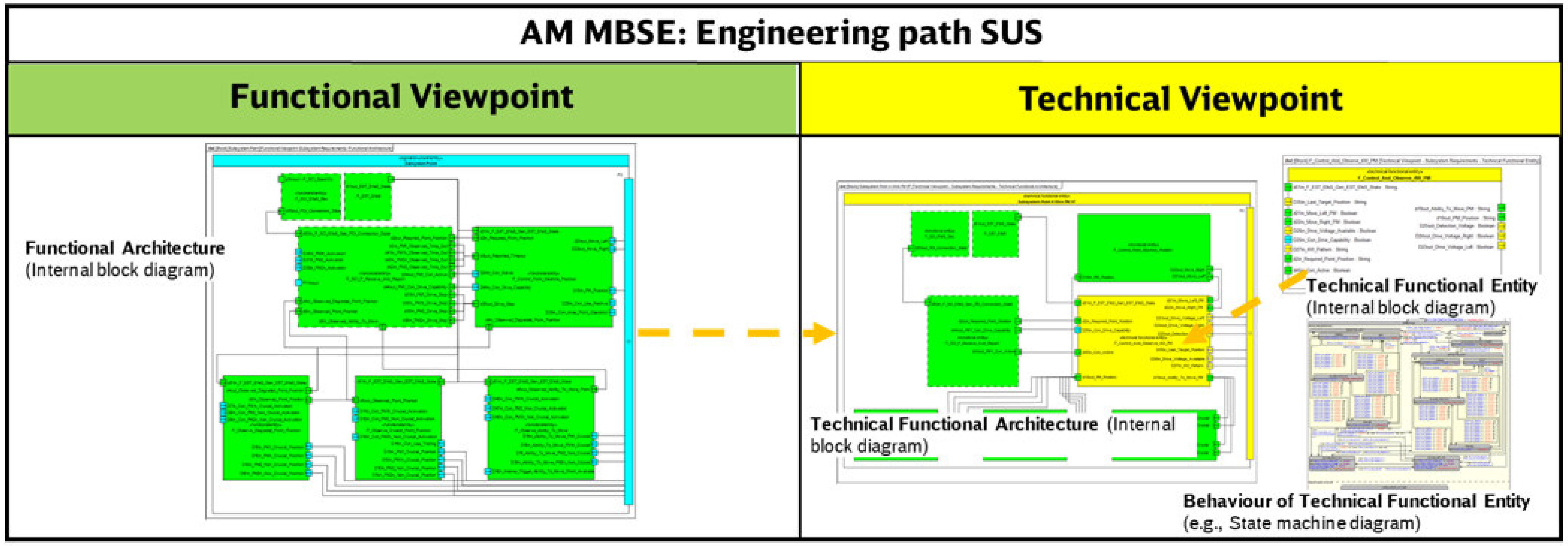
ID	Type	Requirements
Eu.ModSt.7783	Info	**Example:** bdd [Package] Subsystem Point- Functional Partitioning [Functional Viewpoint - Subsystem Requirements]
Eu.ModSt.7811	Head	**8.3.8.2 Model Elements**
Eu.ModSt.7812	Info	*Remains free for the time being.*
Eu.ModSt.7843	Head	**8.3.8.3 Binding** (see *chapter 8.2.1*)
Eu.ModSt.7852	Info	**Diagram of model view "Functional Partitioning"** has a "**Def**" binding.
Eu.ModSt.7028	Head	**8.3.9 Model view "Functional Architecture" of a SUS (AL2) - Description**
Eu.ModSt.7029	Info	*Figure 7755* shows the model view "Functional Architecture" (FA) of Subsystem Point. It is created based on the in model view "Functional Partitioning" defined FEs.
Eu.ModSt.7755	Info	Figure 7755 Model view "Functional Architecture" of Subsystem Point 
Eu.ModSt.7756	Info	The model view "Functional Architecture" is explained in the following with a simple example as shown exemplarily in *Figure 7031*. It describes the external visible stimulus-response behaviour of a SUS **(1)** represented by a Logical Structural Entity (LSE) that is structured in a way that enables an interface centric specification approach as described in *chapter 8.2.4.* The behaviour of the SUS is divided into Functional Entities" (FE), which communicate with each other via internal interfaces and with the environment via external interfaces.

ID	Type	Requirements
Eu.ModSt.7033	Info	**Functional Entities** To describe the overall behaviour of an SUS observable externally in an FA structured, two different representations of the FEs **(4, 5)** are used: FEs with a solid border **(5)** and FEs with a dashed border **(4)**. Following the interface centric specification paradigm explained in *chapter 8.2.4*, a solid-bordered FE represents the directly specified behaviour of the SUS that is the "linking behaviour" (e.g. S_P : S_P). It is an inseparable part of the SUS behavioural model. FEs with dashed borders, on the other hand, are references (reference properties) to the interface protocols specified in the models of the application levels. These local behaviours are linked to the overall behaviour of the SUS by the directly specified SUS linking behaviour. The model view "Functional Entity" is described in *chapter 8.5* and *chapter 8.6*.
Eu.ModSt.7759	Info	In *Figure 7031*, for example, the functional entity ":S_SCI_P_Command_and_Receive" is shown as a dashed block. This means that it is the local behaviour of the SCI-P protocol at application level, which is defined in the SCI-P specification (see *chapter 8.4*).
Eu.ModSt.7037	Info	**Internal FE-coupling** Internal FE-couplings are implemented in two variants. In variant 1 **(6)**, communication between two FEs takes place by means of signals and in variant 2 **(7)**, permanent information is transmitted.
Eu.ModSt.7038	Info	**Variant 1 (6):** an internal FE-coupling according to variant 1 defines an event-driven flow. It consists of two SysML proxy ports with the same name that are connected via a connector (SysML Connector). The connector represents the communication channel over which the information objects defined in the port type (SysML interface block) such as "w_p" can be exchanged. The information objects are represented by SysML signals (see *chapter 8.7.4* and *chapter 8.6.6.10.1*). The port type is used conjugated on one side (e.g., ~w_p). This means that an information object defined as outgoing in the interface block (port type) becomes an incoming information object through conjugation.
Eu.ModSt.7039	Info	Port name and port type are written in lower case. In addition, the ports are shown in the colour of the FEs.
Eu.ModSt.7040	Info	**Variant 2 (7):** an internal FE-coupling according to variant 2 defines a continuous flow. It consists of two SysML proxy ports or alternatively SysML flow ports with the same name that are connected via a connector (SysML Connector). The continuity of the information transmission is indicated by the abbreviation "d = data" at the beginning of the names of the ports involved.
Eu.ModSt.7036	Info	The information flows defined in the internal FE-couplings or the couplings themselves are to be interpreted as descriptive elements of the behaviour and are only binding in the context of the overall behaviour. That means that an information flow defined in an internal FE-coupling only becomes a mandatory requirement in the context of its active use, e.g. in a transition.
Eu.ModSt.7885	Info	**Please note:** In some cases, flow ports are still used to describe internal FE-couplings (see for example *Figure 7755*). However, these will gradually be replaced by proxy ports in the future.
Eu.ModSt.7041	Info	Ports used for internal FE-coupling are defined as **functional ports**. Their names are written in lower case. In addition, the ports are shown in the colour of the FEs.
Eu.ModSt.7043	Info	**External FE-coupling** The overall behaviour to be implemented by the manufacturers is connected to the **logical SUS interfaces (2)** via external FE-couplings **(3)**.
Eu.ModSt.7044	Info	An external FE-coupling consists of a proxy port representing a logical SUS interface, located at the SUS outer boundary and labelled with the designator of the interface concerned (e.g. SCI_P : SCI_P_Subsystem_EIL). The proxy ports delegated from the FEs relevant to the interface using binding connectors **(3)** and representing the information flows (e.g. P11in : ~SCI_P_2 or P10inout : SCI_P_1) are embedded in it **(9)**.
Eu.ModSt.7860	Info	In other words, the port (e.g. P10inout : ~SCI_P_1) at the FE is duplicated on the SUS outer boundary. Both ports are connected with a binding connector. The information flows and their direction remain unchanged in the interface block of the duplicated port.
Eu.ModSt.7045	Info	The names of the proxy ports used in an external coupling (e.g. P11in or P10inout) designate the information flows assigned to the logical SUS interface. The port types (e.g. SCI_P_2 or SCI_P_1) define the information objects of the information flows that must be able to be exchanged via the respective interface.
Eu.ModSt.7861	Info	The information objects defined in the information flows or the couplings themselves are to be interpreted as descriptive elements of the behaviour and are only binding in the context of the overall behaviour. That means that an information object defined in an external FE-coupling only becomes a mandatory requirement in the context of its active use, e.g. in a transition.
Eu.ModSt.7884	Info	**Please note:** In some cases, flow ports are still used to describe external FE-couplings (see for example interface P3 in *Figure 7755*). However, these will gradually be replaced by proxy ports in the future.
Eu.ModSt.7046	Info	Ports used for external FE-coupling are defined as **logical ports**. Port name and port type are written in capital letters. In addition, the ports are shown in the colour blue.
Eu.ModSt.7049	Info	**Open ports** Open ports **(8)** that is ports not associated to connectors define interfaces to specification parts not contained in the model, i.e. expected behaviour in the environment of the FEs. This behaviour can be implemented proprietarily by each manufacturer, as long as the information expected at the ports is provided or the information delivered via the ports is processed accordingly.
Eu.ModSt.7762	Info	Ports used as open ports are defined as **logical ports**. Port name and port type are written in capital letters. In addition, the ports are shown in the colour blue.
Eu.ModSt.7050	Info	Open ports are also used to configure the specified behaviour.
Eu.ModSt.7030	Info	**Please note:** The FA is not to be understood as a specification for an internal architecture of the SUS, but as a descriptive structuring. The FEs in communication relationship represent the expected overall behaviour of a SUS, which must be fulfilled by the respective manufacturer in its entirety.

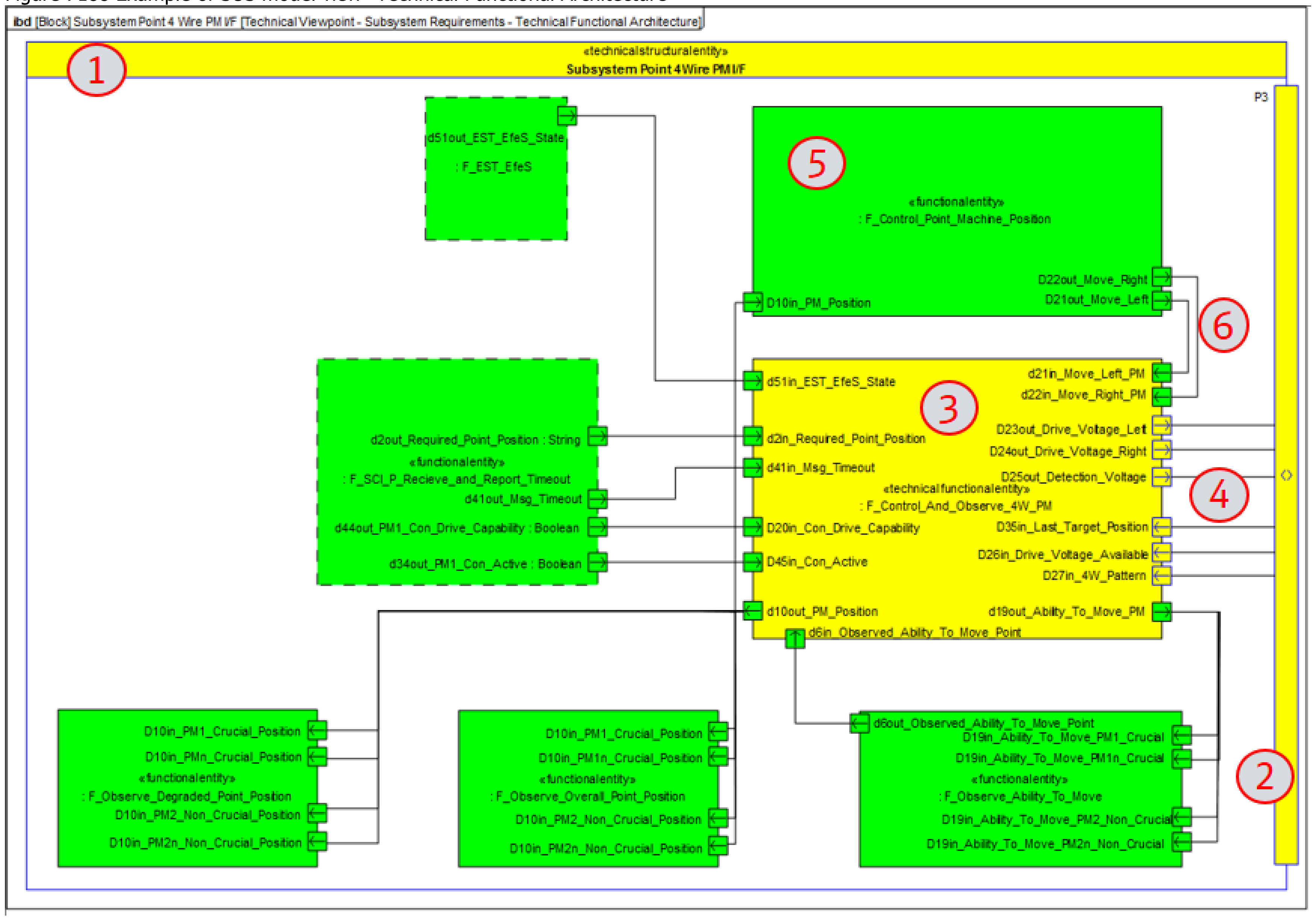
ID	Type	Requirements
Eu.ModSt.7031	Info	Figure 7031 Example of SUS model view "Functional Architecture" 
Eu.ModSt.1800	Head	**8.3.10 Model view "Functional Architecture" of a SUS (AL2) - Modelling rules**
Eu.ModSt.1813	Head	**8.3.10.1 SysML diagram**
Eu.ModSt.1832	Info	**Internal Block Diagram (ibd):** depicts the model view "Functional Architecture".
Eu.ModSt.1833	Info	**Diagram heading:** *ibd[Block]<><System block signature><>[Functional Viewpoint<>-<>System Requirements<>-<>Functional Architecture]*
Eu.ModSt.1834	Info	**Example:** ibd[Block] Subsystem Electronic Interlocking[Functional Viewpoint-System Requirements-Functional Architecture]
Eu.ModSt.7758	Head	**8.3.10.2 Model elements**
Eu.ModSt.7763	Info	**Block:** Modular unit of structure in SysML that is used to define the Logical Structural Entity (LSE) representing the SUS at the Logical Viewpoint and the Functional Entities (FE) in the form of parts and reference properties.
Eu.ModSt.7764	Info	**Part:** Parts **(5)** describe composition relationships between blocks. A composition relationship is also called a whole-part relationship. Thus, the parts used in a Functional Architecture of a SUS describe the composition relationships between the LSE and the corresponding FEs representing linking behaviour as introduced in *chapter 8.2.4*.
Eu.ModSt.7857	Info	**Reference properties:** Reference properties **(4)** enable an instance of a block that contains the reference property to refer to an instance of the block which types the reference property. They can be used to describe a logical hierarchy that references blocks that are part of other composition hierarchies. Reference properties are depicted in a similar fashion to parts when shown on the internal block diagram, except that their box symbol has a dashed instead of a solid boundary. In the model view "Functional Architecture" of a SUS reference properties represent FEs which are references to the local behavioural parts of the interface application protocol as defined in model view "Functional Architecture" of the SIUS (see *chapter 8.4.5*).
Eu.ModSt.1137	Info	**Part/reference property signature :=** *<Name of the part/reference property>:<FE_TFE block signature>*
Eu.ModSt.694	Info	**Name of the part/reference property :=** 1) | 2) | 3) 1) A part/reference property is not named when the type (FE_TFE block signature) provides sufficient information to infer the role the part plays in the context of the Functional Architecture. 2) A part/reference property is given a name (Freely selectable designator) when the type (FE_TFE block signature) does not adequately describe the role the part plays in the context of the Functional Architecture. 3) A part/reference property is given a name (Freely selectable designator) when it is used within a SySim simulation.
Eu.ModSt.7858	Info	**Example:** S_P : S_P :S_SCI_P_Command_and_Receive

ID	Type	Requirements
Eu.ModSt.7765	Info	**Connector:** SysML connectors **(6,7)** are used to model the connections between parts or reference properties. Thus, they specify the communication-channels between the ports of FEs.
Eu.ModSt.7766	Info	Whereas an out port of a FE may be connected to no connector or an infinite number of connectors, an in port may be connected to either no connector or only one connector, but must not be connected to more than one connector.
Eu.ModSt.7859	Info	**Binding Connector:** A binding connector **(3)** is a special kind of connector that constrains its ends to have the same value. It is used, among other things, to bind proxy ports to parts or reference properties. For example, the value of the proxy port "P11in: ~SCI_P_2" **(9)** at the SUS interface **(2)** in *Figure 7031* corresponds to that of the port of the same name of the FE ":S_SCI_P_Command_and_Receive". A binding connector is shown using the connector notation, except that the connector path optionally has the keyword <<equal>> shown near its centre.
Eu.ModSt.7862	Info	**Designator of a logical SUS interface** := *<Interface kind><>:<><Signature of Interface block aggregating information flows>*
Eu.ModSt.7863	Info	*<Signature of Interface block aggregating information flows> := <Interface kind>_<System block signature>*
Eu.ModSt.7865	Info	*<Interface kind>*: see *chapter 8.3.6.2* (Example: SCI_P)
Eu.ModSt.7867	Info	*<System block signature>*: see *chapter 8.3.6.2* (Example: Subsystem_EIL)
Eu.ModSt.7864	Info	**Example of a designator of a logical SUS interface:** SCI_P : SCI_P_Subsystem_EIL
Eu.ModSt.7868	Info	**Designator of an Information flow** := *P<PNo><Port direction>_<Port information><>:<><Signature of Interface block aggregating information objects>*
Eu.ModSt.7869	Info	*<PNo>, <Port direction>, <Port information>* are defined in *chapter 8.6.5.2*.
Eu.ModSt.7870	Info	*<signature of Interface block aggregating information objects> := <Interface kind>_<IFNo>*
Eu.ModSt.7871	Info	**Information flow number (IFNo):** natural number
Eu.ModSt.7872	Info	**Example:** P11in : SCI_P_2 P10inout : SCI_P_1 P1inout : SCI_CC_1
Eu.ModSt.7948	Info	**Please note:** Regarding the use of flow ports, flow specifications and flow properties see **Eu.Doc.30 v3.0(2.A)**.
Eu.ModSt.7760	Head	**8.3.10.3 Binding** (see *chapter 8.2.1*)
Eu.ModSt.7761	Info	**Diagram of model view "Functional Architecture"** has a "**Def**" binding.
Eu.ModSt.7197	Info	**Ports** have a "**Def**" binding.
Eu.ModSt.7945	Info	**Flow specifications** have an "**Info**" binding.
Eu.ModSt.7946	Info	**FLow properties** of the flow specifications have a "**Def**" binding if they are further refined elsewhere (e.g. by linked telegram definitions in separate interface specifications or further requirements in chapter 5.X. of the subsystem requirements specification in the requirements management tool).
Eu.ModSt.7947	Info	**FLowProperties** of the FlowSpecifications have a "**Req**" binding if they are not further refined elsewhere.
Eu.ModSt.7186	Head	**8.3.11 Model view "Technical Functional Architecture" of a SUS (AL2) - Description**
Eu.ModSt.7193	Info	*Figure 7194* shows the engineering path of the model views used to specify a SUS at the Technical Viewpoint on abstraction level AL2.

