SPECIFICATION

Submodel Control configuration and parametrization for NC/CNC machines

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Submodel Template of the Control configuration of NC/CNC machines Asset Adminstration Shell

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2023-07-10	1.0	Release of the Submodel template

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Foreword

1 General

1.1 About this document

This document is a part of a specification series. Each part specifies the contents of a Submodel template for the Asset Administration Shell (AAS). The AAS is described in [1-3] and [6]. First exemplary Submodel contents were described in [4], while the actual format of this document was derived by the "Administration Shell in Practice" [5]. The format aims to be very concise, giving only minimal necessary information for applying a Submodel template, while leaving deeper descriptions and specification of concepts, structures and mapping to the respective documents [1-6].

The target group of the specification are developers and editors of technical documentation and manufacturer information, which are describing assets in smart manufacturing by means of the Asset Administration Shell (AAS) and therefore need to create a Submodel instance with a hierarchy of SubmodelElements. This document especially details on the question, which SubmodelElements with which semantic identification shall be used for this purpose.

1.2 Scope of the Submodel

This Submodel template aims at interoperable provision of information describing the “Control configuration and parametrization for NC/CNC machines” in regard to the asset of the respective Asset Administration Shell. Central element is the provision of properties [7], ideally interoperable by the means of dictionaries such as ECLASS and IEC CDD (Common Data Dictionary). The purpose of this document is to make selected specifications of Submodels in such manner that information about assets can be exchanged in a meaningful way between partners in a value creation network. It targets people who are commissioning or integrate CNC machines. Therefore a they need data to parametrize the CNC control.

The intended use-case is the provision of a standardized property structure for Control configuration and parametrization for NC/CNC machines, which enables an easy access of data, which is needed to configure or parametrize a CNC controller.

This concept can serve as a basis for standardizing the respective Submodel. The conception is based on existing norms, studies of common practices at enterprises, directives and standards so that a far-reaching acceptance can be achieved.

Beside standardized Submodel this template also introduces standardized SubmodelElementCollections (SMC) in order to improve the interoperability while modelling aspects of Control configuration and parametrization for NC/CNC machines within other Submodels.

1.3 Relevant standards and sources of concepts for the Submodel template

According to [3], interoperable properties might be defined by standards, consortium specifications or manufacturer specifications. Useful standards providing sources of concepts are:

Table 1: List of examplary standards defining interoperable properties

AAS Submodel Digital Nameplate	The digital nameplate AAS is used as a reference to the real asset (control, axis, drive).
AAS Submodel Technial Specification	The technical specification AAS is used as a reference to the technical specification of the real asset (e.g., drive parameters).
AAS Submodel Software Nameplate	The software nameplate AAS is used as a reference to the software asset (control software if one exists)
Gdx Format	To gather more informations about the tool configurations in CNC controls, the gdx format is helbful.
AAS Tool Description wzl Aachen	The main tool description is described in the AAS tool description from WZL Aachen. This description is also used in this AAS.

So called property dictionaries are used identify information elements (see Terms and Definitions of [6]). Such property dictionaries include:

- ECLASS, see: https://www.eclasscontent.com/
- IEC CDD, see: https://cdd.iec.ch/cdd/iec61987/iec61987.nsf and https://cdd.iec.ch/cdd/iec62683/cdddev.nsf

In this document, properties are aimed to be described by ECLASS.