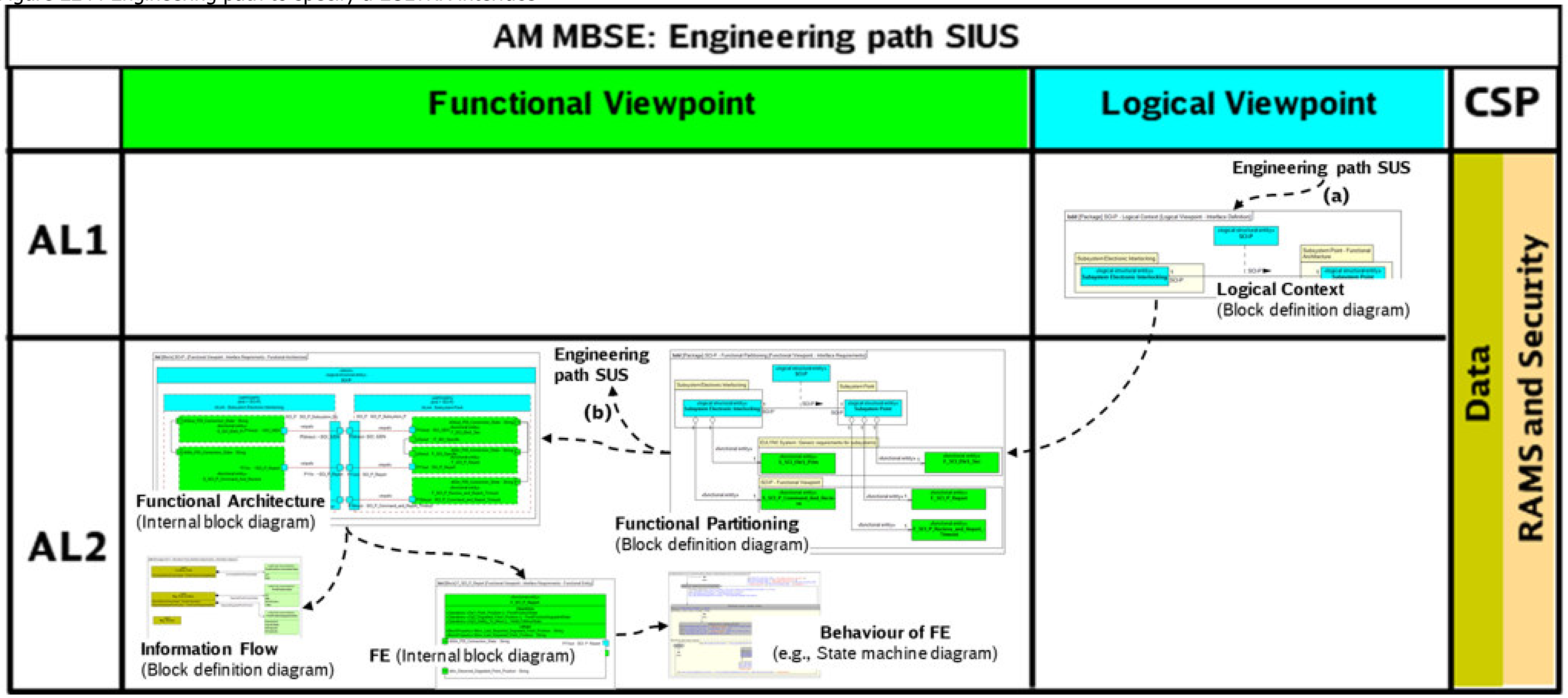
ID	Type	Requirements
Eu.ModSt.7194	Info	Figure 7194 Engineering path to specify a SUS at the Technical Viewpoint on abstraction level AL2



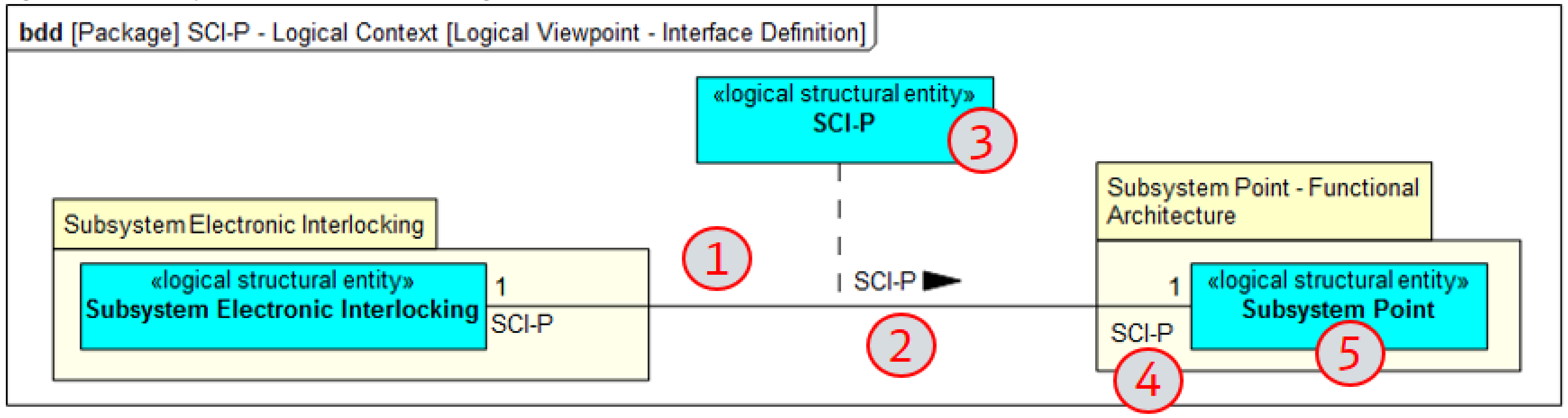
Eu.ModSt.7767	Info	The model view "Technical Functional Architecture" (TFA) supplements or substitutes the behaviour described in the model view "Functional Architecture", which is independent of technology, with behavioural components derived from technical requirements. In other words, the FEs interconnected in the model view "Functional Architecture" are either transferred to the model view "Technical Functional Architecture" or completely or partially replaced by Technical Functional Entities (TFE).
Eu.ModSt.7769	Info	The SUS can either be described completely from a technical point of view (all FEs are replaced by TFEs) or only certain parts of it (interconnection of TFEs and transferred FEs).
Eu.ModSt.7192	Info	*Figure 7188* shows an example of the transfer of the FES defined in the model view "Functional Architecture" to the model view "Technical Functional Architecture" of the SUS Subsystem Point. The SUS **(1)** is represented by a Technical Structural Entity (TSE). The transferred FEs **(5)** are supplemented with the TFE "F_Control_And_Observe_4W_PM" **(3)** that describes the functionality of the four-wire interface to a point machine based on technical requirements.
Eu.ModSt.7189	Info	In model view "Technical Functional Architecture" TFEs are coupled with each other, with the already defined FEs **(6)** and with the environment **(4)** via **external technical functional interfaces (2)**.
Eu.ModSt.7886	Info	The overall behaviour of a SUS structured by a TFA can be divided into several TFAs in the graphical representation.
Eu.ModSt.7887	Info	**Technical Functional Entities** To describe the overall behaviour of an SUS observable externally in an TFA structured, two different representations of the TFEs are used: TFEs with a solid border **(3)** and TFEs with a dashed border. Following the interface centric specification paradigm explained in *chapter 8.2.4*, a solid-bordered FE represents the directly specified behaviour of the SUS that is the "linking behaviour". It is an inseparable part of the SUS behavioural model. TFEs with dashed borders, on the other hand, are references (reference properties) to the interface protocols specified in the models of the application levels. These local behaviours are linked to the overall behaviour of the SUS by the directly specified SUS linking behaviour. The model view "Technical Functional Entity" is described in *chapter 8.5* and *chapter 8.6*.
Eu.ModSt.7888	Info	**Internal TFE-coupling and external TFE-coupling** The definitions for internal FE-coupling and external FE-coupling in *chapter 8.3.9* apply accordingly.
Eu.ModSt.7889	Info	Ports used for external TFE-coupling and internal TFE-coupling are defined as **technical functional ports**. They are shown in the colour yellow **(4)**.
Eu.ModSt.7890	Info	Ports used for internal coupling of FEs with TFEs are **functional ports**. They are shown in the colour green **(6)**.
Eu.ModSt.7891	Info	Ports representing **technical functional SUS interfaces (2)** can only be connected to technical functional ports **(4)**.
Eu.ModSt.7892	Info	**Open ports** Open ports that is ports not associated to connectors define interfaces to specification parts not contained in the model, i.e. expected behaviour in the environment of the TFEs. This behaviour can be implemented proprietarily by each manufacturer, as long as the information expected at the ports is provided or the information delivered via the ports is processed accordingly.
Eu.ModSt.7893	Info	Ports used as open ports are defined as **logical ports**. Port name and port type are written in capital letters. In addition, the ports are shown in the colour blue.

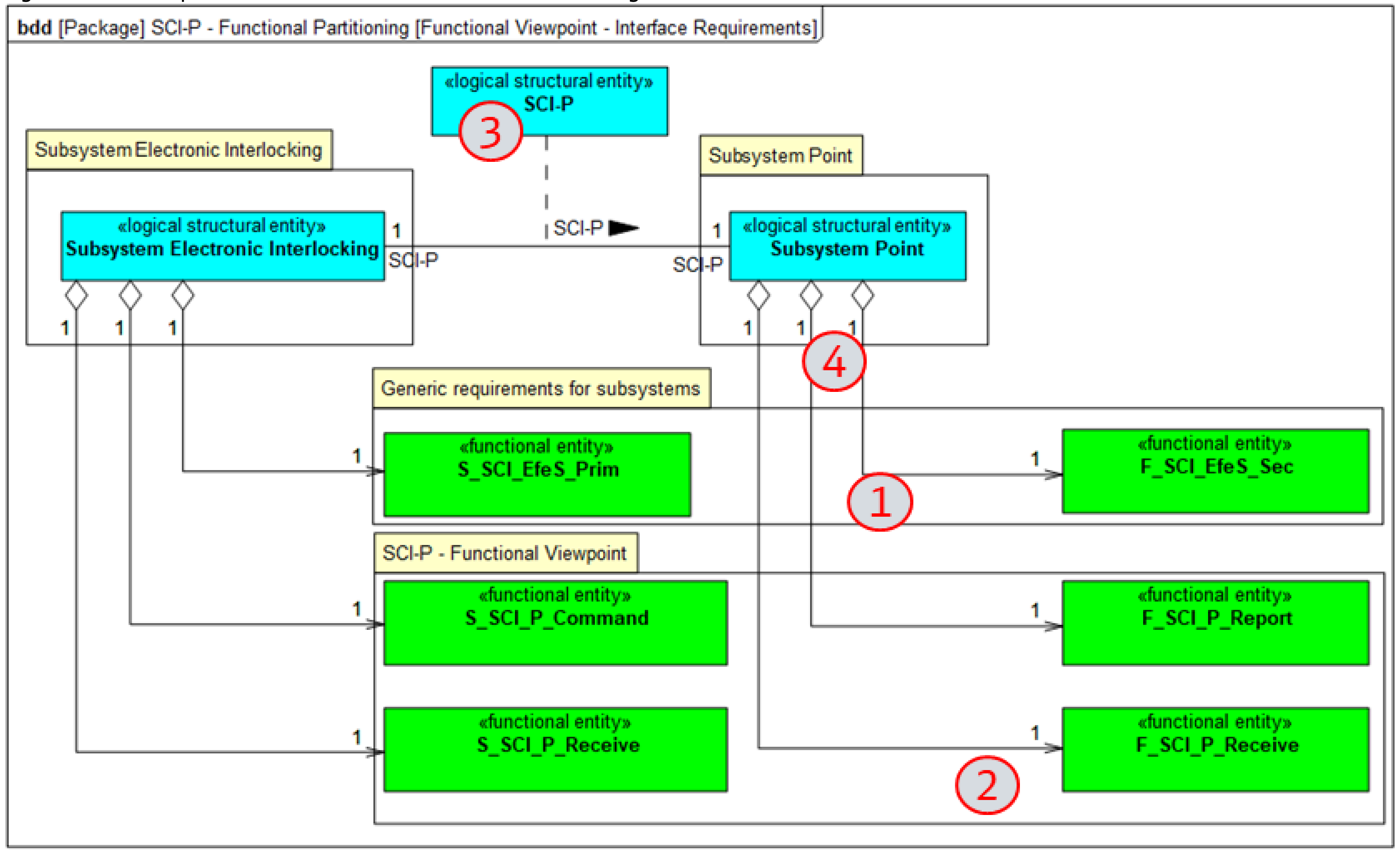
ID	Type	Requirements
Eu.ModSt.7883	Info	**Please note:** The TFA is not to be understood as a specification for an internal architecture of the SUS, but as a descriptive structuring. The TFEs or FEs in communication relationship represent the expected overall behaviour of a SUS, which must be fulfilled by the respective manufacturer in its entirety.
Eu.ModSt.7188	Info	Figure 7188 Example of SUS model view "Technical Functional Architecture" 
Eu.ModSt.7301	Info	**8.3.12 Model view "Technical Functional Architecture" of a SUS (AL2) - Modelling rules**
Eu.ModSt.7303	Head	**8.3.12.1 SysML diagram**
Eu.ModSt.7304	Info	**Internal Block Diagram (ibd):** depicts the model view "Technical Functional Architecture"
Eu.ModSt.7305	Info	**Diagram heading:** *ibd[Block]<><System block signature><>[Technical Viewpoint<>-<>Subsystem Requirements<>-<>Technical Functional Architecture]*
Eu.ModSt.7306	Info	**Example:** ibd [block] Subsystem Point 4 Wire PM I/F [Technical Viewpoint - Subsystem Requirements - Technical Functional Architecture]
Eu.ModSt.7307	Head	**8.3.12.2 Model elements**
Eu.ModSt.7308	Info	**Block:** Modular unit of structure in SysML that is used to define the TSE representing the technical manifestation of the SUS.
Eu.ModSt.7310	Info	**Please note:** For the remaining model elements, the definitions in *chapter 8.3.10.2* apply accordingly.

ID	Type	Requirements
Eu.ModSt.7330	Head	**8.3.12.3 Bindings** (see *chapter 8.2.1*)
Eu.ModSt.7333	Info	**Diagram of model view "Technical Functional Architecture"** has a "**Def**" binding.
Eu.ModSt.7335	Info	**Ports** have a "**Def**" binding.
Eu.ModSt.7336	Info	**Technical functional SUS interface** has a "**Req**" binding if it is not further specified in a refined model view or in the form of a separate requirement.
Eu.ModSt.2486	Head	**8.4 Model views used to specify EULYNX interfaces**
Eu.ModSt.2238	Info	**Model view "Logical Context": Block Definition Diagram (bdd)** The model view "Logical Context" describes the logical view of an interface at the upper level of abstraction.
Eu.ModSt.2239	Info	**Model view "Functional Partitioning": Block Definition Diagram (bdd)** The model view "Functional Partitioning" describes the refinement of the interface defined in model view "Logical Context" using Functional Entities.
Eu.ModSt.2240	Info	**Model view "Functional Architecture": Internal Block Diagram (ibd)** The model view "Functional Architecture" defines the global behaviour of the application protocol (see *chapter 8.2.4*).
Eu.ModSt.2241	Info	**Model view "Functional Entity": Internal Block Diagram (ibd) and State Machine (stm)** The model view "Functional Entity" encapsulates a subset of the functional requirements of an SUS in the form of a function module. It delimits the function module from its environment and defines the inputs and outputs. In the discrete case, the behaviour of the function block is described by means of state machines. In this, the binding functional requirements are specified in the form of states and corresponding state transitions. As the model view "Functional Entity" is used for the specification of EULYNX system elements as well as for the specification of EULYNX interfaces it is described in the separate *chapter 8.5* and *chapter 8.6*.
Eu.ModSt.2242	Info	**Model view "Information Flow": Block Definition Diagram (bdd)** The model view „Information Flow" describes the information objects to be exchanged via an interface which are further refined to telegrams at abstraction level AL3. At present, the telegrams are not yet described in a model-based way. They are defined in the interface specifications (e.g. Interface Specification SCI-P, Eu.Doc.38).
Eu.ModSt.2243	Info	*Figure 2244* shows the engineering path of the model views used to specify a SIUS considering the Functional Viewpoint and the Logical Viewpoint. It describes the context of the model views, with the arrows indicating which model views are developed from which. Based on the definition of the logical SUS interfaces in model view "Logical Context" of the SUS (**a**: see *Figure 2129* in *chapter 8.3*) the model views "Logical Context" and "Functional Partitioning" of the corresponding SIUS are created. The model view "Functional Partitioning" in turn forms the basis for the creation of the model view "Functional Architecture" of the SIUS and the model view "Functional Partitioning" of the SUS (**b**: see *Figure 2129* in *chapter 8.3*). Subsequently, the model views "Information Flow" and "Functional Entity" are created.

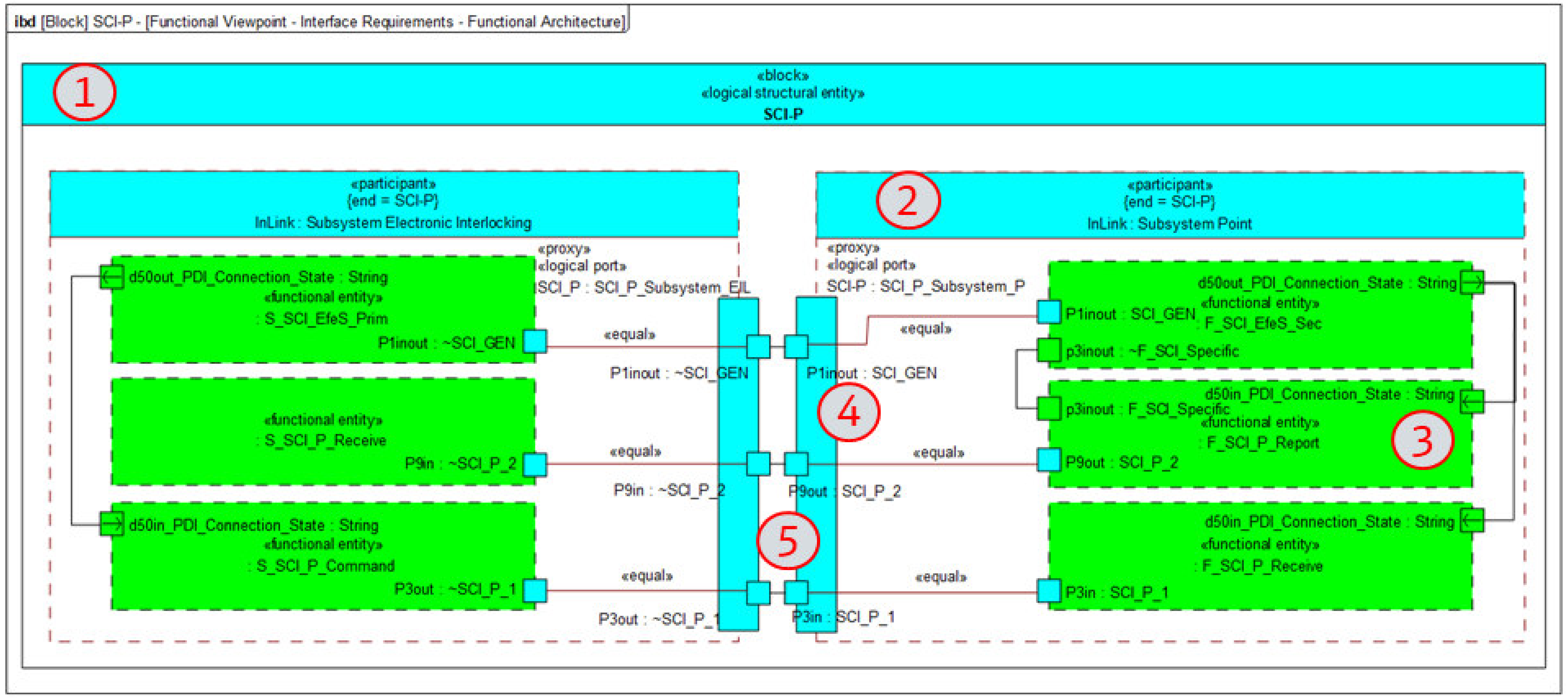
ID	Type	Requirements
Eu.ModSt.2244	Info	Figure 2244 Engineering path to specify a EULYNX interface 

ID	Type	Requirements
Eu.ModSt.7229	Head	**8.4.1 Model view "Logical Context" of a SIUS (AL1) - Description**
Eu.ModSt.7230	Info	The model view "Logical Context" as shown in *Figure 7231* describes the logical view of an interface at the upper level of abstraction. In contrast to the logical context of a SUS in which the logical interfaces are also defined in terms of their number, an interface in its logical context is regarded as a one-to-one relationship.
Eu.ModSt.7233	Info	An interface **(1)** is generally defined as a unique connection between two communication participants **(5)**. From the logical viewpoint at the upper level of abstraction an interface is represented by a SysML association **(1)**. An association is depicted as a continuous line between the communication participants. It also represents the possible interaction directions of the interface. No arrow heads means that the interaction is bidirectional. An arrow head on the other hand indicates that an interaction is only possible in the direction of the arrow. It represents the requirement that the two communication participants must be able to interact with each other.
Eu.ModSt.7235	Info	The logical interface represented by an association **(1)** is linked to a SysML association block **(3)**, which serves to refine the relationship. The global behaviour of the application protocol (Railway Control Protocol: RCP) is then specified in this later in the model view "Functional Architecture".
Eu.ModSt.7237	Info	A defined set of information objects (information flow) is transmitted via the interface in a precisely defined temporal sequence (protocol) in many cases. An information flow and the corresponding definition of the temporal sequence can apply to different interfaces. These two properties of an interface are called interface kind **(4)**. The interface kind is mapped at the association ends in the form of roles **(4)**. This separation of interface and interface kind makes it possible to communicate in the same way via several different "unique relationships = interfaces". The interface kind represents the requirement that it is to be applied to a specific interface.
Eu.ModSt.7239	Info	An interface is identified by a unique name **(2)** placed above or below the association **(1)** representing the interface.
Eu.ModSt.7240	Info	The black arrow shown in connection with the association indicates the reading direction. The directional arrow specifies the top-level navigation through the interface model to improve readability. It is taken into account when refining the model, for example when defining the conjugation of information flows. Beyond that, it has no meaning for the model.
Eu.ModSt.7241	Info	The interface name can be identical to the interface kind if it is certain that the interface kind is only applied to a specific interface and not to several different ones. If the interface name is the same as the interface kind, it may not be displayed.

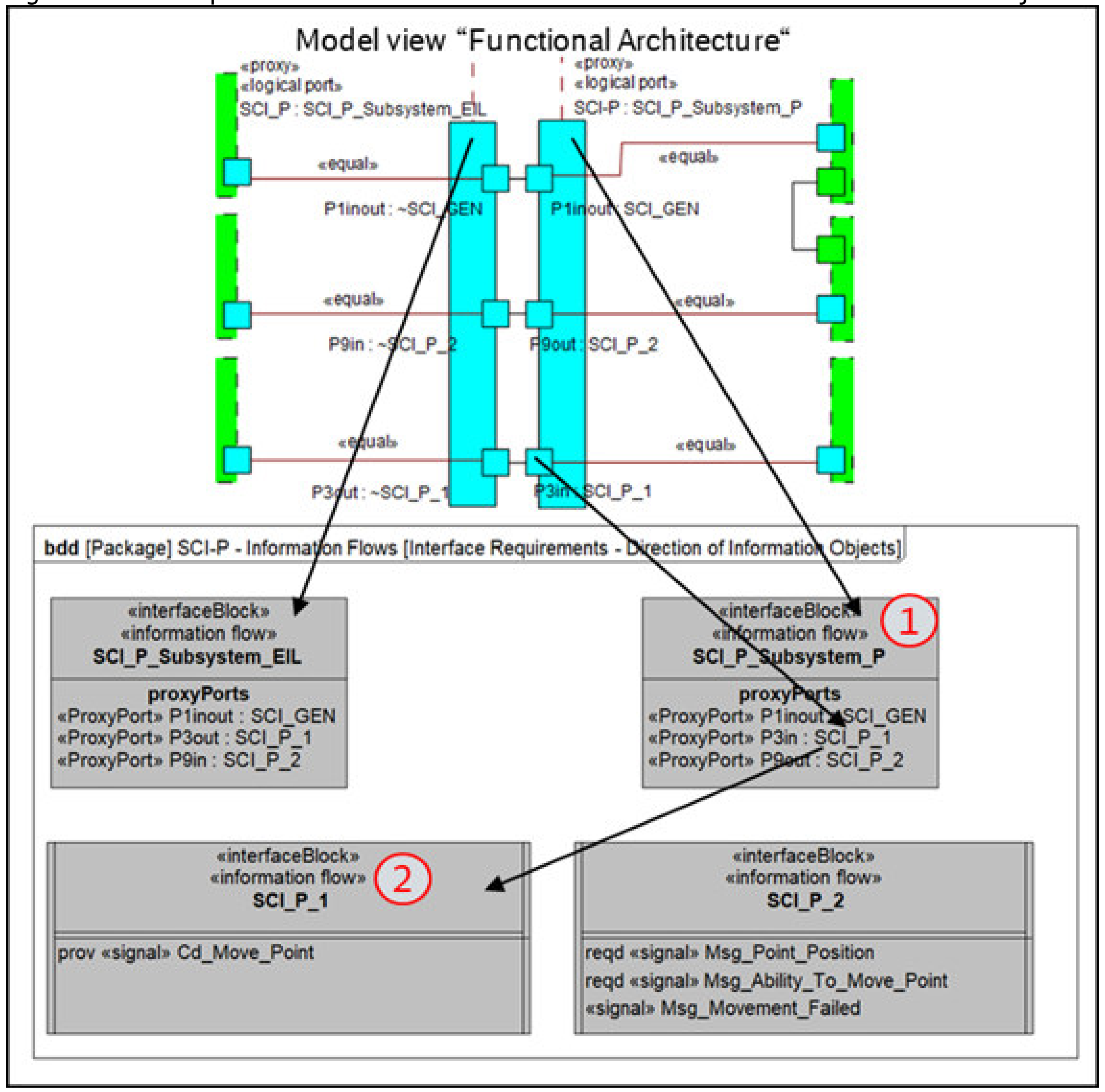
ID	Type	Requirements
Eu.ModSt.7231	Info	Figure 7231 Example of SIUS model view "Logical context" 
Eu.ModSt.1730	Head	**8.4.2 Model view "Logical Context" of a SIUS (AL1) - Modelling rules**
Eu.ModSt.1732	Head	**8.4.2.1 SysML diagram**
Eu.ModSt.1733	Info	**Block definition diagram (bdd):** depicts the view Technical Connection Domain Context.
Eu.ModSt.1734	Info	**Diagram heading:** *bdd[Package]<><Interface name><>-<>Logical Context<>[Logical Viewpoint<>-<>Interface Definition].*
Eu.ModSt.1735	Info	**Example:** bdd SCI-P - Logical Context [Logical Viewpoint - Interface Definition]
Eu.ModSt.7238	Head	**8.4.2.2 Model elements**
Eu.ModSt.7784		**Block:** Modular unit of structure in SysML that is used to define the LSE representing the communication participants that is, the communicating subsystems **(5)**.
Eu.ModSt.1364	Info	**Association block (3):** an association block is a combination of an association and a block, so it can relate two blocks together but can also have internal structure and other features. The internal structure can be used to decompose the connector that is typed by the association block. Association blocks are shown on block definition diagrams as an association path with a block symbol attached to it via a dashed line.
Eu.ModSt.7786	Head	**8.4.2.3 Bindings** (see *chapter 8.2.1*)
Eu.ModSt.7787	Info	**Diagram of model view "Logical Context"** has a "**Def**" binding.
Eu.ModSt.2260	Head	**8.4.3 Model view "Functional Partitioning" of a SIUS (AL2) - Description**
Eu.ModSt.2261	Info	The model view "Functional Partitioning" as shown in *Figure 2262* describes the refinement of the interface defined in model view "Logical Context" using Functional Entities. These Functional Entities specify the local behaviours of the communication protocol stack scaled-down to the application layer (PDI: Process Data Interface Protocol) at each side of the communicating system elements.
Eu.ModSt.2264	Info	The specific **(2)** and generic **(1)** local behavioural parts of the application protocol defined by FEs are referenced by the communication partners via SysML reference associations **(4)**. Reference associations are marked with a white diamond and express that the FEs are not part of the subsystems, but are only used there. They are part of the PDI.
Eu.ModSt.7904	Info	The FEs are used in the model view "Functional Architecture" to specify the global behaviour of the application protocol represented by the internal structure of the association block **(3)** associated with the association representing the interface.

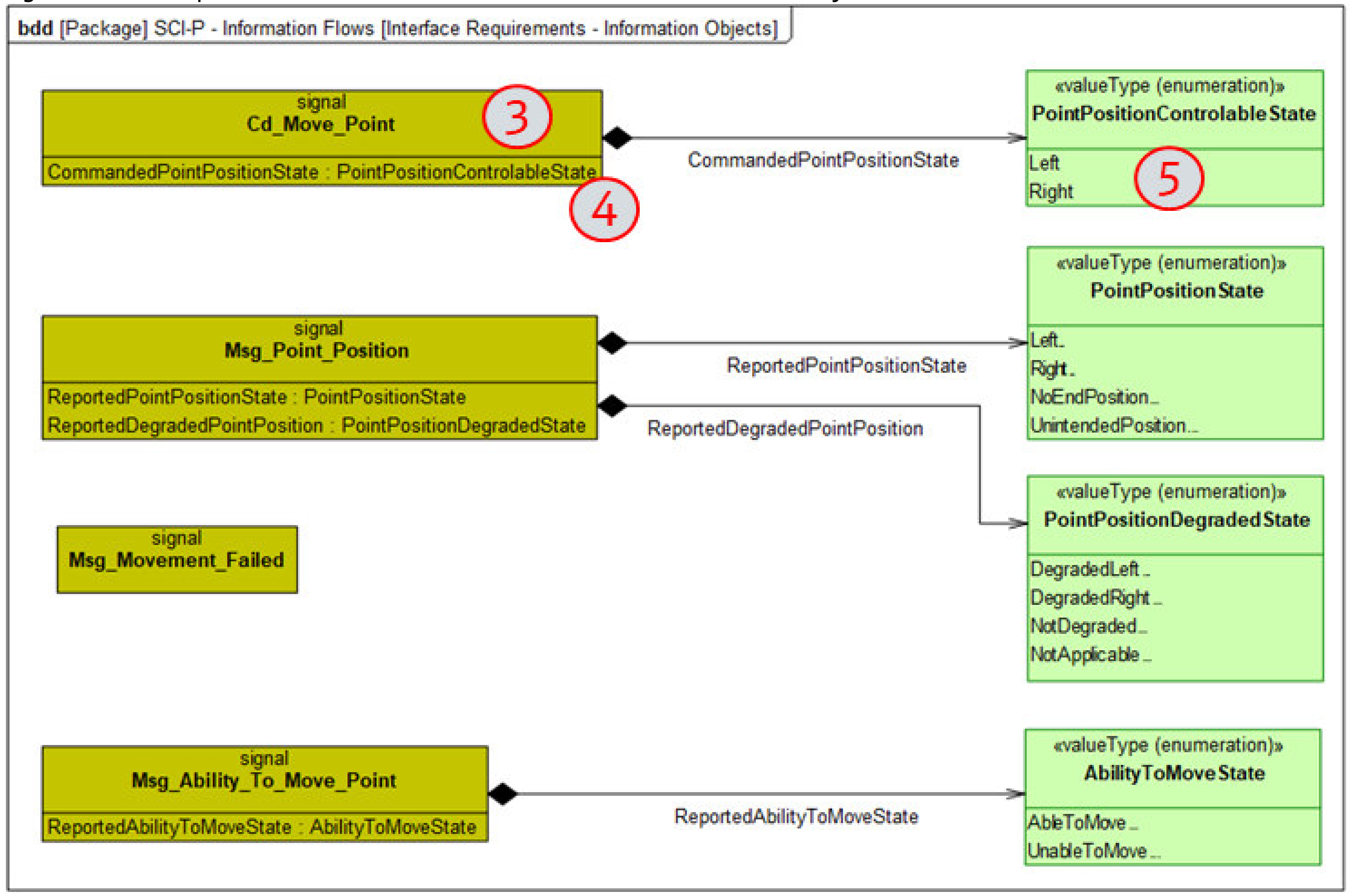
ID	Type	Requirements
Eu.ModSt.2262	Info	Figure 2262 Example of SIUS model view "Functional Partitioning" 
Eu.ModSt.1359	Head	**8.4.4 Model view "Functional Partitioning" of a SIUS (AL2) - Modelling rules**
Eu.ModSt.1361	Head	**8.4.4.1 SysML diagram**
Eu.ModSt.1362	Info	**Block Definition Diagram (bdd):** depicts the model view "Functional Partitioning".
Eu.ModSt.1405	Info	**Diagram heading:** *bdd[Package]<><Interface name><>-<>Functional Partitioning<>[Functional Viewpoint<>-<>Interface Requirements]*
Eu.ModSt.1406	Info	**Example:** bdd SCI-P - Functional Partitioning [Functional Viewpoint - Interface Requirements]
Eu.ModSt.1363	Head	**8.4.4.2 Model elements**
Eu.ModSt.1407	Info	*Remains free for the time being.*
Eu.ModSt.7796	Head	**8.4.4.3 Bindings** (see *chapter 8.2.1*)
Eu.ModSt.7797	Info	**Diagram of model view "Functional Partitioning"** has a "**Def**" binding.
Eu.ModSt.2265	Head	**8.4.5 Model view "Functional Architecture" of a SIUS (AL2) - Description**
Eu.ModSt.2266	Info	The model view "Functional Architecture" as shown in *Figure 2267* defines the global behaviour of the application protocol. The global behaviour is described by connecting the local behavioural components referenced by a communication partner with the corresponding ones of the neighbour via communication channels.

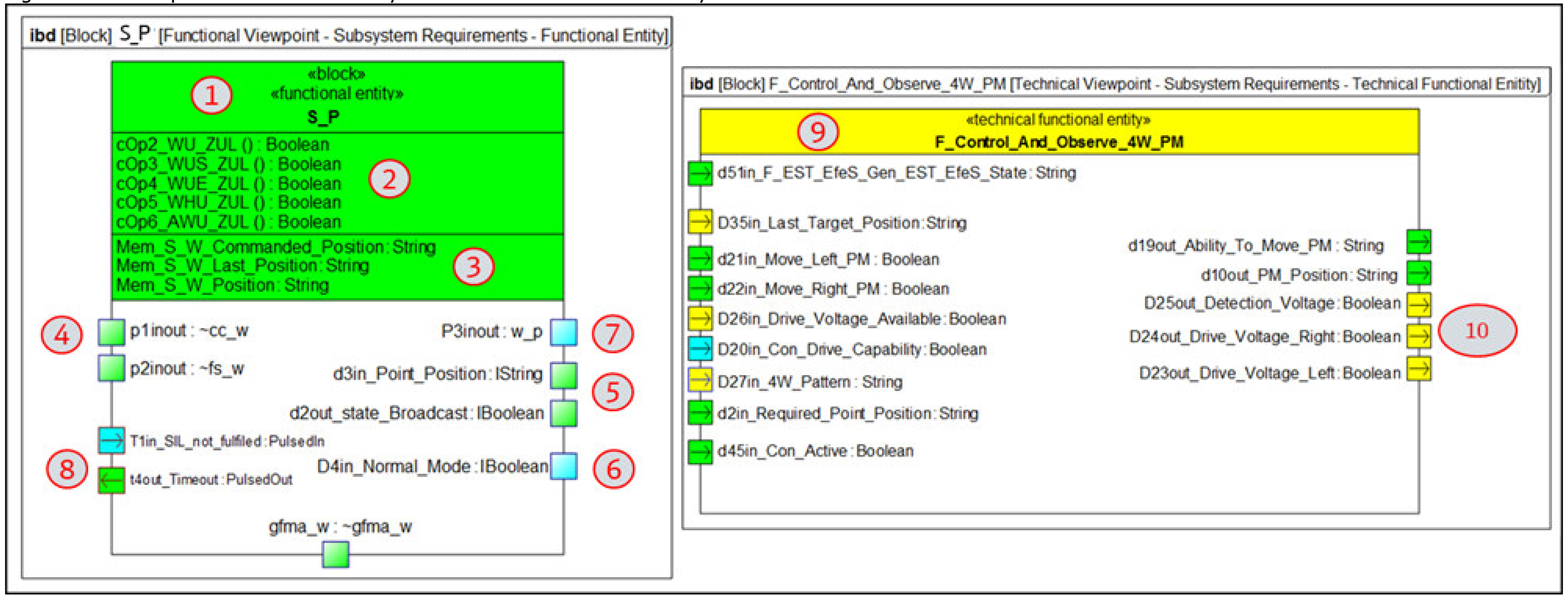
ID	Type	Requirements
Eu.ModSt.2269	Info	The description of the global behaviour of the application protocol is done by the internal structuring of the association block **(1)** defined in the model view "Functional Partitioning". In this process, the communication partners **(2)**, which in turn reference the local behavioural parts of the protocol represented by FEs **(3)**, are referenced in the form of SysML participant properties and connected via their logical SUS interfaces **(4)** with connectors **(5)**.
Eu.ModSt.2267	Info	Figure 2267 Example of SIUS model view "Functional Architecture"



Eu.ModSt.7203	Head	**8.4.6 Model view "Functional Architecture" of a SIUS (AL2) - Modelling rules**
Eu.ModSt.1370	Head	**8.4.6.1 SysML diagram**
Eu.ModSt.1371	Info	**Internal Block Diagram (ibd):** depicts model view "Functional Architecture".
Eu.ModSt.1410	Info	**Diagram heading:** *ibd[Block]<><Interface name><>[Functional Viewpoint<>-<>Interface Requirements<>-<>Functional Architecture]*
Eu.ModSt.1411	Info	**Example:** ibd[Block] SCI-P [Functional Viewpoint - Interface Requirements - Functional Architecture]
Eu.ModSt.1372	Head	**8.4.6.2 Model elements**
Eu.ModSt.1963	Info	**Paricipant property:** Participant properties are placeholders that represent the blocks at the end of an association block, and are used when it is desired to decompose a connector. A participant property is depicted as a dashed box, like a reference property, but distinguished from other properties by the keyword <<participant>>.
Eu.ModSt.7802	Head	**8.4.6.3 Bindings** (see *chapter 8.2.1*)
Eu.ModSt.7803	Info	**Diagram of model view "Functional Architecture"** has a "**Def**" binding.
Eu.ModSt.7909	Info	**Ports** have a "**Def**" binding.
Eu.ModSt.2270	Head	**8.4.7 Model view "Information Flow" of a SIUS (AL2) - Description**
Eu.ModSt.2271	Info	The model view "Information Flow" describes the information objects to be exchanged via an interface. It consists of the two sub-model views "Direction of Information Objects" and "Information Objects", which are shown in *Figure 7774* and *Figure 2272* respectively.

ID	Type	Requirements
Eu.ModSt.7807	Info	As shown in *Figure 7774*, the SUS interfaces such as SCI_P are depicted by proxy ports. These are typified with interface blocks such as SCI_P_Subsystem_P **(1)**, which represent information flows in the form of embedded proxy ports such as P10inout. The embedded proxy ports are typed with interface blocks **(2)**, which in turn contain the information objects (e.g. Cd_Move_Point).
Eu.ModSt.7774	Info	Figure 7774 Example of SIUS model view "Information flow" - Direction of Information Objects 
Eu.ModSt.1376	Info	As shown in *Figure 2272*, the information objects are represented by SysML signals such as "Cd_Move_Point" **(3)**. These signals can in turn have attributes such as "CommandedPointPositionState" **(4)** that represent parameters of the information objects. The attributes are typed with basic data types or for example enumerations such as "PointPositionControlableState" **(5)**.

ID	Type	Requirements
Eu.ModSt.2272	Info	Figure 2272 Example of SIUS model view "Information flow" - Information Objects 
Eu.ModSt.7842	Info	**Please note:** These model views can also be used in an adapted form to define the information flows for internal couplings between FEs or TFEs in a Functional Architecture or Technical Functional Architecture.
Eu.ModSt.7206	Head	**8.4.8 Model view "Information Flow" of a SUS - Modelling Rules**
Eu.ModSt.1379	Head	**8.4.8.1 SysML diagram**
Eu.ModSt.1380	Info	**Block Definition Diagram (bdd):** depicts the sub-model views "Direction of Information Objects" and "Information Objects" of model view "Information Flow".
Eu.ModSt.1414	Info	**Diagram heading (sub-model view "Direction of Information Objects"):** *bdd[Package]<><Interface name><>-<><Information Flows><>[Interface Requirements<>-<>Direction of Information Objects*
Eu.ModSt.1378	Info	**Diagram heading (sub-model view "Information Objects"):** *bdd[Package]<><Interface name><>-<><Information Flows><>[Interface Requirements<>-<>Information Objects*
Eu.ModSt.1417	Info	**Example:** bdd[Package] SCI-P - Information Flows [Interface Requirements - Direction of Information Objects] bdd[Package] SCI-P - Information Flows [Interface Requirements - Information Objects]
Eu.ModSt.1381	Head	**8.4.8.2 Model elements**
Eu.ModSt.1416	Info	*Remains free for the time being.*
Eu.ModSt.7099	Head	**8.4.8.3 Bindings** (see *chapter 8.2.1*)
Eu.ModSt.7106	Info	**Diagram of model view "Information Flows - Direction of Information Objects"** has a "**Def**" binding.
Eu.ModSt.7100	Info	**Diagram of model view "Information Flows - Information Objects"** has a "**Def**" binding.

ID	Type	Requirements
Eu.ModSt.7107	Info	**Information Objects (Signals)** have a "**Def**" binding if they are further specified in a refined model view or in the form of a separate requirement.
Eu.ModSt.7905	Info	**Information Objects (Signals)** have a "**Req**" binding if they are not further specified in a refined model view or in the form of a separate requirement.
Eu.ModSt.1249	Head	**8.5 Model views "Functional Entity" and "Technical Functional Entity" - Description**
Eu.ModSt.7487	Info	Within the EULYNX approach to specify model-based requirements the concept of Functional Entity (FE) and Technical Functional Entity (TFE) is used.
Eu.ModSt.7488	Info	FE and TFE represent behavioural entities and encapsulate a subset of the functional requirements of a SUS or SIUS in the form of stimulus-response behaviour independent of any architectural constraints. While FEs define technology-independent functional requirements, TFEs describe technology-dependent ones.
Eu.ModSt.7489	Info	**Please note:** FEs and TFEs are not to be interpreted as elements of the hardware- or software architecture.
Eu.ModSt.7490	Info	The stimulus-response behaviour of FEs and TFEs is defined by SysML state machines (see *chapter 8.6.6*).
Eu.ModSt.7491	Info	The principle structure of a Functional Entity and a Technical Functional Entity is shown in *Figure 7492.*
Eu.ModSt.7492	Info	Figure 7492 Example of a Functional Entity and a Technical Functional Entity 
Eu.ModSt.7493	Info	Apart from state machines, FEs and TFEs may own • SysML block properties **(3)**, • SysML block operations **(2),** • SysML proxy ports used as atomic "in ports" and "out ports" **(5, 6)** or typed with an interface block in which the information objects to be exchanged via the port are defined **(4, 7)**, • SysML flow ports used as atomic "in ports" and "out ports" **(8, 10)**.
Eu.ModSt.7494	Info	The description of a FE **(1)** contains the stereotype <<functional entity>> as well as the FE name (e.g. S_W).
Eu.ModSt.7495	Info	The description of a TFE **(9)** contains the stereotype <<technical functional entity>> as well as the TFE name (e.g. F_Control_And_Observe_4W_PM).
Eu.ModSt.7808	Head	**8.6 Model views "Functional Entity" and "Technical Functional Entity" - Modelling rules**
Eu.ModSt.7829	Info	The numbers **(2)** to **(10)** added in the following descriptions refer to Figure 7492.
Eu.ModSt.7809	Head	**8.6.1 SysML Diagram**
Eu.ModSt.7815	Info	**Internal Block Diagram (ibd):** depicts model views "Functional Entity" and "Technical Functional entity".