2 Information set for Submodel Control configuration and parametrization for NC/CNC machines

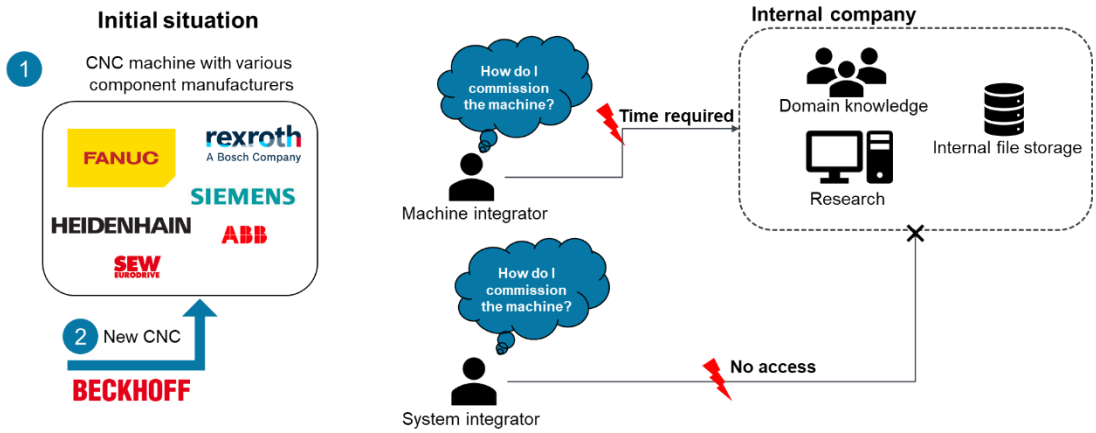
While defining Submodels the following three aspects must be considered as suggested in [5]:

Use and economic relevance

This submodel is designed to simplify the configuration and parameterization of a controller, especially CNC controllers. In general, there are many different CNC manufacturers and there are also different component manufacturers for CNC machines. This makes commissioning a CNC control system increasingly complex, as the parameterization data must first be found.

Two different use cases have been identified (see Figure 1):

Figure 1: Use Cases



Use Case A:
In use case A, a machine integrator commissions a new CNC machine that has not yet been parameterized in the company. For this use case, the machine integrator must draw on internal company knowledge by accessing domain knowledge or internal repositories. They also have to carry out their own research. This process is time-consuming and can be avoided by presenting the information that already exists in a structured way.

Use Case B:

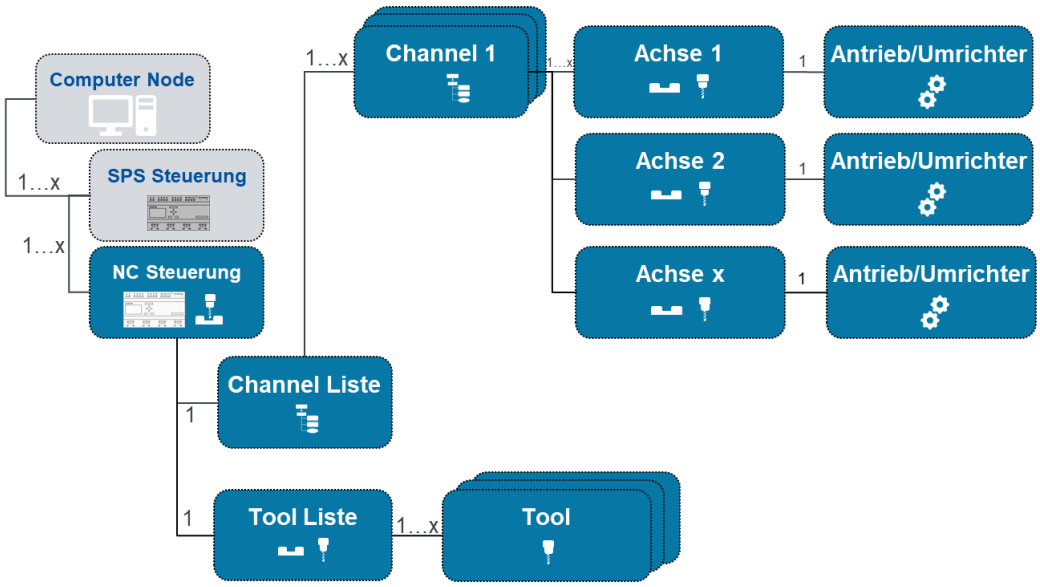
In use case B, a system integrator is also trying to commission a CNC control system. This has a further disadvantage in that it does not even have access to the company's internal files. This makes it even more time-consuming to parameterize the control system.