ID	Type	Requirements
Eu.ModSt.7816	Info	**Diagram heading - FE:** *ibd[Block]<><FE_TFE block signature><>[Functional Viewpoint<>-<>Subsystem Requirements<>-<>Functional Entity*]
Eu.ModSt.7817	Info	**Diagram heading - TFE:** *ibd[Block]<><FE_TFE block signature><>[Functional Viewpoint<>-<>Subsystem Requirements<>-<>Technical Functional Entity*]
Eu.ModSt.7818	Info	**Example:** ibd[Block] S_Point [Functional Viewpoint - Subsystem Requirements - Functional Entity] ibd[Block] F_Control_And_Observe_4W_PM [Functional Viewpoint - Subsystem Requirements - Technical Functional Entity]
Eu.ModSt.7819	Head	**8.6.2 Block**
Eu.ModSt.7820	Info	**Block:** Modular unit of structure in SysML that is used to define a FE or TFE
Eu.ModSt.7821		**Block name:** *<FE_TFE block signature>*
Eu.ModSt.7822	Info	**Example:** S_P F_Control_And_Observe_4W_PM
Eu.ModSt.906	Info	**<FE_TFE block signature> :=** <Layer of LA modelling pattern >_ <Name of functionality>_<Operational entity>
Eu.ModSt.911	Info	**<Layer of LA modelling pattern>** := C | S | F | "" **C**: Command control layer, **S**: Safety layer, **F**: Field layer "": if no layer is applicable See *chapter 8.2.2*
Eu.ModSt.916	Info	**<Name of functionality>** := 1) | 2) | 3) | 4) | 5) | 6) 1) FE/TFE specifies the essential states of an operational entity (operating modes): **EST** 2) FE/TFE specifies the behaviour of an operational entity: **<description of the functionality>** (example: Control_And_Observe_4W_PM) 3) FE/TFE specifies local behaviour of the application protocol layer (RCP) assigned to a certain operational entity (see *chapter 8.2.4*): **<Interface name>** (example: SCI_P) or **<Interface name>_<description of the functionality>** (example: SCI_P_Report_Status) 4) FE/TFE specifies generic local behaviour of the application protocol layer (RCP): **<Abbr. Type of interface>_Gen (** example: SCI_Gen) **<Abbr. Type of interface>_<description of the functionality>_Gen** (example: SCI_Check_Version_Gen) 5) FE/TFE specifies generic local behaviour of the application protocol layer (RCP) assigned to a certain group of operational entities: **<Abbr. Type of interface>_<Operational entity_Operational entity_..._Operational entity>_Gen** (example: SCI_LS_P_Gen) or **<Abbr. Type of interface>_<Operational entity_Operational entity_..._Operational entity>_<description of the functionality>_Gen** (example: SCI_LS_P_Check_Version_Gen) 6) FE/TFE specifies generic local behaviour of the application protocol layer (RCP) assigned to a certain group of operational entities using a common designator: **<Abbr. Type of interface>_<group designator>_Gen (** example: SCI_EfeS_Gen) or **<Abbr. Type of interface>_<group designator>_<role of communication partner>** (SCI_EfeS_Prim) **<Abbr. Type of interface>_<group designator>_<description of the functionality>_Gen** (example: SCI_EfeS_Check_Version_Gen) **<Abbr. Type of interface>_<group designator>_<role of communication partner>_<description of the functionality>** (example: SCI_EfeS_Prim_Check_Version) **<group designator>** := Freely selectable common designator (example: FE for field elements) **<role of communication partner>** := freely selectable designator such as Prim (Primary) and Sec (Secondary)
Eu.ModSt.966	Info	**<Operational entity>** := 1) | 2) | 3) | 4) | 5) 1) FE/TFE specifies the behaviour or the essential states of an operational entity: Name of the operational entity (vertical slice of the LA modelling pattern) Examples: LS, P, SOR (start of route), EOR (end of route) 2) FE/TFE specifies generic behaviour or the essential states of an operational entity: **Gen** 3) FE/TFE specifies generic behaviour or the essential states assigned to a certain group of operational entities: **<Operational entity_Operational entity_..._Operational entity>_Gen** (example: LS_P_Gen) 4) FE/TFE specifies generic behaviour or the essential states assigned to a certain group of operational entities using a common designator: **<group designator>_Gen** (example: EfeS_Gen) **<group designator>** := Freely selectable common designator (example: FE for field elements) 5) FE/TFE specifies the local behaviour of the application protocol layer (RCP): no operational entity
Eu.ModSt.7810	Head	**8.6.3 Model elements - Block properties**

<table>
<tr><th>ID</th><th>Type</th><th>Requirements</th></tr>
<tr><td>Eu.ModSt.7497</td><td>Info</td><td>Block properties (3) are to be interpreted in the sense of variables or constants that store values. They are prefixed with "Mem".
Examples: Mem_last_Target_Requested, Mem_Current_Point_Position.</td></tr>
<tr><td>Eu.ModSt.534</td><td>Info</td><td>Block properties are to be typed using the defined SySim value types.</td></tr>
<tr><td>Eu.ModSt.533</td><td>Info</td><td>All SysML block properties have to be initialised. The initialisation must be carried out in an init-operation using ASAL. This SysML block operation is systematically named cOp1_init().</td></tr>
<tr><td>Eu.ModSt.7498</td><td>Info</td><td>The initialisation can be carried out in the body of the init-block operation systematically named cOp1_init(). Alternatively it can be carried out directly in the transition effect of the transition outgoing from initial state of the state machine.
Example:
Mem_S_W_Position := "";
Mem_SW_Last_Position := "";
The assignments of values to the corresponding block properties are to be interpreted as definitions. They become mandatory requirements (binding character "Req") when they are used in a mandatory requirement, such as a transition of a state.</td></tr>
<tr><td>Eu.ModSt.536</td><td>Info</td><td>Some reasons to use SysML block properties are given below. This is expressed by means of corresponding naming conventions:</td></tr>
<tr><td>Eu.ModSt.539</td><td>Info</td><td>Defining configuration data: Con_data-name (e.g. Con_t_ini_max)</td></tr>
<tr><td>Eu.ModSt.540</td><td>Info</td><td><blockpropertyname> ::= <Con><mark><propertyinformation>
<propertyinformation>::= <alphaNum><remaininginformation>
<remaininginformation> ::= „“ | <alphaNum><remaininginformation>
<Con>::= Con
<alphaNum> ::= A | B | … | Z | a | b | … | _ | 0 | … | 9
<mark>::= _</td></tr>
<tr><td>Eu.ModSt.897</td><td>Info</td><td>Defining site data: Site_data-name</td></tr>
<tr><td>Eu.ModSt.898</td><td>Info</td><td><blockpropertyname> ::= <Site><mark><propertyinformation>
<propertyinformation>::= <alphaNum><remaininginformation>
<remaininginformation> ::= „“|<alphaNum><remaininginformation>
<Site>::= Site
<alphaNum> ::= A | B | … | Z | a | b | … | _ | 0 | … | 9
<mark>::= _</td></tr>
<tr><td>Eu.ModSt.537</td><td>Info</td><td>Caching a value (except the value of a port): Mem_value-identifier (e.g. Mem_signal_aspect_to_be_indicated)</td></tr>
<tr><td>Eu.ModSt.541</td><td>Info</td><td>Caching the value of a port: Mem_port-name (e.g. Mem_T6_Msg_defective)</td></tr>
<tr><td>Eu.ModSt.542</td><td>Info</td><td><blockpropertyname> ::= <Mem><mark><port-name>
<Mem>::= Mem
<mark>::= _</td></tr>
<tr><td>Eu.ModSt.538</td><td>Info</td><td><blockpropertyname> ::= <Mem><mark><propertyinformation>
<propertyinformation>::= <alphaNum><remaininginformation>
<remaininginformation> ::= „“ | <alphaNum><remaininginformation>
<Mem>::= Mem
<alphaNum> ::= A | B | … | Z | a | b | … | _ | 0 | … | 9
<mark>::= _</td></tr>
<tr><td>Eu.ModSt.7813</td><td>Head</td><td>8.6.4 Model elements - Block operations</td></tr>
<tr><td>Eu.ModSt.7500</td><td>Info</td><td>Block operations (2) are used in order to specify
• internal broadcast events or
• algorithms of data transformations defined in the operation body (call behaviour, time advance behaviour).</td></tr>
<tr><td>Eu.ModSt.7951</td><td>Info</td><td>The content of an operation defined in the operation body shall always be displayed in the requirements management tool in "Requirements Part 1" and the name of the operation must be noted above it as a comment. The actual name of the operation, which comes from the model element, shall then be displayed in "Requirements Part 2".</td></tr>
<tr><td>Eu.ModSt.1011</td><td>Info</td><td>8.6.4.1 Internal broadcast events</td></tr>
<tr><td>Eu.ModSt.545</td><td>Info</td><td>Internal broadcast events are supposed to submit broadcasts within the state machine of a FE/TFE.</td></tr>
</table>

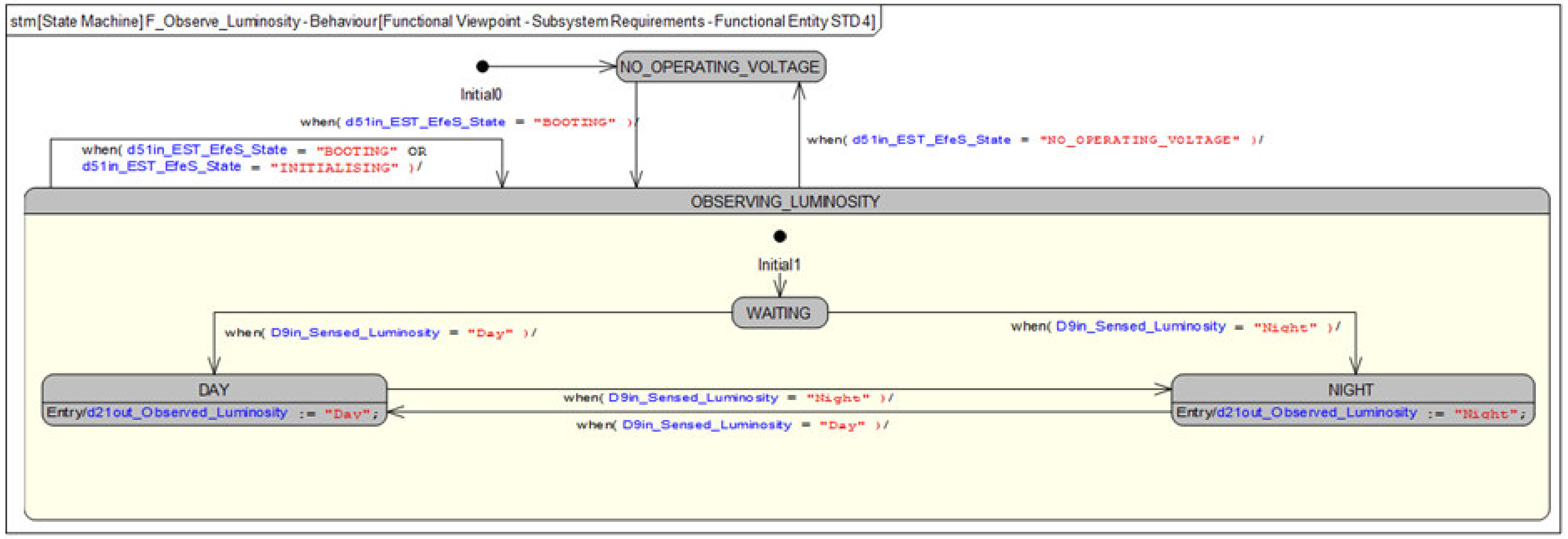
ID	Type	Requirements
Eu.ModSt.550	Info	**Naming of internal broadcast events** bc<Id>_<broadcast information>, Example: bc1_indicate_signal_aspect.
Eu.ModSt.969	Info	**Id:** Natural number starting with 1
Eu.ModSt.548	Head	**8.6.4.2 Definition of algorithms for data transformation**
Eu.ModSt.549	Info	There are two types of behaviour that can be defined by means of SysML block operations: • **call behaviour** and • **time advance behaviour**.
Eu.ModSt.7823	Head	**8.6.4.2.1 Call behaviour**
Eu.ModSt.7502	Info	Block operations used to define call behaviour are prefixed with cOp<Id> where "Id" is a natural number starting with 1.
Eu.ModSt.7504	Info	Call operations are used as • boolean expressions or parts of it in change events: e.g. when(cOp3_No_End_Position)/ • transition guards: e.g. when(cOp5_Trailed)[cOp7_Is_Trailable]/ • transition effects: e.g after(D5in_Con_tmax_Point_Operation/cOp12_Timeout();

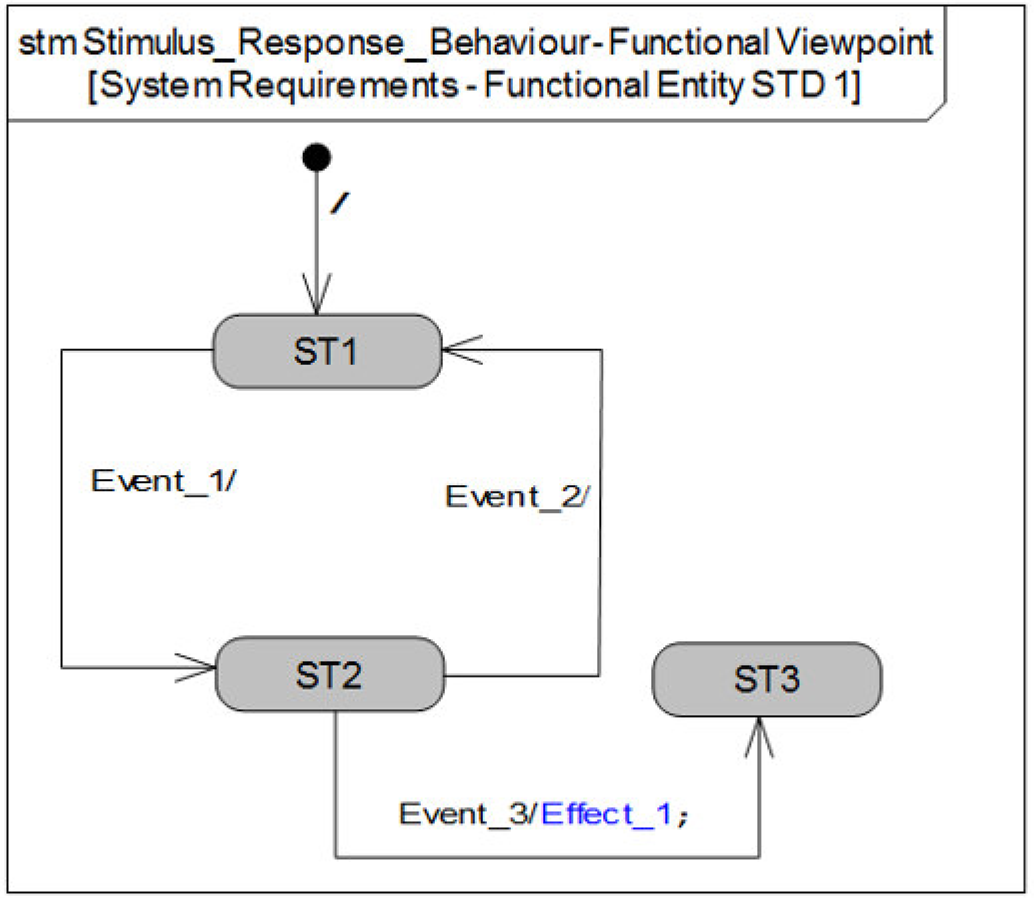
Eu.ModSt.7503	Info	Call behaviour is invoked on demand, executed and terminated after execution. It is supposed to define event-driven data transformations. The algorithm of the data transformations is described in the body of the corresponding block operation using the Atego Structured Action Language (see *chapter 8.6.7*).
		
		Example: cOp2_All_Left
		if cOp8_Supports_Multiple_PMs() then
		    return (
		       (D21in_PM1_Position = "LEFT") and
		       (D22in_PM2_Position = "LEFT" or D13in_PM2_Activation= "INACTIVE")
		                    );
		else
		    return D21in_PM1_Position = "LEFT";
		end if

Eu.ModSt.7505	Info	The call operation to initialise the block properties and Out Ports of a FE is named cOp1_init() systematically.
Eu.ModSt.7506	Info	Call operations are to be interpreted as definitions. They become mandatory requirements (binding character "Req") when they are used in a mandatory requirement, such as a transition of a state.
Eu.ModSt.1014	Head	**8.6.4.2.2 Time advance behaviour**
Eu.ModSt.1015	Info	Time advance behaviour is invoked once during system activation and executes continuously. It is supposed to define continuous data transformation. The algorithm of the data transformations is to be described in the ***body*** of the corresponding block operation using the Atego Structured Action Language (see *chapter 8.6.8*).
Eu.ModSt.553	Info	**Naming of time advance behaviour** tOp<Id>_<behaviour name> Example: tOp1_indicate_availability_ratio
Eu.ModSt.1017	Info	**Id:** Natural number starting with 1
Eu.ModSt.7814	Head	**8.6.5 Model elements - Ports**
Eu.ModSt.7507	Head	**8.6.5.1 Atomic SysML in ports and out ports**
Eu.ModSt.7508	Info	A FE features interfaces that define the stimuli consumed by the assigned state machine, represented by atomic in ports, and responses generated by the assigned state machine, represented by atomic out ports.
Eu.ModSt.7509	Info	In ports and out ports are specified as SysML proxy ports or SysML flow ports of the SysML block representing the FE/TFE depicted in an internal block diagram (ibd).

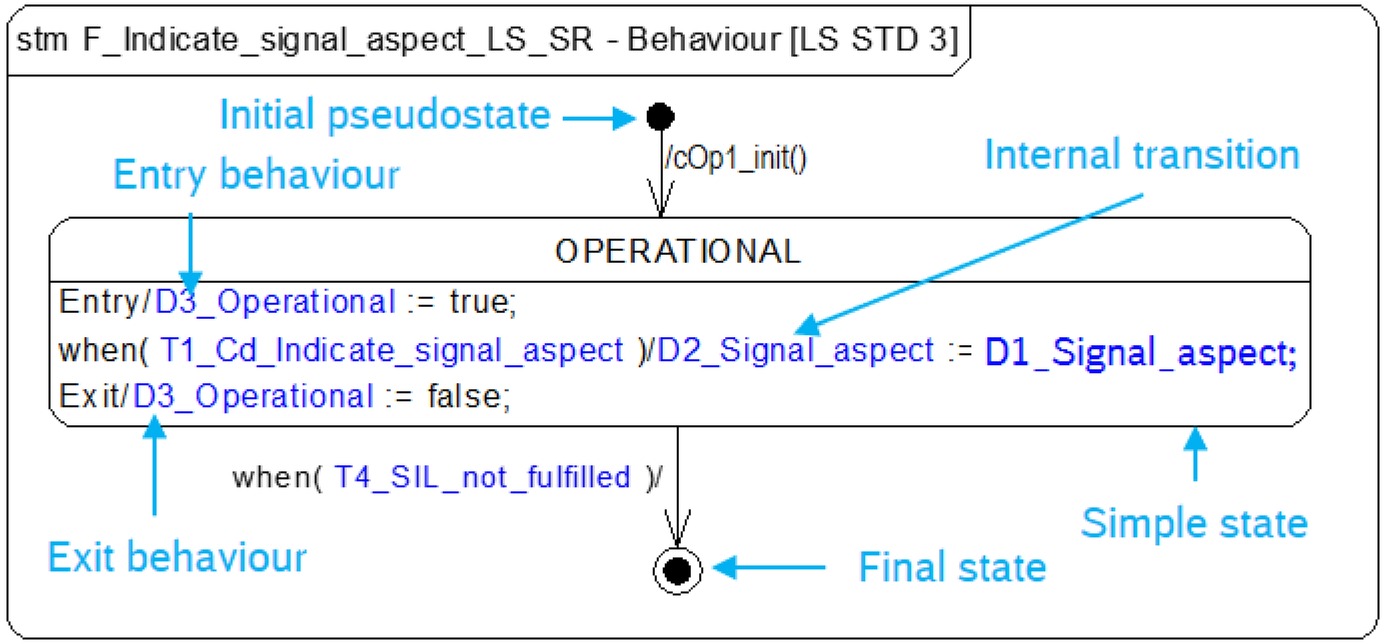
ID	Type	Requirements
Eu.ModSt.7510	Info	In ports and out ports are described according to the port definition schema below: *<Port information type><PNo><Port direction>_<Port information>:<Data type>.*
Eu.ModSt.7511	Info	**Port information type** Used port information type: • **D** or **d**: data ports (D-Ports), • **T** or **t**: trigger ports (T-Ports).
Eu.ModSt.7512	Info	Data ports and trigger ports start with a small letter (such as d3in_Point_Position or t4out_Timeout) if they are part of an internal connection between two FEs or between a FE and a TFE. In this case they are referred to as **functional ports** and have the colour green like the corresponding F E **(5)**.
Eu.ModSt.7513	Info	**Data ports** and **trigger ports** start with a capital letter if they are part of an external connection between a FE and the system environment (system interface) or if it is an open port (such as D4in_ Normal_Mode or T1in_SIL_not_fulfiled). In this case they are refered to as **logical ports** and have the colour blue **(6)**.
Eu.ModSt.7514	Info	Data ports and trigger ports which are part of a connection between TFEs or a TFE and the system environment (technical system interface) are referred to as **technical functional ports** and have the colour Yellow **(10)**. They start with a small letter if they are part of an internal connection between two TFEs and with a capital letter if they are part of an external connection between a TFE and the system environment (technical system interface).
Eu.ModSt.7515	Info	**Data ports (5), (6)** Data ports are especially suited to indicate permanently available information. The value of a D-port only changes if it is explicitly changed.
Eu.ModSt.7516	Info	Data in ports are used as arguments of Boolean expressions in change events or transition guards. They may represent arguments in data transformations or other data, that need to be permanently reachable by the behaviour of a FE (e.g configuration data: d21in_Con_Downgrade_Most_Restrict). Their values can be permanently regarded as valid.
Eu.ModSt.7517	Info	Data out ports are used to provide continuous data created within a FE for its environment (e.g. to be available for adjacent FEs, reachable via their data in ports).
Eu.ModSt.7518	Info	**Trigger ports (8)** Trigger ports are especially suited to indicate singular events. They have a Boolean value that always enters false and only briefly changes to true when the event occurs (data types PulsedIn or PulsedOut). Afterwards the value is automatically returned to false.
Eu.ModSt.7519	Info	Trigger in ports are mainly used as arguments of Boolean expressions in change events.
Eu.ModSt.7520	Info	**Port number (PNo)** For each port of a FE/TFE with the port information type "D or d" or "T or t", a unique PNo is to be assigned in the format of a natural number. The ports need not be numbered consecutively. For example port numbers like 1, 2, 3, 4, 5 are possible, but also 1, 3, 6.
Eu.ModSt.7521	Info	**Port direction** The direction of the in Ports and out Ports are additionally defined, i.e. whether it is a stimulus or a response for the FE. • An "in" after the port number represents a stimulus or a permanently present value, • An "out" after the port number represents a response.
Eu.ModSt.7522	Info	**Port information** The port information defines the information type and the semantic meaning of the information to be transmitted, e.g. "Cd_Indicate_signal_aspect". *<Port information> := <Information type> _<Information>*
Eu.ModSt.7523	Info	**Information type:** Msg (message), Cd (command), Con (configuration data), Site (site data) or project-specifically determined information types.
Eu.ModSt.7524	Info	**Information:** semantic meaning of the information to be transmitted, e.g. Indicate_signal_aspect.
Eu.ModSt.7525	Info	**Data type** The data type which is assigned to any in port and out port is only shown on the diagram if it is necessary for a correct interpretation.

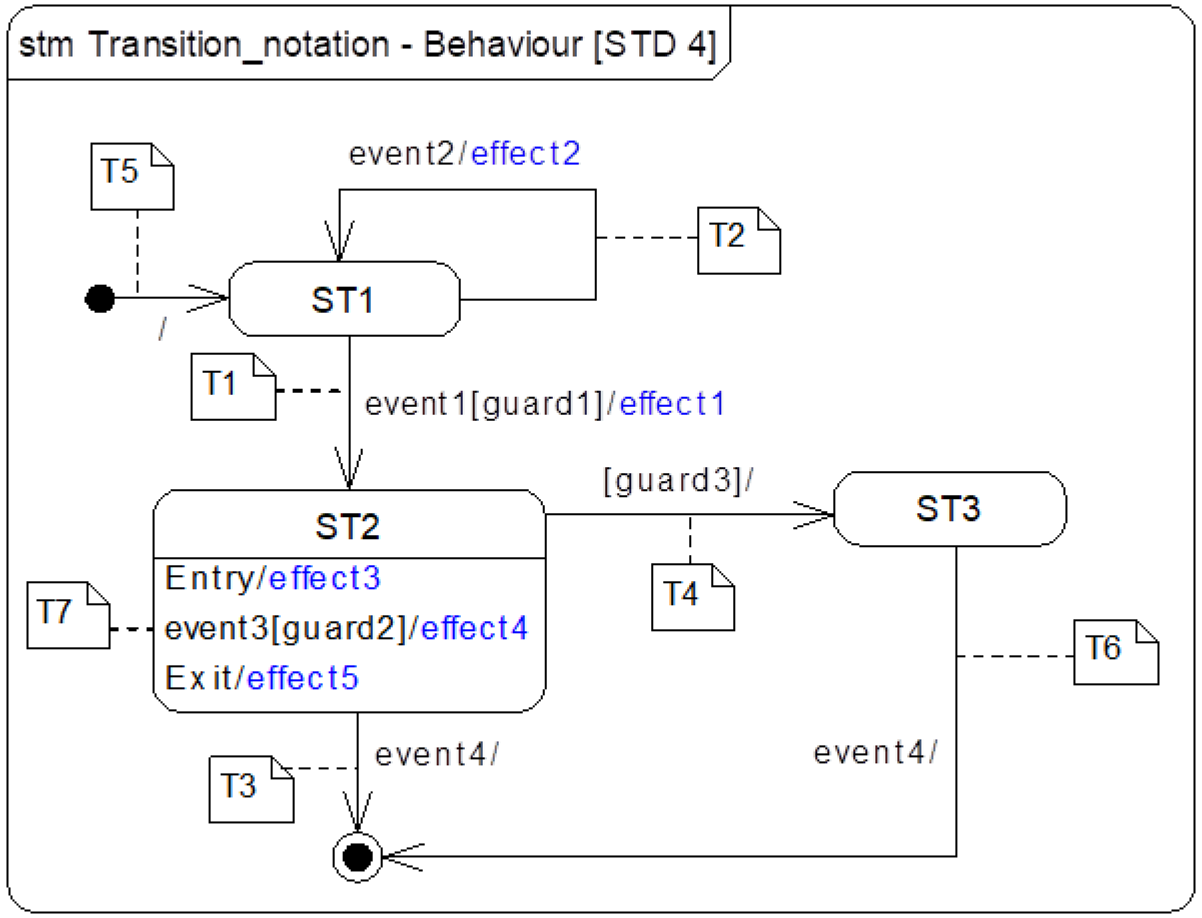
ID	Type	Requirements
Eu.ModSt.7526	Info	**Initialisation of out ports** All data out ports are initialised. The initialisation can be carried out in the body of the init-block operation systematically named cOp1_init(). Alternatively it can be carried out directly in the transition effect of the transition outgoing from initial state of the state machine. Trigger out ports are set to "FALSE" by default and are not explicitly initialised. Example: D25out_Redrive := FALSE; The assignments of values to the corresponding out ports are to be interpreted as definitions. They become mandatory requirements (binding character "Req") when they are used in a mandatory requirement, such as a transition of a state.
Eu.ModSt.7527	Head	**8.6.5.2 SysML proxy ports to describe a signal-based communication**
Eu.ModSt.7528	Info	A FE features interfaces that define event-driven in-flow of information consumed by the assigned state machine and event-driven out-flow of information generated by the assigned state machine.
Eu.ModSt.7529	Info	The information flows are represented by **SysML proxy ports** typed with **SysML interface blocks (4, 7)**.
Eu.ModSt.7530	Info	The information objects to be exchanged are represented by **signals**. The interface blocks define the **receptions** for these signals.
Eu.ModSt.7531	Info	When a signal is received, a signal event is triggered by the corresponding reception, which is then used as a trigger for a state transition, for example.
Eu.ModSt.7824	Info	Proxy ports to describe a signal-based information flow are described according to the port definition schema below: *<Port information type><PNo><Port direction>_<Port information>:<Signature of Interface block aggregating information objects>*.
Eu.ModSt.7825	Info	**Port information type** Used port information type: **P** or **p**
Eu.ModSt.7532	Info	Ports and their interface blocks are written in small letter (such as p1inout : ~cc_w) if they are part of an internal connection between two FEs. In this case they are referred to as **functional ports** and have the colour green like the corresponding FE **(4)**.
Eu.ModSt.7533	Info	Ports and their interface blocks are written in capital letters if they are part of an external connection (system interface) between a FE and the system environment (such as P3inout : W_P) or if they are open ports. In this case they are referred to as **logical ports** and have the colour blue **(7)**.
Eu.ModSt.7534	Info	Ports which are part of a connection between TFEs or a TFE and the system environment (technical system interface) are referred to as **technical ports** and have the colour yellow **(10)**. They start with a small letter if they are part of an internal connection between two TFEs and with a capital letter if they are part of an external connection between a TFE and the system environment (technical system interface) or if they are open ports.
Eu.ModSt.7535	Info	An information object defined as outgoing in the interface block (port type) becomes an incoming information object through conjugation. This conjugation is indicated by the character "~" preceding the corresponding interface block (example: p1inout : ~cc_w).
Eu.ModSt.7826	Info	**Port number (PNo)** For each port of a FE/TFE with the port information type "P or p", a unique PNo is to be assigned in the format of a natural number. The ports need not be numbered consecutively. For example port numbers like 1, 2, 3, 4, 5 are possible, but also 1, 3, 6.
Eu.ModSt.7827	Info	**Port direction** The direction of the ports are additionally defined ("in", "out", "inout").
Eu.ModSt.7828	Info	**Port information** Freely selectable and optional.
Eu.ModSt.7536	Info	**Signature of Interface block aggregating information objects** The information flow through a proxy port is represented by an interface block in which the receptions for the incoming and outgoing information objects are defined. The information objects are represented by signals. The use of interface blocks and signals is described in the *chapters 8.4.7* (Model view "Information Flow"), *8.6.6.9.4* (Signal event) and *8.6.6.10.1* (Event-driven responses using signals).
Eu.ModSt.7565	Head	**8.6.6 Model elements - state machines**
Eu.ModSt.7566	Info	In the following, the term "Functional Entity" and the corresponding abbreviation "FE" stand for both a FE and a TFE.
Eu.ModSt.7567	Info	A FE is always in a state that abstracts a combination of values given in the FE. Events arriving at the FE lead to reactions - depending on the state - that change values of SysML out ports or SysML block properties, invoke a local trigger or a call operation or send a signal via a port and result in new states.

ID	Type	Requirements
Eu.ModSt.7568	Info	The state machine diagrams (see *figure 7569*) are children of the state machine and illustrate its behaviour, i.e. they describe the stimulus-response behaviour of a FE. The state machine contains states and state transitions that are triggered by trigger in ports, data in ports, internal broadcast events, signal events as well as timing events. The state transitions represent the binding functional requirements of the system to be specified.
Eu.ModSt.7830	Info	**State Machine Diagram (STD):** defines the behaviour of a FE.
Eu.ModSt.7934	Info	For each STD, a description must be inserted in the modelling tool (e.g. Properties ->Text->Description) that corresponds to a defined schema: • The SUS or SIUS receives a stimulus and responds with the result to....
Eu.ModSt.7935	Info	A possible application of the schema is shown below using the example of the subsystem LS: Information: This state machine diagram describes the requirements for the following functionalities: • receives the observed Signal Aspect and reports this to the Subsystem - Electronic Interlocking • receives the observed intentionally dark state and reports this to the Subsystem - Electronic Interlocking • receives the observed Luminosity and reports this to the Subsystem - Electronic Interlocking
Eu.ModSt.7936	Info	The description is to be transferred to "Requirements Part 2" of the specification document generated in the requirements management tool.
Eu.ModSt.7832	Info	**Diagram heading:** *stm[State Machine]<><FE_TFE block signature><>[Functional Viewpoint<>-<>Subsystem Requirements or Interface Requirements<>-<>Functional Entity or Technical Functional Entity<>STD<DiaNo>]*
Eu.ModSt.1128	Info	**<DiaNo> :=** Natural number starting with 1
Eu.ModSt.7569	Info	Figure 7569 Example of a state machine diagram 
Eu.ModSt.7570	Head	**8.6.6.1 Region**
Eu.ModSt.7571	Info	Each state machine contains at least one region, which itself can contain a number of states and pseudostates, as well as the transitions between them. During execution of a state machine, each of its regions has a single active state that determines the transitions that are currently viable in that region. A region must have an initial pseudostate and can have a final state that correspond to its beginning and completion, respectively.
Eu.ModSt.7572	Info	If a state machine contains a single region, it is represented by the area inside the frame of the state machine diagram and it is not to be named. Multiple regions are named and shown separated by dashed lines. A state machine with multiple regions may describe some concurrent behaviour happening within the state machine's owning block.
Eu.ModSt.7573	Head	**8.6.6.2 State**
Eu.ModSt.7574	Info	The UML specification defines a state as „a situation during which some (usually implicit) invariant condition holds. The invariant may represent a static situation such as an object waiting for some external or internal event to occur". The „object", in the present case the FE, is waiting for a stimulus from its environment or for an internal stimulus such as a time event or a local trigger.
Eu.ModSt.7575	Info	Thus, a state represents a "between stimuli" condition of the external observable stimulus-response behaviour of a FE. In other words, it specifies the responses to incoming stimuli.

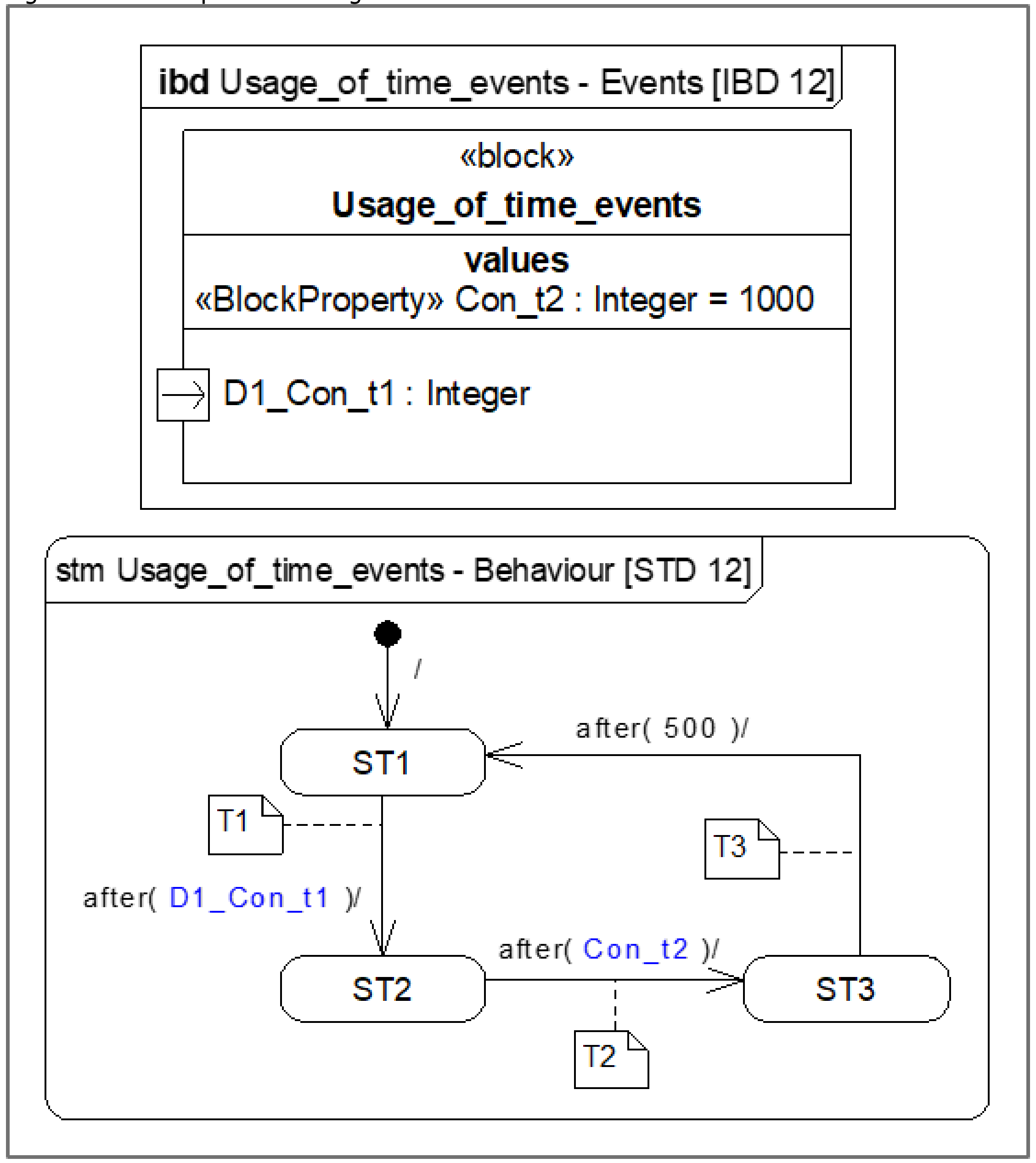
ID	Type	Requirements
Eu.ModSt.7576	Info	It is helpful to use the analogy that a block, i.e. the FE, is controlled by a switch. Each state corresponds to a switch position. The state machine defines all valid switch positions (i.e. states) and transitions between switch positions (i.e. state transitions). If there are multiple regions, each region is controlled by its own switch with its switch positions corresponding to its states. The switch positions can be specified by a form of truth table - similar to how logic gates can be specified - in which the current states and transitions define the next state.
Eu.ModSt.7577	Info	In the example depicted in *Figure 427*, the state ST2 represents a "between stimuli condition", i.e. it constitutes the precondition for triggering a response in the form of Effect_1. Following the analogy that the FE is controlled by a switch, the switch would be positioned to ST2. When Event_3 occurs Effect_1 is executed while the FE changes to state ST3.
Eu.ModSt.7578	Info	Figure 427 Example of a state specifying a response 
Eu.ModSt.7579	Info	In the EULYNX requirements specification documents there are below the depicted state machine diagrams (as for example depicted in *figure 33*) the corresponding state transitions listed as atomic mandatory functional requirements: **Info | Initial** **Req | {Initial - ST1}** **Info | ST1** **Req | Event_1/{ST1 -ST2}** **Info | ST2** **Req | Event_2/{ST2 -ST1}** **Req | Event_3/Effect_1; {ST2 - ST3}** **Info | ST3**
Eu.ModSt.7580	Info	A state is represented on the state machine diagram by a round-cornered box containing its name.
Eu.ModSt.7581	Info	**Kinds of states:** The following three kinds of states are distinguished: • **simple state** (state with no regions and therefore without nested states), • **sequential state** (state with exactly one region) and • **concurrent state** (state with at least two regions)