The possible solution is the use of administration shells as structured data storage to provide information for the parameterization and configuration of a CNC control. To this end, component manufacturers and CNC manufacturers should either provide this administration shell or the machine integrator should create the administration shell so that the reconfiguration of CNC machines can be simplified.

In order to provide an asset administration shell for this application purpose, the first step is to analyze what can be configured. The following sub-components have been identified as shown in Figure 2:

- Channel configuration
- Axis configuration
- Drive configuration
- Tool configuration

Figure 2: CNC Control sub-components



Additionally, the following configuration options are also highlighted:

- Communication configuration
- NC program configuration

Possible functions and interactions

- Consistent use of data that already exists
- Preparation of data that already exists
- Simple provision of data for configuring a CNC control system

Property specification

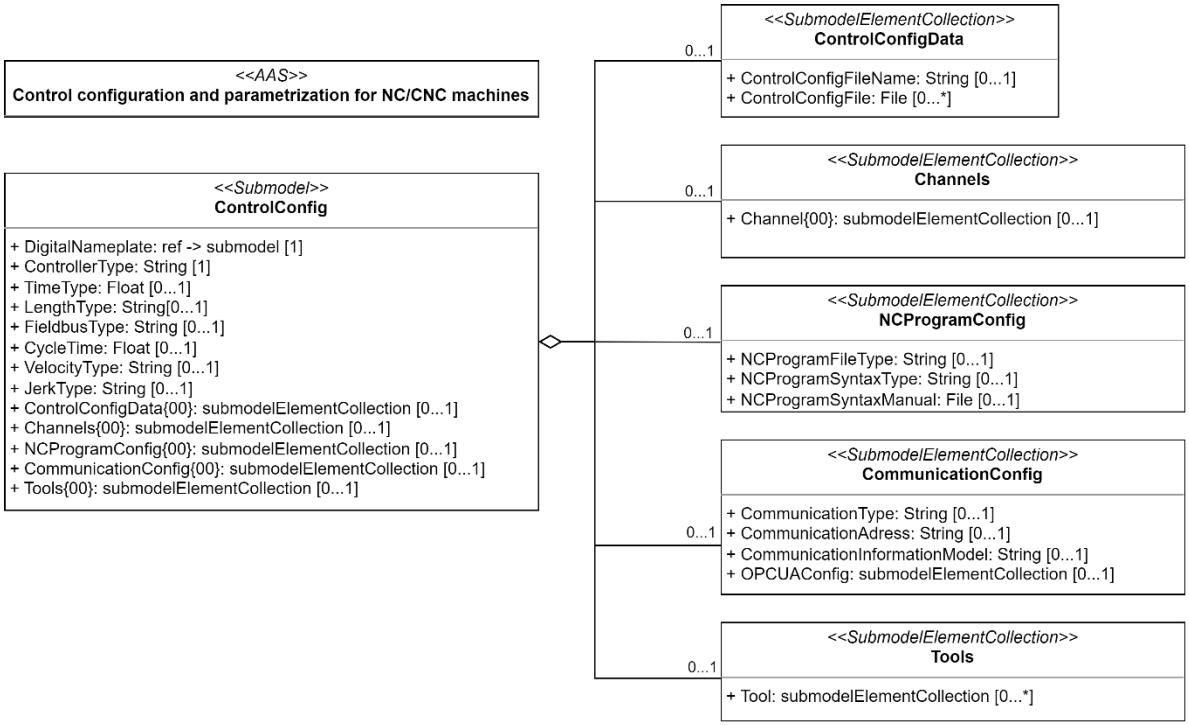
See section 3 Submodel and Collections.

3 Submodel and Collections

3.1 Properties of the Submodel “Control configuration and parametrization for NC/CNC machines”

The figure below shows the UML-diagram defining the relevant properties which need to be set. Table 2 describes the details of the Submodel structure combined with examples.

Figure 3: UML-Diagram for Submodel “Control configuration and parametrization for NC/CNC machines”



The submodel itself is devided into different parts, which can be used to parametrize the CNC control:

- Control configuration
- Channels
- Axis configuration
- Drive configuration
- NC programming configuration
- Communication configuration
- Tool configuration

First of all, we will start with the main Submodel collection “ControllerConfig”. In this submodel the main configuration information of the control is defined like what type is my controller or in which cycle time the controller is operating.

4 shows the more detailed UML diagram and the properties of the SMC ControlConfig.

Figure 4: UML-diagram for the Submodel "ControllerConfig"

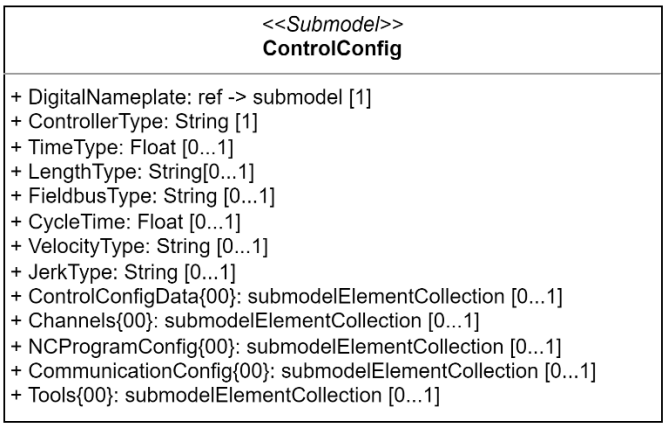


Table 2: Properties of Submodel “ControlConfig”

idShort	ControlConfig *Note: the above idShort shall always be as stated.*		
Class	Submodel		
semanticId			
Explanation	The Submodel “ControlConfig” is the collection for various parametrizations for the control of CNC machines		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] ControllerType	The Controller Type describes the type of controller.	[String]	[1]
[Property] TimeType	Time Configuration of the control	[String] s, ms, us…	[0…1]
[Property] LengthType	Length Type of the control	[string] m, mm, cm, um	[0…1]
[Property] FieldbusType	Fieldbus Type of control	[String] EtherCAT	[0…1]
[Property] CycleTime	Defines the cycle time of the CNC control	[Float] 10ms	[1]
[Property] VelocityType	Defines the velocity type of the CNC control	[String] mm/s	[0…1]
[Property] JerkType	Defines the jerk type of the CNC control	[String]+ m/s^3	[0…1]
[SMC] ControlConfigurationData	Collection of configuration data for the control itself	n/a	[0…1]
[SMC]	Collection of channels of the control	n/a	[0…1]

Channels			
[SMC] NCProgramConfig	Collection of Nc Program configuration information of the control	n/a	[0…1]
[SMC] CommunicationConfig	Collection of Communication configuration of the control	n/a	[0…1]
[SMC] Tools	Collection of tools for the control	n/a	[0…1]

3.2 Properties of the SMC “ControlConfigData”

Figure 5: UML-diagram for the SMC "ControlConfigData"