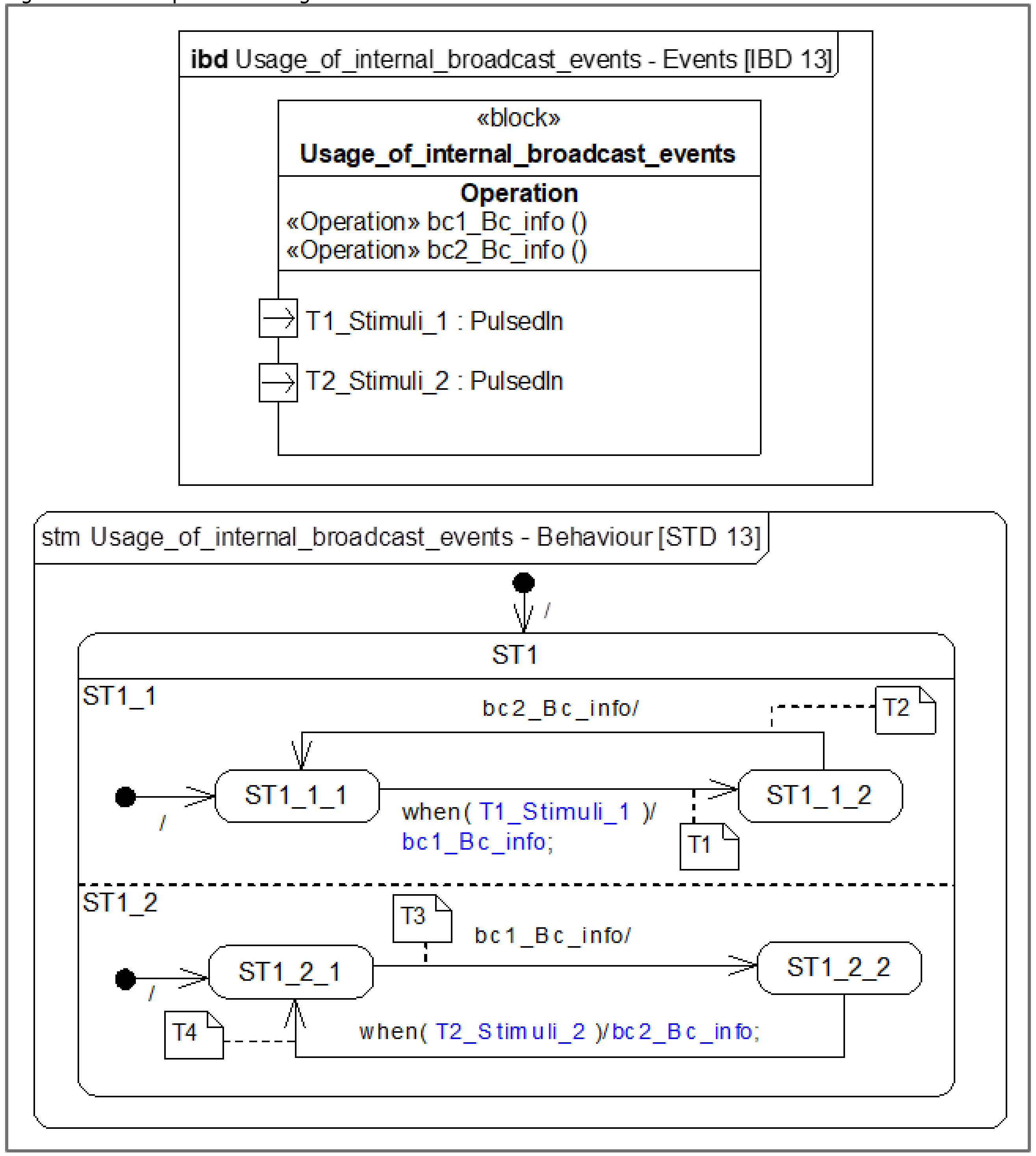
ID	Type	Requirements
Eu.ModSt.7582	Info	Each state may contain entry and exit behaviour that are performed whenever the state is entered or exited respectively. Entry and exit behaviour are described as text expressions using the chosen action language preceded by the keywords entry or exit and a forward slash.
Eu.ModSt.7583	Info	A state machine can contain transitions, called internal transitions, which do not effect a change in state. An internal transition has the same source and destination and, if triggered, simply executes the transition effect.
Eu.ModSt.7584	Info	By contrast, an external transition with the same source and destination state - sometimes called a transition-to-self - triggers the execution of that state's exit and entry behaviour as well as the transition effect.
Eu.ModSt.7585	Info	Additional to the states, SysML includes a number of pseudostates to provide additional semantics. The difference between a state and a pseudostate is that a region can never stay in a pseudostate, which merely exists to help determine the next active state.
Eu.ModSt.7586	Info	The EULYNX methodology adopts the following SysML pseudostates: • **initial pseudostate**, • **final state**, • **choice pseudostate**, • **fork pseudostate** and • **join pseudostate**.
Eu.ModSt.7587	Info	Pseudostates have a defined name, that may be visible on the diagrams.
Eu.ModSt.7588	Head	**8.6.6.3 Initial pseudostate and final state**
Eu.ModSt.7589	Info	An initial pseudostate is shown as a filled circle. It is used to determine the initial state of a region (see *Figure 7609*). The outgoing transition from an initial pseudostate may include an effect. Such effects are often used to set the initial values of properties used by the state machine (e.g. call operation cOp1_init() shown in *Figure 7609*).
Eu.ModSt.7590	Info	A final state is shown as a bulls-eye (i.e. a filled circle surrounded by a larger hollow circle). It indicates that a region has completed execution. When the active state of a region is the final state, the region has completed, and no more transitions take place within it. Hence, a final state can have no outgoing transitions.
Eu.ModSt.7591	Head	**8.6.6.4 Choice pseudostate**
Eu.ModSt.7592	Info	A choice pseudostate is shown as a white diamond with one transition arriving and two or more transitions leaving. It is used to construct a compound transition path between states. The compound transition allows more than one alternative path between states to be specified, although only one path can be taken in response to any single event.
Eu.ModSt.7593	Info	Multiple transitions may either converge on or diverge from the choice pseudostate. When there are multiple outgoing transitions from a choice pseudostate, the selected transition will be one of those whose guard evaluates to true at the time after the choice pseudostate has been reached. This allows effects executed on the prior transition to affect the outcome of the choice.
Eu.ModSt.7594	Info	When a choice pseudostate is reached in the execution of a state machine, there must always be at least one valid outgoing transition. If not, the state machine is invalid.
Eu.ModSt.7595	Info	If a compound transition contains choice pseudostates, any possible compound transition must contain only one trigger, normally on the first transition in the path.
Eu.ModSt.7596	Head	**8.6.6.5 Fork pseudostate**
Eu.ModSt.7597	Info	A fork pseudostate is shown as a vertical or horizontal bar with transition edges either starting or ending on the bar.
Eu.ModSt.7598	Info	It has a single incoming transition and as many outgoing transitions as there are orthogonal regions in the target state. Unlike choice pseudostates, all outgoing transitions of a fork are part of the compound transition. When an incoming transition is taken to the fork pseudostate, all the outgoing transitions are taken.
Eu.ModSt.7599	Info	Because all outgoing transitions of the fork pseudostate have to be taken, they may not have triggers or guards but may have effects.
Eu.ModSt.7600	Head	**8.6.6.6 Join pseudostate**
Eu.ModSt.7601	Info	A join pseudostate is shown as a vertical or horizontal bar with transition edges either starting or ending on the bar.
Eu.ModSt.7602	Info	The coordination of outgoing transitions from a concurrent state is performed using a join pseudostate that has multiple incoming transitions and one outgoing transition. The rules on triggers and guards for join pseudostates are the opposite of those for fork pseudostates.
Eu.ModSt.7603	Info	Incoming transitions of the join pseudostate may not have triggers or a guard but may have an effect. The outgoing transition may have triggers, a guard and an effect.
Eu.ModSt.7604	Info	When all the incoming transitions can be taken and the join's outgoing transition is valid, the compound transition can occur. Incoming transitions occur first followed by the outgoing transition.
Eu.ModSt.7605	Head	**8.6.6.7 Simple state**
Eu.ModSt.7606	Info	As shown in the examples depicted in *Figure 427* (states ST1, ST2, ST3) and *Figure 7609* (state "OPERATIONAL"), a simple state has no regions and therefore no nested states.

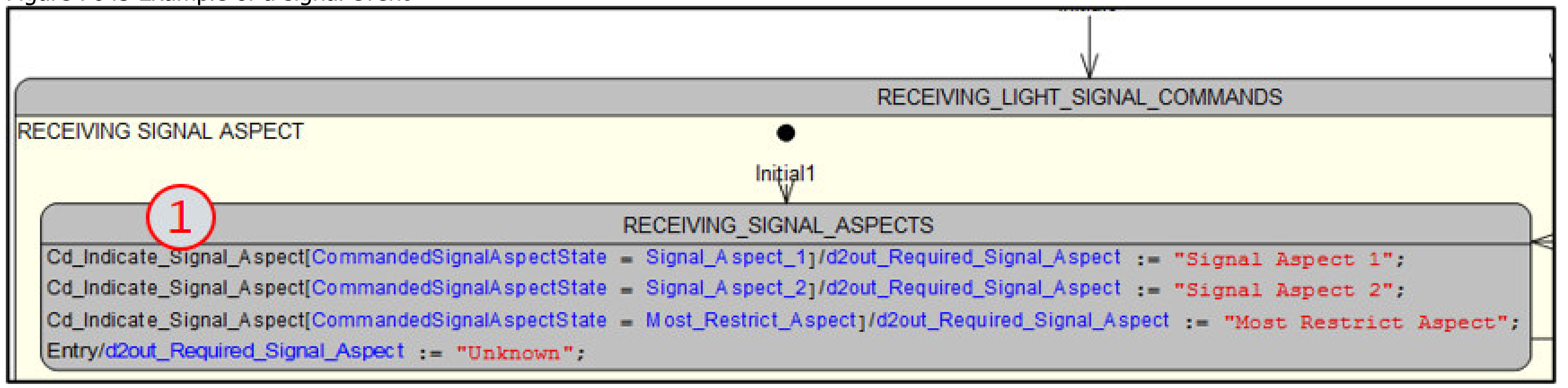
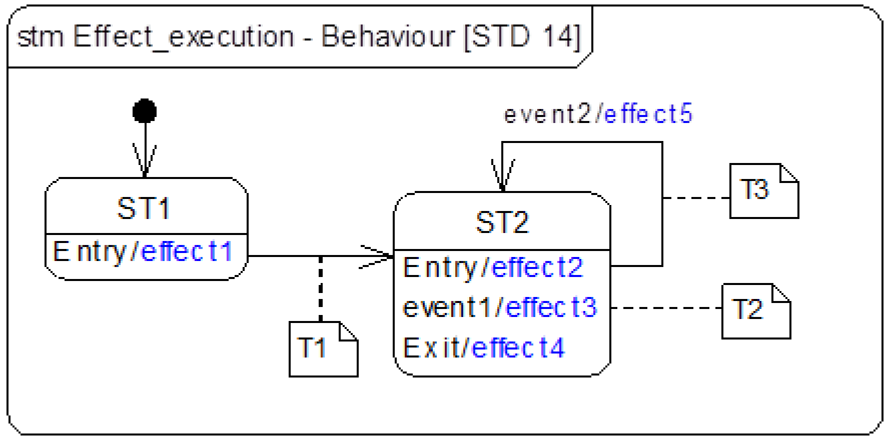
ID	Type	Requirements
Eu.ModSt.7607	Info	A simple state may, like any kind of state, contain entry behaviour, that is executed immediately upon entering the state, exit behaviour, that is executed immediately before exiting the state, and behaviour executed during internal transitions. (see *Figure 7609*). All three kinds of behaviour are not interruptible.
Eu.ModSt.7608	Info	*Figure 34* shows a simple example of a FE defining the functionality "Indicate signal aspect" of a light signal (LS) with a single OPERATIONAL state in its single region. A transition from the region's initial pseudostate goes to the OPERATIONAL state. On entry, the light signal indicates that it is operational, setting the value of the out port "D3_Operational" to true, and on exit it indicates a non operational status, setting the value of "D3 _Operational" to false. While the light signal is in the state OPERATIONAL, it may receive commands to indicate a transmitted signal aspect (T1_Cd_Indicate_signal_aspect) and indicate it (D2_Signal_aspect). When in the OPERATIONAL state, the intrasystem event "T4_SIL_not_fulfiled" triggers a transition to the final state, and because there is only one single region, the state machine terminates.
Eu.ModSt.7609	Info	Figure 7609 Example of a simple state 
Eu.ModSt.7610	Head	**8.6.6.8 Transition**
Eu.ModSt.7611	Info	A transition specifies a change of state within a state machine. It is a directed relationship between a source and a destination state, and defines an event (trigger) and a guard (condition) that both lead to the state transition, as well as an effect (behaviour) that is executed during the transition. Source and destination can be the same state (see T2 in *Figure 7626*).
Eu.ModSt.7612	Info	**Run to completion:** State machines always run to completion, which means that they are not able to consume another event until the state machine has completed the processing of the current event. Thus, the next event will be consumed only if all effects (behaviour) of the previous event have been completed.
Eu.ModSt.7613	Info	Run to completion does not mean that a state machine owned by a FE interconnected with neighbouring FE monopolises all FEs in this network until the run to completion step is complete. The preemption restriction only applies to the context of the corresponding FE.
Eu.ModSt.7614	Info	An event that cannot be consumed, for example because there is no matching transition, is discarded.
Eu.ModSt.7615	Info	**Transition notation:** A transition is shown as an arrow between two states, with the head pointing to the target state.
Eu.ModSt.7616	Info	Transitions-to-self are shown with both ends of the arrow attached to the same state (see T2 in *Figure 7626*).
Eu.ModSt.7617	Info	Internal transitions are not shown as graphical paths but are listed on separate lines within the state symbol (see T7 in *Figure 7626*).
Eu.ModSt.7618	Info	The definition of the transition's behaviour is shown in a formatted string on the transition with the event first, followed by a guard in square brackets, and finally the transition effect preceded by a forward slash (event-effect block or even-action block). As shown in *Figure 7626*, any or all of the behavioural elements as event, guard and effect may be omitted. In T5 for example, all the behavioural elements are omitted. Transition **T3**, to give another example, is only triggered by an event without guard and effect.
Eu.ModSt.7619	Info	**Event:** An event specifies some occurrence that can be measured with regard to location and time and causes a transition to occur. Descriptions of the triggering events are provided in *chapter 8.6.6.9 Event*.

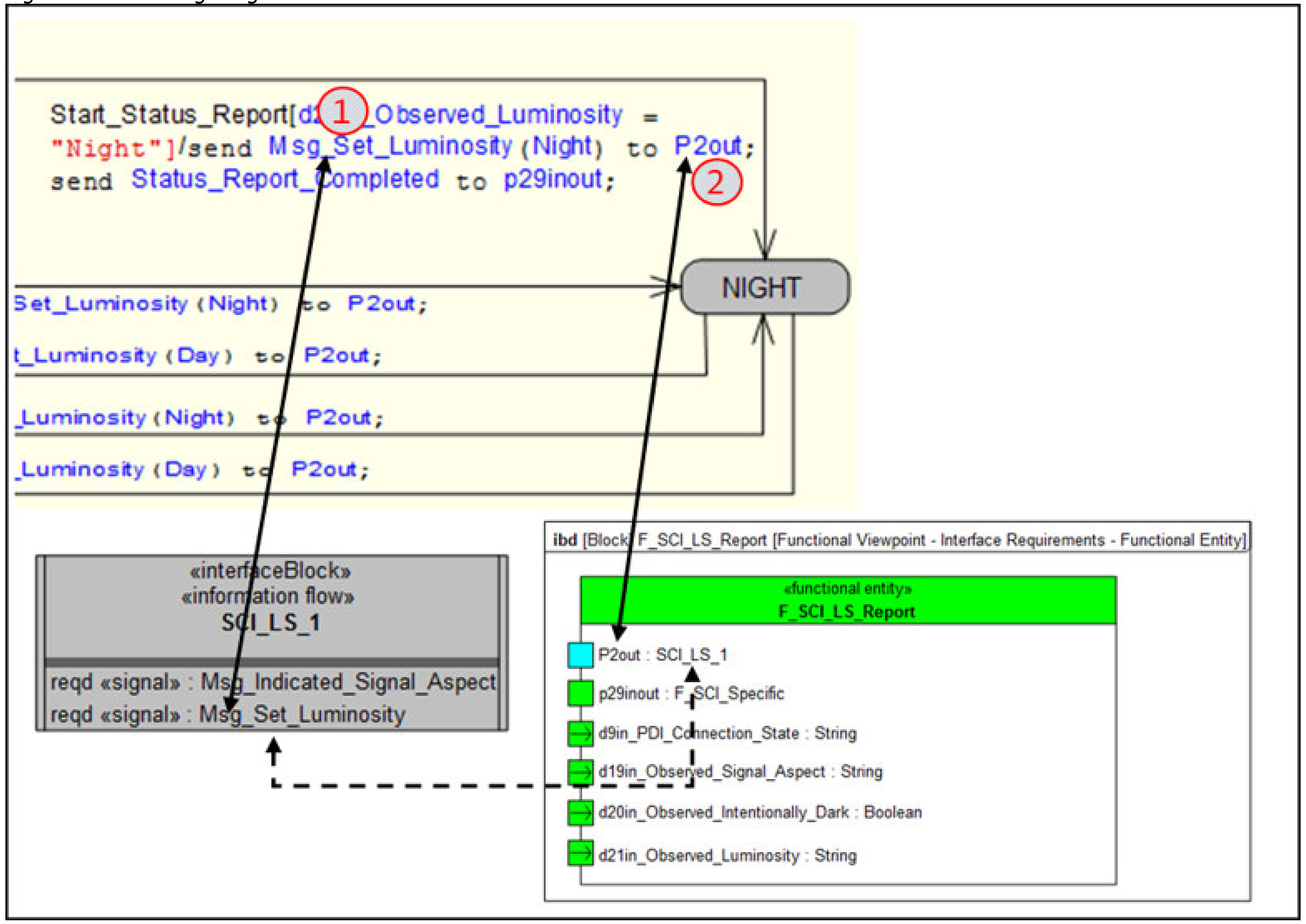
ID	Type	Requirements
Eu.ModSt.7620	Info	**Guard:** The transition guard contains an expression that must evaluate true in the moment of the triggering event so that the transition is performed (see T1, T4 and T7 in *figure 35*). The guard is specified using a constraint which includes an expression formulated in the applied action language to represent the guard condition. If preceded by an event (see T1 and T7 in *Figure 7626*) and if the event satisfies a trigger, the guard on the transition is evaluated. If the guard evaluates to true, the transition is triggered; if the guard evaluates to false, then the event is consumed with no effect.
Eu.ModSt.7621	Info	Transitions can also be triggered by internally generated completion events. For a simple state a completion event is generated when the entry behaviour (for example Entry/effect3 in *Figure 7626*) has completed.
Eu.ModSt.7622	Info	Thus, where a guard is shown without a preceding event (see T4 in *Figure 7626*), the guard condition is evaluated immediately after entering the source state, i.e. after its entry behaviour has completed, and a transition takes place if true, triggered by the generated completion event of the source state.
Eu.ModSt.7623	Info	**Please note:** if the guard condition of a transition without trigger changes to true while the state machine is already in the source state (for example in state ST2), the guard condition won't be evaluated and no transition will take place.
Eu.ModSt.7624	Info	**Effect:** The effect is a behaviour executed when entering or exiting a state (entry and exit behaviour, respectively), during an internal transition (see T7 in *Figure 7626*) and during the external transition from one state to another (see T1 in *Figure 7626*). If an external transition is triggered, first the exit behaviour of the current (source) state, then the transition effect and finally the entry behaviour of the target state are executed. Descriptions of the effects used in the methodology underlying this Modelling standard are provided in chapter *8.6.6.10 Effect*.
Eu.ModSt.7625	Info	A transition may also be formulated textually as atomic functional requirement: **Event [Guard]/Effect {Source state - Target state}**.
Eu.ModSt.7626	Info	Figure 7626 Transition notation 
Eu.ModSt.7627	Head	**8.6.6.9 Event**
Eu.ModSt.7628	Info	An event specifies some occurrence that can be measured with regard to location and time and causes a transition to occur.

ID	Type	Requirements
Eu.ModSt.7629	Info	In the EULYNX methodology, the following types of events are used: • **Change event**, • **Time event** • **Internal broadcast event** • **Signal event**.
Eu.ModSt.7630	Head	**8.6.6.9.1 Change event**
Eu.ModSt.7631	Info	A change event indicates that some condition has been satisfied, that is, the value of a specified Boolean expression holds. A defined change event occurs during system operation each time the specified Boolean expression toggles from false to true. Change events are continuously evaluated.
Eu.ModSt.7632	Info	According to the EULYNX methodology, the Boolean expression of a change event may contain the following arguments: • **Data In Port,** • **block property** • **block operation.**
Eu.ModSt.7633	Info	**Notation of change events:** Change events use the term „when" followed by the Boolean expression that has to be met in parenthesis. Like other constraint expressions, the Boolean expression is to be expressed in text using the applied action language: **when(boolean expression)[guard]/effect;**
Eu.ModSt.7634	Head	**8.6.6.9.2 Time event**
Eu.ModSt.7635	Info	A time event indicates that a given time interval has passed since the current state was entered.
Eu.ModSt.7636	Info	**Notation of time events:** Time events use the term "after" followed by the time period (in milliseconds by default) in parenthesis, e.g. after(D1_Con_t1) as depicted in *Figure 7638.*
Eu.ModSt.7637	Info	"after" indicates that the time is relative to the moment the state is entered. The transition T1 shown in *Figure 7638* is, for example, triggered after the time D1_Con_t1 has expired. The time starts on entering the state ST1.

ID	Type	Requirements
Eu.ModSt.7638	Info	Figure 7638 Example of the usage of time events 
Eu.ModSt.7639	Head	**8.6.6.9.3 Internal broadcast event**
Eu.ModSt.7640	Info	Internal broadcast events occur when corresponding SysML block operations are invoked. They are supposed to submit broadcasts within the state machine of a FE.
Eu.ModSt.7641	Info	In *Figure 7642* for example, the SysML block operations bc1_Bc_info() and bc2_Bc_info() represent internal broadcast events. During transition T1, the internal broadcast event bc1_Bc_info() is invoked in order to trigger transition T3. Furthermore, during transition T4, the internal broadcast event bc2_Bc_info() is invoked to trigger transition T2.