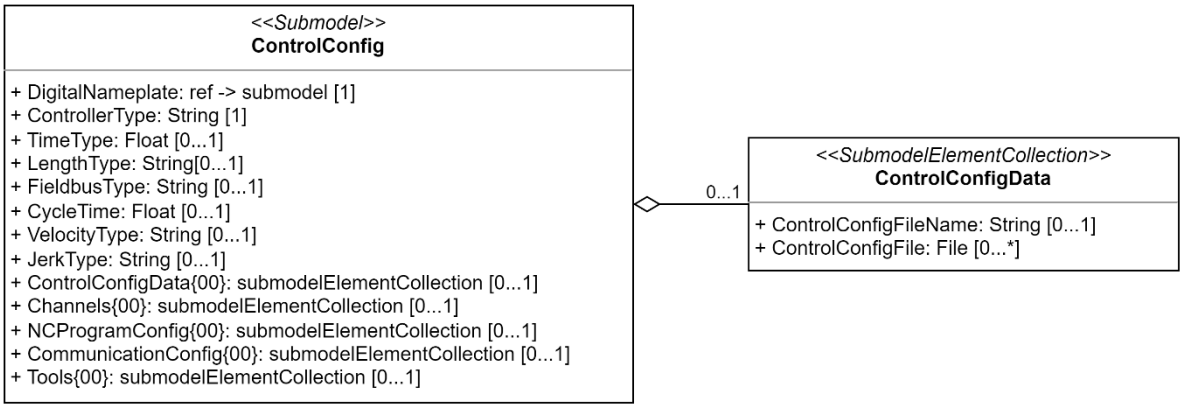


Table 3: Properties of SMC "ControlConfigData"

idShort	ControlConfigData *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	ControlConfig		
Explanation	The SMC “ControlConfigData” is a collection to store configuration data for the main part of the control of CNC machines.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property]	Name of the control configuration file	[String]	[1]

ControlConfigFileName			
[File][1] ControlConfigFile	File to configure the control	[File]	[1]

[1] Recommendation: property declaration as MLP is required by its semantic definition. As the property value is language independent, users are recommended to provide maximal 1 string in any language of the user’s choice.

3.3 Properties of the SMC “Channels”

Figure 6: UML-diagram for the SMC "Channels"

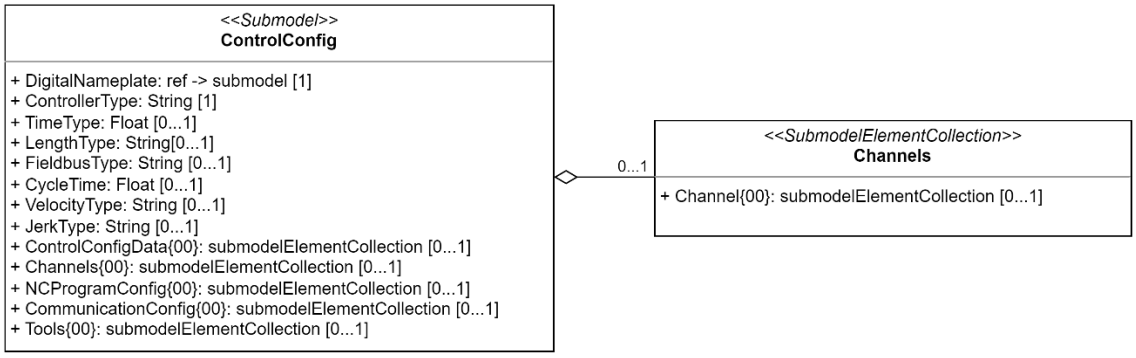


Table 4: Properties of SMC "Channels"

idShort	Channels *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	False		
Parent	ControlConfig		
Explanation	The SMC “Channels” is a collection of channels of the CNC controller.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] Channel	Configuration information of a specific channel	n/a	[1..*]

3.4 Properties of the SMC “Channel”

Figure 7: UML-diagram for the SMC "Channel"

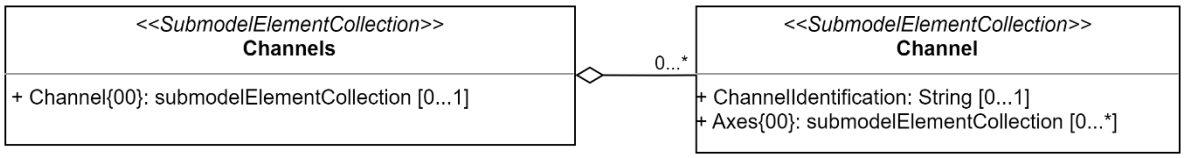


Table 5: Properties of SMC "Channel"

idShort	Channel *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Channels		
Explanation	The SMC “Channel” is a collection of channel informations of the CNC controller.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] ChannelId	This describes the unique channel id of the specific channel	[String] Channel1	[0…1]
[SMC] Axes	Collection of axes under the channel	n/a	[0…*]

3.5 Properties of the SMC “Axes”

Figure 8: UML-diagram for the SMC "Axes"

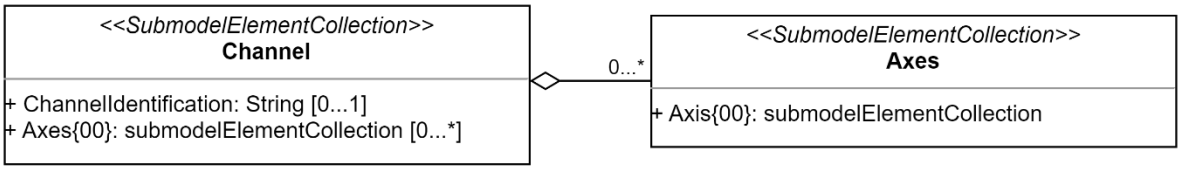


Table 6: Properties of SMC "Axes”

idShort	Axes *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Channel		
Explanation	The SMC “Axes” is a collection of axes of the CNC controller.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] Axis	Specific Axis description	n/a	[0…*]

3.6 Properties of the SMC “Axis”

Figure 9: UML-diagram for the SMC "Axis"

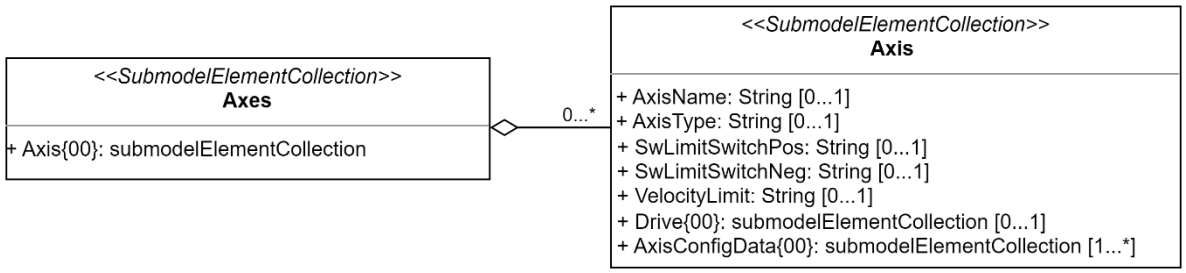


Table 7: Properties of SMC "Axis”

idShort	Axis *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Axes		
Explanation	The SMC “Axis” is a collection of axis configuration information.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] AxisName	Name of the axis	[String] Axis1 @en	[0…1]
[Property] AxisType	Type of the axis	[String] Linear axis	[0…1]
[Property] SwLimitSwitchPos	Positive software limit switch	[Float]	[0…1]
[Float] SwLimitSwitchNeg	Negative software limit switch	[Float]	[0…1]
[Float] VelocityLimit	Velocity limit of the axis	[Float]	[0…1]
[SMC] Drive	Collection of drive configuration	n/a	[0…1]

[SMC] AxisConfigData	Collection of axis configuration data	n/a	[0…1]

3.7 Properties of the SMC “AxisConfigData”

Figure 10: UML-diagram for the SMC "AxisConfigData"

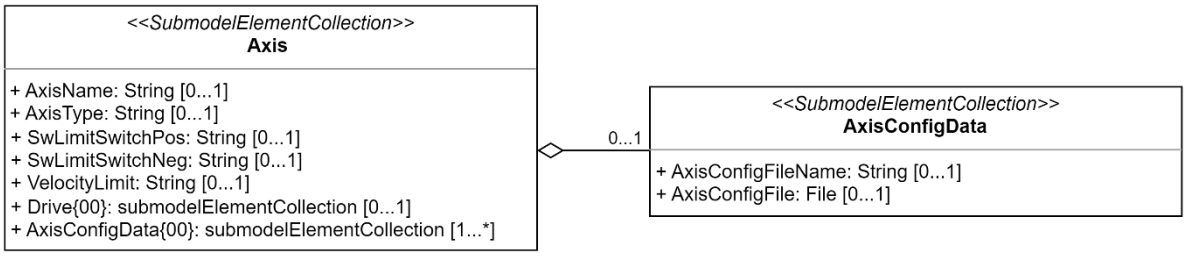


Table 8: Properties of SMC "AxisConfigData”

idShort	AxisConfigData *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Axis		
Explanation	The SMC “AxisConfigData” is a collection of axis configuration data.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] AxisConfigFileName	Axis configuration file name	[String]	[0…1]
[File] AxisConfigFile	Configuration file of the axis	n/a	[0…1]