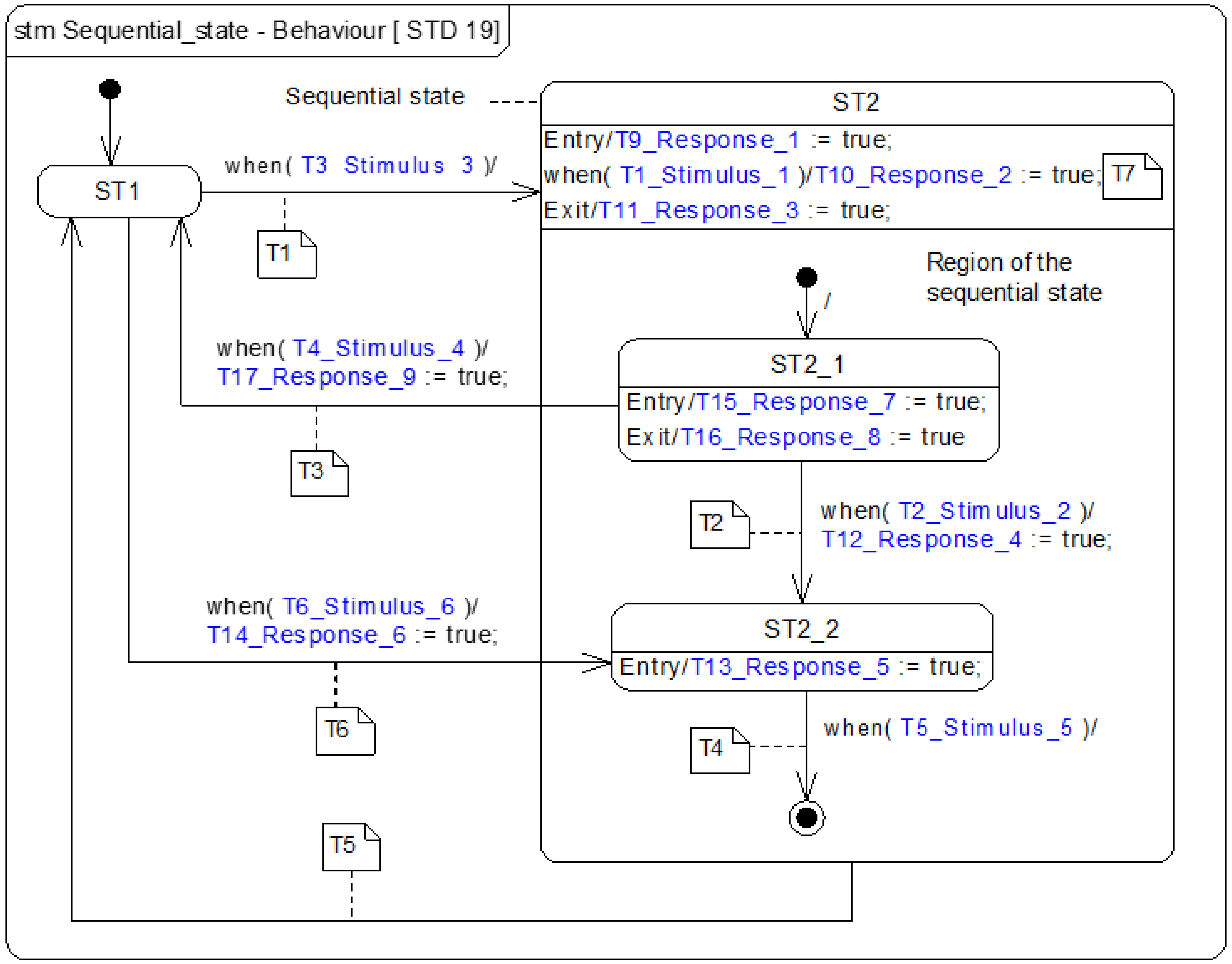
ID	Type	Requirements
Eu.ModSt.7642	Info	Figure 7642 Example of the usage of internal broadcast events 
Eu.ModSt.7643	Head	**8.6.6.9.4 Signal event**
Eu.ModSt.7644	Info	A signal event is generated when a reception of an interface block receives a signal. This is then used in the state model to trigger a state transition **(1)**.

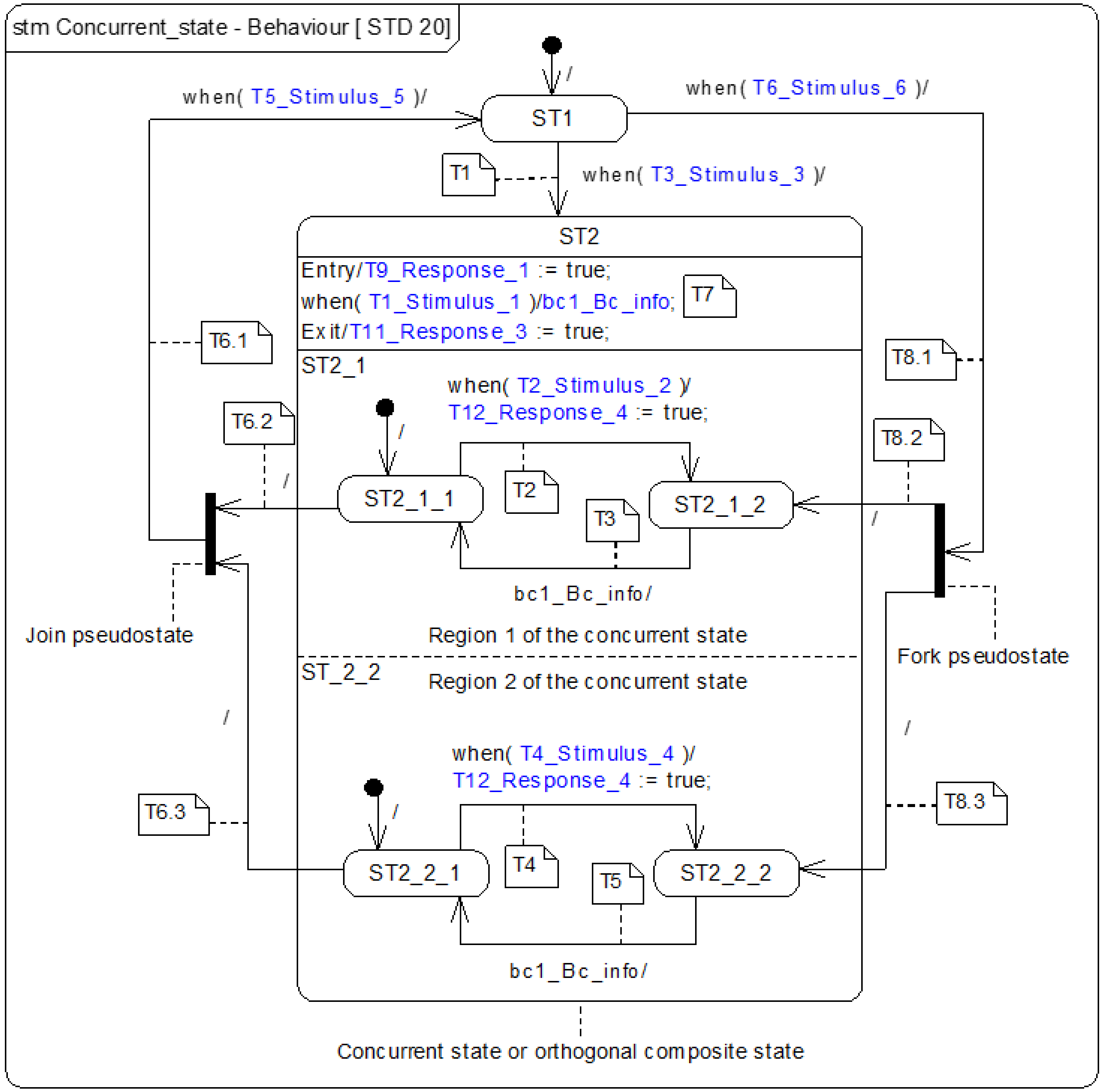
ID	Type	Requirements
Eu.ModSt.7645	Info	Figure 7645 Example of a signal event 
Eu.ModSt.7646	Head	**8.6.6.10 Effect**
Eu.ModSt.7647	Info	An effect is a behaviour executed when entering or exiting a state (entry and exit behaviour, respectively), during an internal transition or during an external transition from one state to another.
Eu.ModSt.7648	Info	The sequence of effect execution is demonstrated in *figure 7649*. Transition T1 is taken immediately on completion of effect1. The sequence of effect execution when event2 occurs (T3) is: effect4, then effect5, then effect2. Event1 generates only one effect (T2): effect3.
Eu.ModSt.7649	Info	Figure 7649 Sequence of effect execution 
Eu.ModSt.7650	Info	The following elements of behaviour may be represented as **effect**: • **Event-driven responses using signals,** • **Responses in form of continuous flows,** • **Call behaviour.**
Eu.ModSt.7651	Head	**8.6.6.10.1 Event-driven responses using signals**
Eu.ModSt.7652	Info	As shown in *Figure 7652*, signals **(1)** are sent as an effect of a state transition or triggered in a block operation via the corresponding port **(2)** of the respective FE.

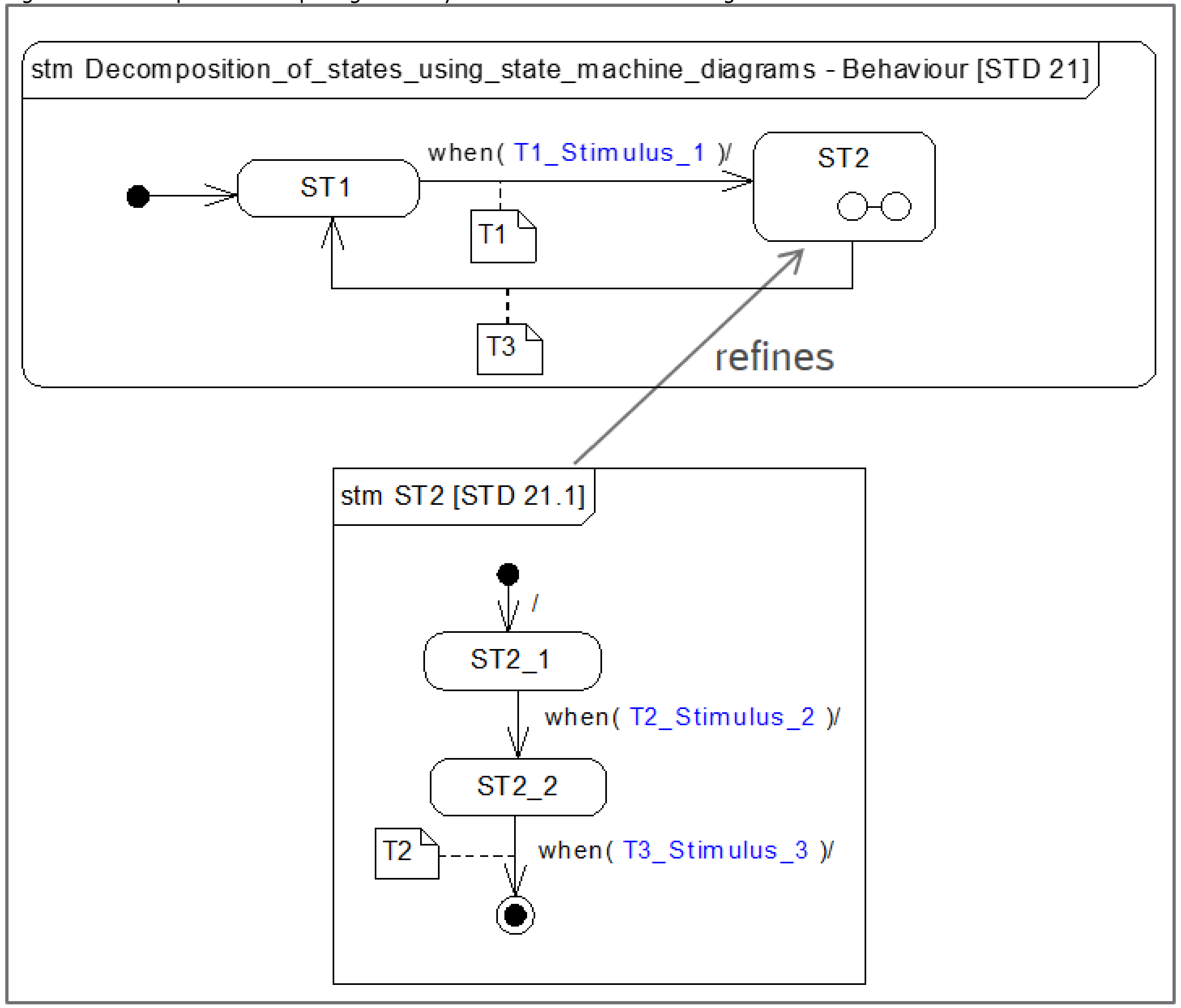
ID	Type	Requirements
Eu.ModSt.7653	Info	Figure 7653 Sending a signal 

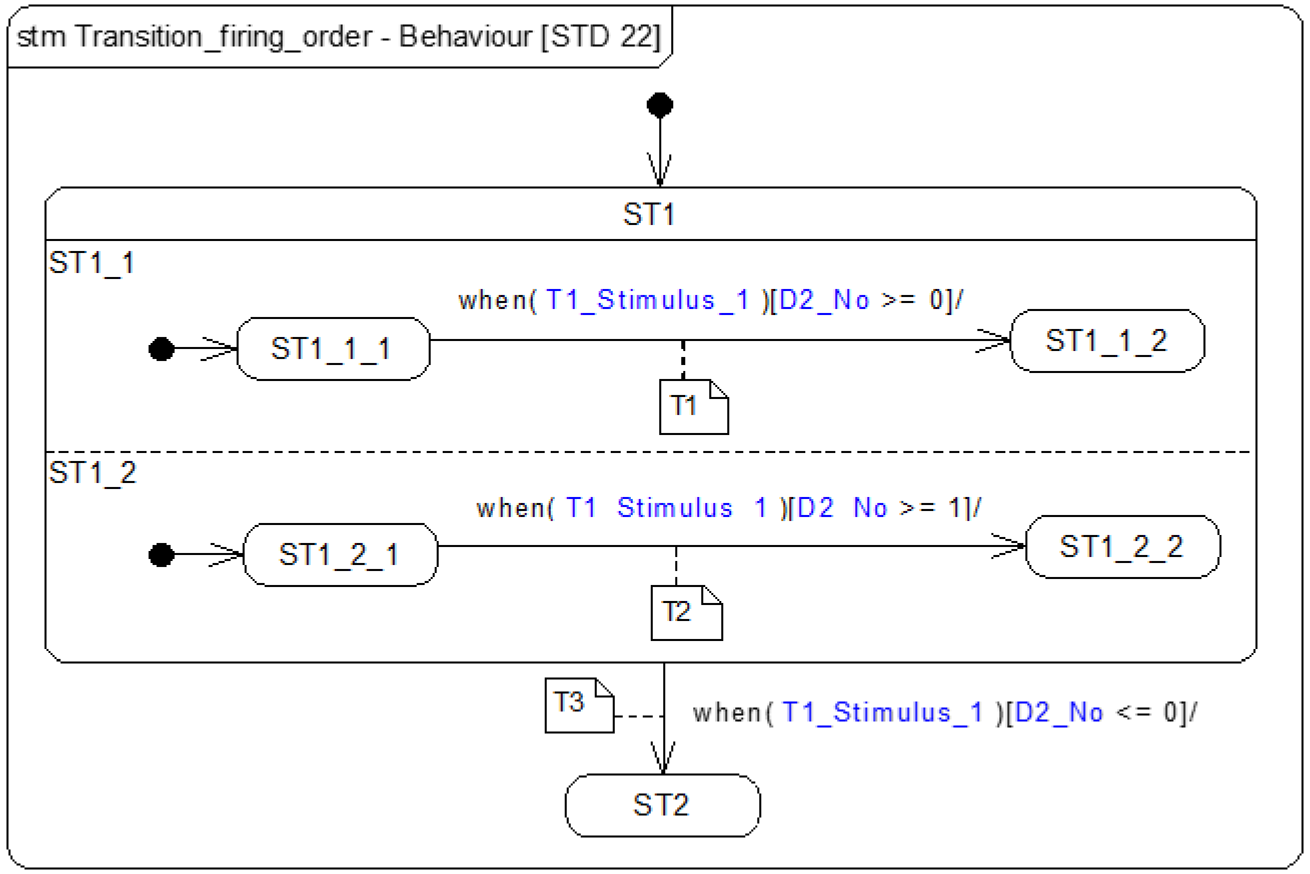
ID	Type	Requirements
Eu.ModSt.7654	Head	**8.6.6.10.2 Responses in form of continuous flows**
Eu.ModSt.7655	Info	A response is sent in form of a continuous flow by assigning the desired value to a data out port, e.g. D1out_Temperature := 40.
Eu.ModSt.7656	Info	All out ports are initialised. The initialisation can be carried out in the body of the init-block operation systematically named cOp1_init(). Alternatively it can be carried out directly in the transition effect of the transition outgoing from initial state of the state machine.
Eu.ModSt.7657	Info	Furthermore, the sender of a response must always configure the current value of the Data Out Port.
Eu.ModSt.7658	Head	**8.6.6.10.3 Call behaviour**
Eu.ModSt.1013	Info	Call behaviour is invoked on demand, executed and terminated after execution. It is supposed to define event-driven data transformations. The algorithm of the data transformations is to be described in the body of the corresponding block operation using ASAL (see *chapter 8.6.8*).
Eu.ModSt.551	Info	**Naming of Call behaviour** cOp<Id>_<behaviour name>, Example: cOp2_establish_safe_state
Eu.ModSt.1016	Info	**Id:** Natural number starting with 1
Eu.ModSt.552	Info	The call behaviour to initialise the block properties and out ports of a FE is to be named **cOp1_init()** systematically.
Eu.ModSt.7660	Head	**8.6.6.11 Composite state**

ID	Type	Requirements
Eu.ModSt.7661	Info	States can have regions. Such states are called composite states or hierarchical states. They allow state machines to scale to represent state-based behaviour of any complexity. A composite state may have one single region (sequential state) but also multiple orthogonal regions (concurrent state or orthogonal composite state).
Eu.ModSt.7662	Info	Instead of using a region to decompose the behaviour of a state, a state machine diagram may be assigned to the corresponding state alternatively, defining its behaviour.
Eu.ModSt.7663	Info	Each region or state machine diagram assigned to a state has a set of mutually exclusive disjoint subvertices and a set of transitions. In other words, it typically will contain an initial pseudostate and a final state, a set of pseudostates, and a set of substates, which may themselves be composite states.
Eu.ModSt.7664	Info	Any state enclosed within a region of a composite state is called a substate of that composite state.
Eu.ModSt.7665	Head	**8.6.6.12 Sequential state**
Eu.ModSt.7666	Info	A sequential state, such as ST2 shown in the example depicted in *Figure 7674,* is a composite state that has one region.
Eu.ModSt.7667	Info	*Figure 7674* shows the decomposition of the state ST2 into the substates ST2_1 and ST2_2. On entry to the state ST2, two entry behaviours are executed: the entry behaviour of ST2, T9_Response_1 := true and then the entry behaviour of ST2_1, T15_Response_7 := true. This is because on entry, as indicated by the initial pseudostate, the initial substate of ST2 is ST2_1.
Eu.ModSt.7668	Info	When in state ST2_1, T2_Stimulus_2 will cause the transition T2 to the state ST2_2 and will successively process T16_Response_8 := true, T12_Response_4 := true and T13_Response_5 := true. If T5_Stimulus_5 is received while in state ST2_2, the change event will trigger the transition T4 to the final state. A completion event is generated when the final state is reached, triggering the transition T5 to state ST1. When leaving ST2, T11_Response_3 := true is executed.
Eu.ModSt.7669	Info	A composite state (sequential state or concurrent state) may be porous, which means transitions such as transition T3 and T6 shown in *Figure 7674* may cross the state boundary, starting or ending on states within its regions.
Eu.ModSt.7670	Info	In the case of a transition ending on a nested state, such as transition T6 shown in *Figure 7674*, the behaviours are executed in this order: **1.** the effect T14_Response_6 := true of the transition T6, **2.** the entry behaviour T9_Response_1 := true of the composite state, **3.** the entry behaviour T13_Response_5 := true of the transition's target nested state.
Eu.ModSt.7671	Info	In the opposite case, such as transition T3 shown in *Figure 7674*, the behaviours are exited in this order: **1.** the exit behaviour T16_Response_8 := true of the source nested state, **2.** the exit behaviour of the composite state T11_Response_3 := true is executed, **3.** the transition effect T17_Response_9 := true.
Eu.ModSt.7672	Info	In the case of more deeply nested state hierarchies, the same rule can be applied recursively to all the composite states whose boundaries have been crossed.
Eu.ModSt.7673	Info	If T1_Stimulus_1 is received while in state ST2, the change event will trigger the internal transition T7 and the effect T10_Response_2 := true will be executed without a change of state.