3.8 of the SMC “Drive”

Figure 11: UML-diagram for the SMC "Drive"

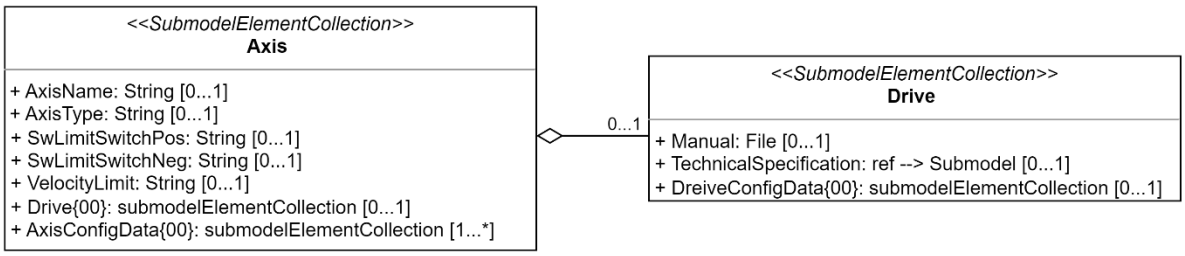


Table 9 : Properties of SMC "Drive”

idShort	Drive *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Axis		
Explanation	The SMC “Drive” is a collection of drive configuration information.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[File] Manual	The manual file of the drive	n/a	[0…1]
[Ref] TechnicalSpecification	Reference to the Submodel Technical Specification of the axis to gather more informations about e.g.: • Drive transmission • Nominal Torque • Nominal Speed • Firmware File • …	n/a	[0…1]
[SMC] DriveConfigData	Collection of configuration data of the drive	n/a	[0…1]

3.9 Properties of the SMC “DriveConfigData”

Figure 12: UML-diagram for the SMC "DriveConfigData"

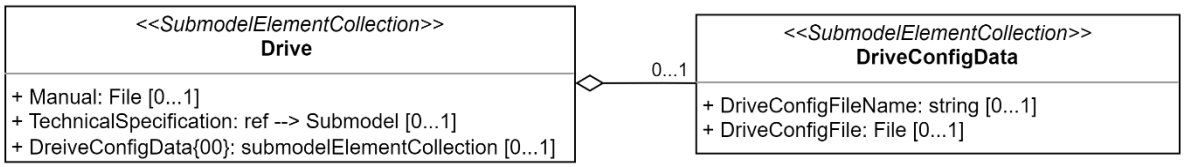


Table 10: Properties of SMC "DriveConfigData”

idShort	DriveConfigData *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Drive		
Explanation	The SMC “DriveConfigData” is a collection of drive configuration data.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] DriveConfigFileName	Name of the configuration file of the drive	[String]	[0…1]
[File] DriveConfigFile	Configuration File of the drive	n/a	[0…1]

3.10 Properties of the SMC “NCProgramConfig”

Figure 13: UML-diagram for the SMC "NCProgramConfig"