ID	Type	Requirements
Eu.ModSt.7674	Info	Figure 7674 Example of a sequential state 
Eu.ModSt.7675	Head	**8.6.6.13 Concurrent state**
Eu.ModSt.7676	Info	A concurrent state as shown in *Figure 7683*, sometimes also called an orthogonal composite state, contains at least two regions.
Eu.ModSt.7677	Info	When a concurrent state is active, each region has its own active state that is independent of the others, and any incoming event is independently analysed within each region.
Eu.ModSt.7678	Info	A transition that ends on the concurrent state, such as transition T1 in *Figure 7683*, will trigger transitions from the initial pseudostate of each region, so there must be an initial pseudostate in each region for such a transition to be valid.
Eu.ModSt.7679	Info	Similarly, a completion event for the concurrent state will occur when all the regions are in their final state.
Eu.ModSt.7680	Info	When an event, as for example the internal broadcast event bc1_Bc_info shown in *Figure 7683*, is associated with triggers in multiple orthogonal regions, the event may trigger a transition in each region (e.g. transitions T3 and T5), assuming the transition is valid based on the other usual criteria.
Eu.ModSt.7681	Info	**Please note:** a transition can never cross the boundary between two regions of the same concurrent state.
Eu.ModSt.7682	Info	In addition to transitions that start or end on the concurrent state, such as transition T1 in *Figure 7683*, transitions from outside the concurrent state may start or end on the nested states of its regions. In this case, one state in each region must be the start or end of one of a coordinated set of transitions. This coordination is performed by a fork pseudostate in the case of incoming transitions, such as T8.1, T8.2 and T8.3 in *Figure 7683*, and a join pseudostate for outgoing transitions, such as T6.1, T6.2 and T6.3 in *Figure 7683*.

ID	Type	Requirements
Eu.ModSt.7683	Info	Figure 7683 Example of a concurrent state 
Eu.ModSt.7684	Head	**8.6.6.14 Decomposition of states using state machine diagrams**
Eu.ModSt.7685	Info	Instead of decomposing the behaviour of a state within a region of a sequential state or multiple regions of a concurrent state, the behaviour may alternatively be specified by a state machine diagram assigned to the corresponding state (see *Figure 7689*).
Eu.ModSt.7686	Info	The region of the corresponding state machine diagram typically will contain an initial pseudostate and a final state, a set of pseudostates, and a set of substates, which themselves may be decomposed by state machine diagrams.
Eu.ModSt.7687	Info	As illustrated in *Figure 7689*, a transition (e.g. transition T1) ending on a state (e.g. state ST2) that is refined by a state machine diagram will trigger the transition from the initial pseudostate of the diagram to its initialising state (e.g. state ST2_1).

ID	Type	Requirements
Eu.ModSt.7688	Info	Similarly, when the behaviour specified on the state machine diagram completes (e.g. the final state is entered after triggering the transition T2), it will generate a completion event that can trigger transitions (e.g. transition T3) whose source is the state (e.g. state ST2) the state machine diagram is assigned to.
Eu.ModSt.7689	Info	Figure 7689 Principle of decomposing states by means of state machine diagrams 
Eu.ModSt.7690	Head	**8.6.6.15 Transition firing order in nested state hierarchies**
Eu.ModSt.7691	Info	The same event may trigger transitions at several levels in a state hierarchy, and with the exception of concurrent regions, only one of the transitions can be taken at a time. Priority is given to the transition whose source state is innermost in the state hierarchy.
Eu.ModSt.7692	Info	Suppose the state machine depicted in *Figure 7695* is in its initial state (i.e. in state ST1_1_1 and ST1_2_1). The stimulus T1_Stimulus_1 is associated with the triggers of the transitions T1, T2 and T3, each with guards based on the value of D2_No.
Eu.ModSt.7693	Info	The following list shows the transitions that will fire upon receipt of T1_Stimulus_1 based on values of D18_No from -1 to 1 if the system is in the states ST1_1_1 and ST1_2_1: • D2_No equals -1: transition T3 will be triggered because it is the only transition with a valid guard; • D2_No equals 0: transition T1 will be triggered because, although transition T3 also has a valid guard, state ST1_1_1 is the innermost of the two source states; or • D2_No equals 1: both transitions T1 and T2 will be triggered because both their guards are valid.
Eu.ModSt.7694	Info	The normal rules for execution of exit behaviour apply, so, before the transition from state ST1 to state ST2 can be taken, any exit behaviour of the active nested states of state ST1, as well as the exit behaviour of state ST1, must be executed.

ID	Type	Requirements
Eu.ModSt.7695	Info	Figure 7695 Illustration of transition firing order 
Eu.ModSt.1078	Head	**8.6.6.16 Interaction between state machines**
Eu.ModSt.1082	Info	State machines in different blocks, may interact with one another by sending stimuli and returning responses. For example, the state machine of one block can send a stimulus to another block as part of a transition effect or state behaviour. The event corresponding to the receipt of this stimulus by the receiving block can trigger a state transition in its state machine.
Eu.ModSt.1083	Info	Thus, different behaviour, each specifying a certain functionality of the system, may be encapsulated in blocks and interconnected with each other in a network of FEs or TFEs, i.e. in a Functional or Technical Functional Architecture.
Eu.ModSt.7831	Head	**8.6.7 Bindings** (see *chapter 8.2.1*)
Eu.ModSt.7833	Info	**Diagram of model view "Functional Entity" (ibd and stm)** has a "**Req**" binding.
Eu.ModSt.7834	Info	**Diagram of model view "Technical Functional Entity" (ibd and stm)** has a "**Req**" binding.
Eu.ModSt.7837	Info	The algorithm defined in a **time advanced operations** has a "**Req**" binding. The algorithm defined in a time advanced operation represents the mandatory externally visible behaviour of a FE or TFE in place of or in cooperation with a state machine.
Eu.ModSt.7839	Info	**Transitions, states, ports, block operations and block properties** have "**Def**" bindings.
Eu.ModSt.7537	Head	**8.6.8 Action language**
Eu.ModSt.7538	Info	The EULYNX methodology follows the objective of creating executable specification models. In order to specify the necessary executable behaviours in a target language independent way, the Atego Structured Action Language (ASAL) is used.
Eu.ModSt.7539	Info	ASAL is used to specify block operations or Event Action Blocks that define the transition effects on state machine diagrams.
Eu.ModSt.1940	Info	A description of data types, logical operators and basic statements of the Atego Structured Action Language (ASAL) is provided below.
Eu.ModSt.7541	Head	**8.6.8.1 Logical operators**

ID	Type	Requirements
Eu.ModSt.7542	Info	• Greater than: **>** • Less than: **<** • Greater than or equal: **>=** • Less than or equal: **<=** • Equal: **=** • Not equal: **<>** • Conjunction: **AND** • Disjunction: **OR** • Negation: **NOT** • Exclusive disjunction: **XOR**
Eu.ModSt.7840	Info	The logical operators "AND", "OR", "NOT" and "XOR" are to be written in capital letters.
Eu.ModSt.7543	Head	**8.6.8.2 Data types**
Eu.ModSt.7544	Info	As the EULYNX specification approach follows the objective of creating executable specification models, the range of data types is limited to data types the simulation tool SySim supports (SySim value types).
Eu.ModSt.294	Info	Only the SySim value types, including the redefined data types "PulsedIn" and "PulsedOut" may be used for the specification of systems requirements : • Boolean • DateTime • Single • String • Decimal • Double • Long • Integer • Timespan • PulsedIn • PulsedOut
Eu.ModSt.7546	Info	The data types "PulsedIn" and "PulsedOut" represent redefinitions of the data type Boolean and are exclusively reserved to be assigned to Trigger Ports (T-Ports). That is, a Trigger In Port is typed with the data type "PulsedIn" and a Trigger Out Port with the data type "PulsedOut".
Eu.ModSt.7547	Info	Outgoing data typed with "PulsedOut" (as default false) that are set to true (for example, T1out_Cd_indicate_signal_aspect := true) automatically change back to false after a defined time. The defined time frame is sufficient to trigger a transition in a receiving state machine.
Eu.ModSt.7548	Info	Incoming data at receiver side typed with "PulsedIn" apply the behaviour of the corresponding outgoing data at sender side typed with "PulsedOut".
Eu.ModSt.7906	Info	For the typing of proxy ports, the specially adapted interface blocks are to be used: • IBoolean • IDateTime • IDecimal • IDouble • IInteger • ILong • ISingle • IString
Eu.ModSt.7907	Info	The data types "PulsedIn" and "PulsedOut" can only be used with flow ports but not in connection with proxy ports.
Eu.ModSt.269	Head	**8.6.8.3 Declaring variables**
Eu.ModSt.270	Info	The Declare statement declares local variables. The syntax is as follows: declare <variable list> : <type> ; Where: · <variable list> - specifies a list of variables that are being declared. For each variable an optional initial value can be set through the ':=' assignment operator. · <type> - specifies the type of the variables that are being declared.

ID	Type	Requirements

Eu.ModSt.270		**Example:**
		declare A : Boolean;
		declare B := False : Boolean;
		declare C, D := 0 : Integer;

Eu.ModSt.7549	Head	**8.6.8.4 Reading the value of a port**
Eu.ModSt.7550	Info	The value of a port may be read using the name of the port on its own: The syntax is as follows: <A> := <port>; Where: <port> specifies the port whose value is being read. <A> specifies for example the value property the value of the port is to be assigned to. **Example:** Mem_D1_Signal_aspect := D1_Signal_aspect;
Eu.ModSt.7551	Head	**8.6.8.5 Setting the value of a port**
Eu.ModSt.7552	Info	The value of a port may be set using the name of the port: The syntax is as follows: <port> := <value>; Where: · <port> - specifies the port whose value is being set. · <value> - specifies the value that is being set for the port. **Example:** T1_Cd_Indicate_signal_aspect := true;
Eu.ModSt.7553	Head	**8.6.8.6 Calling an operation**
Eu.ModSt.7554	Info	To call an Operation item in ASAL, reference the Operation with its default (the default is 'This'). You must use parentheses for the operation, even if there are no parameters to pass. The syntax is as follows: <operation> ([<parameters>]); Where: · <operation> - specifies the operation that is being called. By default, the Operation is called against 'This'. · <parameters> - specifies any parameter values that are passed to the operation that is being called. **Examples:** MyOperation(True); OperationWithNoParameters();
Eu.ModSt.7555	Head	**8.6.8.7 Assigning values to variables**
Eu.ModSt.7556	Info	Values can be assigned to variables. The syntax is as follows: <variable> := <expression> ; Where: · <variable> - specifies the variable that is being assigned. · <expression> - specifies the value that is being assigned, which can be defined through an expression. **Example:** Mem_ped_wait := False;
Eu.ModSt.7557	Head	**8.6.8.8 Conditional execution of code**

ID	Type	Requirements

Eu.ModSt.7558	Info	The if, then, else statements provide a mechanism for conditional execution of code.
		The syntax is as follows:
		if <condition> then
		... //code to execute
		elseif <condition> then
		... //code to execute
		else
		... //code to execute
		end if
		Where:
		· <condition> - specifies the condition that is being tested.
		
		Example:
		if A < 100 then
		A := A + 1;
		elseif B < 100 then
		B := B + 1;
		else
		NowStop := True;
		end if

Eu.ModSt.7559	Head	**8.6.8.9 While loops**
Eu.ModSt.7560	Info	The while loop provides a mechanism for executing code while a condition is true. The syntax is as follows: while <condition> ... //code to execute end while Where: · <condition> - specifies the condition that is being tested. **Example:** while A < 100 A := A + 1; end while
Eu.ModSt.7561	Head	**8.6.8.10 Case selection**
Eu.ModSt.7562	Info	The case selection provides a mechanism for executing code when a case is true. The syntax is as follows (note that there can be many cases): select case <condition> case <condition>: ... //code to execute case else: ... //code to execute end select Where: · <condition> - specifies the condition that is being tested. **Example:** select case A + B case 200: ResultIs200 := True; case else: ResultIs200 := False; end select
Eu.ModSt.7563	Head	**8.6.8.11 Return statement**

ID	Type	Requirements
Eu.ModSt.7564	Info	The Return statement can return the result of an expression. The syntax is as follows: return <expression> ; Where: · <expression> - specifies the expression that returns the result. **Example:** return A + B;
Eu.ModSt.287	Head	**8.6.8.12 Comments**
Eu.ModSt.288	Info	The Comment statement specifies text that is ignored by the target language. The syntax is as follows for single line comments: // <text> Where: · <text> - specifies the text that is generated as a comment.
Eu.ModSt.289	Info	Example: // return the sum of A + B
Eu.ModSt.290	Head	**8.6.8.13 Example program written in ASAL**

Eu.ModSt.291	Info	This is an example program that is written in ASAL.
		declare A := 0, B: Integer; // Former declared variable initialized, latter is not. Both share the same type
		declare GoOn := True : Boolean;
		declare NowStop := False : Boolean;
		B := 0; // Assignment
		NowStop := not B = 0 AND (GoOn or NowStop); // Assignment (it's False) using a logical expression
		while GoOn AND NOT NowStop do // While loop
		if A < 100 then // Condition … if
		A := A + 1;
		elseif B < 100 then // Condition, elseif
		B := B + 1;
		else // Condition, else
		NowStop := True;
		end if // end of condition.
		end while
		declare TestOk : Boolean;
		select case A + B // Selection statement. It's similar to C/C++ switch (but no “break”, only one case is executed at most)
		case 199 + (A + B) / (A + B): // Case expression, equates to 200
		TestOk := True;
		case else: // Default case
		TestOk := False;
		end select
		return A + B; // Return statement

Eu.ModSt.825	Head	**9 References**
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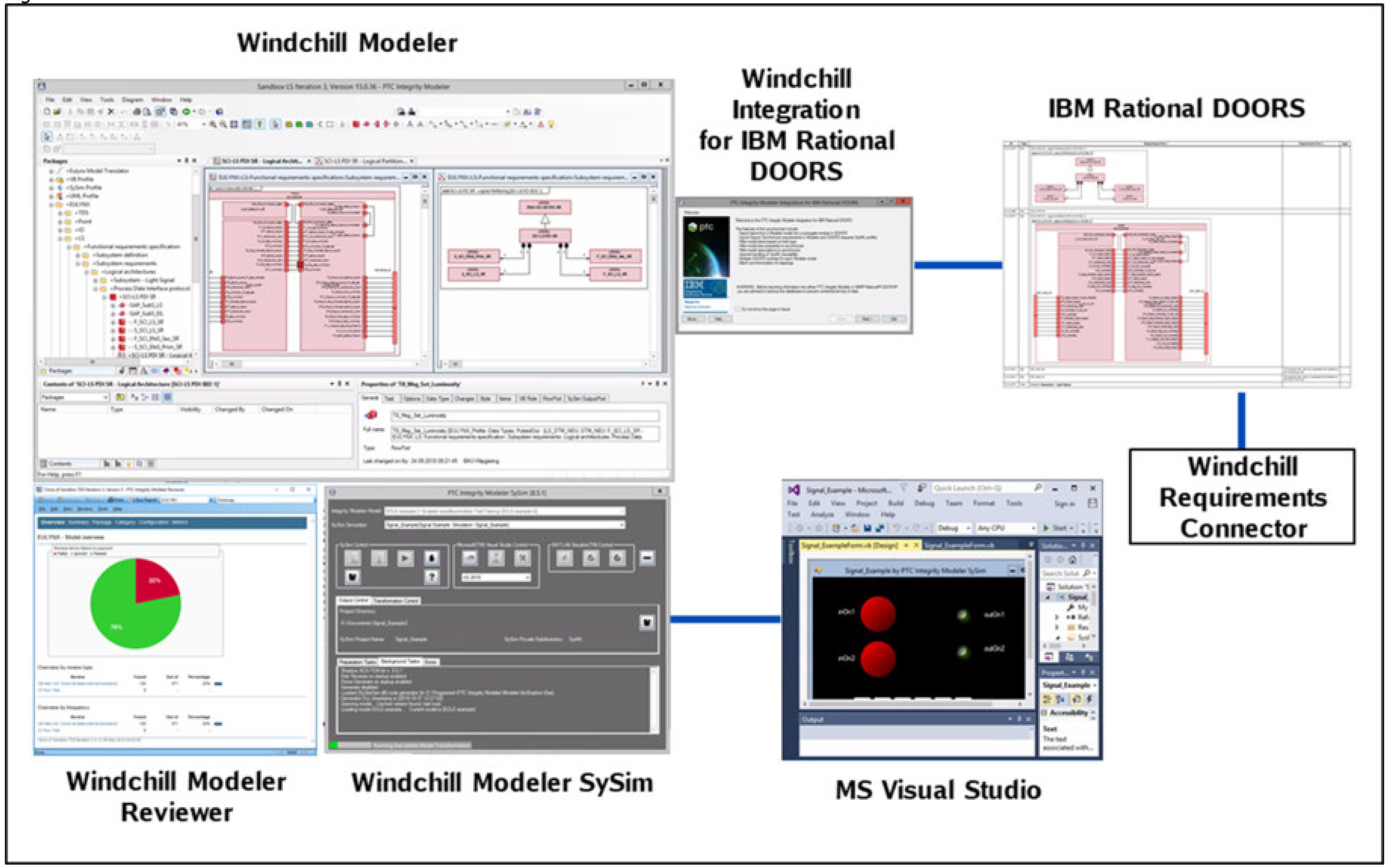
Eu.ModSt.7911	Info	**10 Appendix A - Reference Tool Chain**
Eu.ModSt.7916	Info	A tool chain that fully supports the EULYNX MBSE process is shown below and is intended to be a reference for the use of alternative tools. When using alternative tools, make sure that they have the same capabilities.
Eu.ModSt.302	Info	The EULYNX MBSE process is currently supported by a toolchain as illustrated in Figure 3553. It enables the creation of SysML specification models (Windchill Modeler), static checks for completeness, correctness, and consistency (Windchill Reviewer) and simulation-based validation of the models (Windchill Modeler SySim and MS Visual Studio). A connection to IBM Rational DOORS (Windchill Integration for IBM Rational DOORS) enables the representation of specification model elements in the form of atomic requirements in the requirements management tool. They can be transformed into the standardised Requirements Interchange Format (ReqIF) and exchanged with suppliers using Windchill Requirements Connector.

ID	Type	Requirements
Eu.ModSt.3553	Info	Figure 3553 EULYNX Tool chain 
Eu.ModSt.303	Head	**10.1 Windchill Modeler**
Eu.ModSt.304	Info	Windchill Modeler [14], an all-in-one integrated collaborative development tool suite, is used to create the EULYNX SysML specification models. It provides systems and software modelling and component-based development targeted for technical systems and provides comprehensive notation support for the leading industry standards, including OMG SysML, OMG UML, UPDM (DoDAF and MODAF), OVM, data modelling, and architectural frameworks.
Eu.ModSt.3554	Head	**10.2 IBM Rational DOORS**
Eu.ModSt.3557	Info	Requirements management tool IBM Rational DOORS is used to organise the specification contents in a format conforming to classical requirements management (atomic requirements with unique identifiers and allocated bindingness). The requirements are structured in the form of DOORS-objects in the DOORS-modules representing the specification documents. The specification models created in the Windchill Modeler are represented as surrogates in the DOORS-modules structured in the form of atomic requirements.
Eu.ModSt.3555	Head	**10.3 Windchill Integration for IBM Rational DOORS**
Eu.ModSt.3558	Info	Windchill Modeler is connected to the requirements management tool IBM Rational DOORS via the Windchill Integration for IBM Rational DOORS. This connection enables the creation and synchronisation of surrogates of the specification models in the requirements management tool.
Eu.ModSt.3556	Head	**10.4 Windchill Requirements Connector**
Eu.ModSt.3559	Info	Windchill Requirements Connector is used to transform DOORS-modules into Requirements Interchange Format (ReqIF) and retransform ReqIF files into DOORS format.
Eu.ModSt.305	Head	**10.5 Windchill Modeler SySim**

ID	Type	Requirements
Eu.ModSt.306	Info	Windchill Modeler SySim [15] is used together with Windchill modeler and MS Visual Studio to create executable specifications (virtual prototypes) from SysML specification models and validate their behaviours by means of simulation-based testing. That way it is ensured that the corresponding specification model is consistent and formally correct without the need to focus on lower-level details such as code generation or target environments.
Eu.ModSt.307	Info	Furthermore, Windchill Modeler SySim allows the generation of appropriate and intuitive simulation graphics. Graphical components are automatically prepared in an MS Visual Studio toolbox, from which they can be dropped onto a form to create each user interface, for a given simulation scenario. Predefined graphical components are also provided for the most common functions, such as input and output. Developing new graphical components is also made easy, using the de-facto standard Microsoft .NET platform.
Eu.ModSt.308	Head	**10.6 MS Visual Studio**
Eu.ModSt.309	Info	MS Visual Studio is applied to create graphical user interfaces used to play through simulation scenarios and build executables from simulation code generated by Windchill Modeler SySim.
Eu.ModSt.310	Head	**10.7 Windchill Modeler Reviewer**
Eu.ModSt.311	Info	Windchill Modeler Reviewer [16] provides a quick way of reviewing items in a model using provided and optionally user-defined reviews. EULYNX SysML specification models can quickly be checked for completeness, correctness and consistency using the corresponding reviews. Summary reports may be created that provide statistical analysis of review failures and metrics relating to items in a model. Furthermore, user-defined reviews may be created to include in reports.