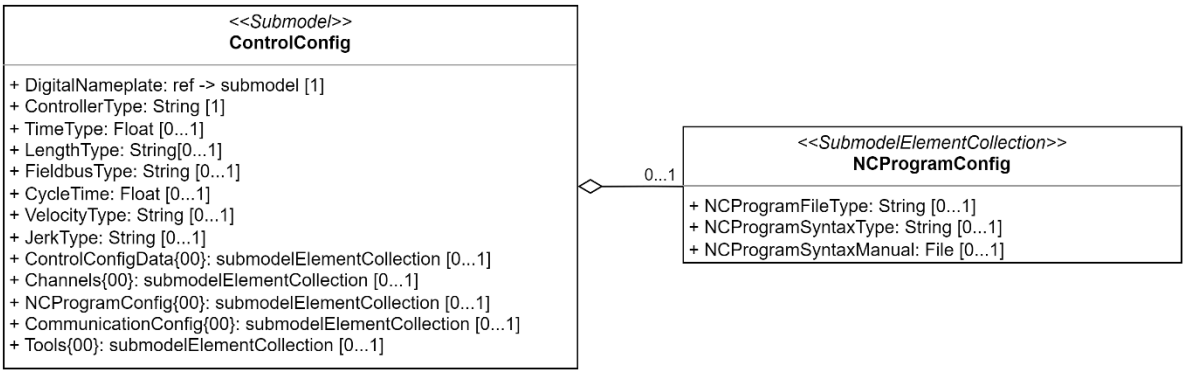


Table 11: Properties of SMC "NCProgramConfig”

idShort	NCProgramConfig *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	ControlConfig		
Explanation	The SMC “NCProgramConfig” is a collection of NC program configuration information.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] NCProgramFileType	NC Program file type, which the CNC control can work with	[String] .nc	[0…1]
[Property] NCProgramSyntaxType	NC Program Syntax type	[String] DIN 66025	[0…1]
[File] NCProgramSyntaxManual	Manual file of the Syntax of the NC Program	n/a	[0…1]

3.11 Properties of the SMC “CommunicationConfig”

Figure 14: UML-diagram for the SMC "CommunicationConfig"

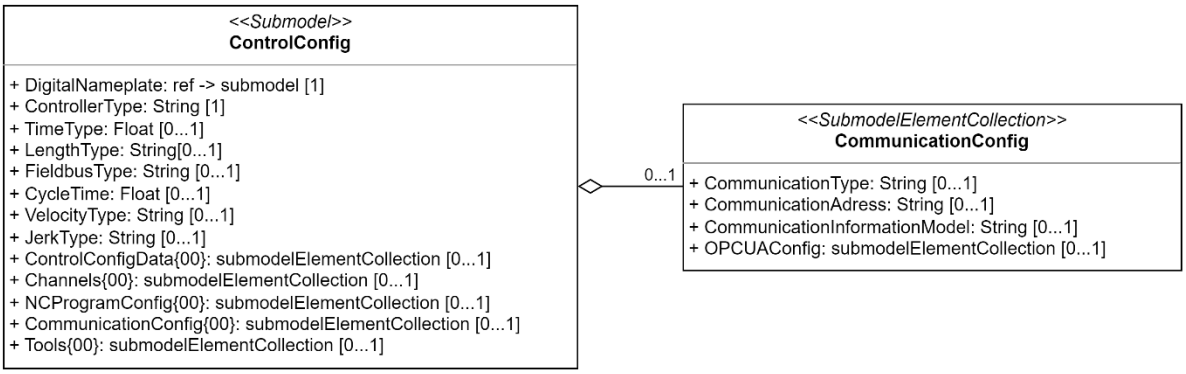


Table 12: Properties of SMC "CommunicationConfig”

idShort	CommunicationConfig *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	ControlConfig		
Explanation	The SMC “CommunicationConfig” is a collection of communication configuration information.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] CommunicationType	Type of communication to the control	[String] MQTT	[0…1]
[Property] CommunicationAdress	Communication address into the control	[String]	[0…1]
[Property] CommunicationInformationModel	Communication information model if ones exist like OPCUA	[String] OPCUA	[0…1]
[SMC] OPCUAConfig	Collection of the OPCUA configuration	n/a	[0…1]

3.12 Properties of the SMC “OPCUAConfig”

Figure 15: UML-diagram for the SMC "OPCUAConfig"

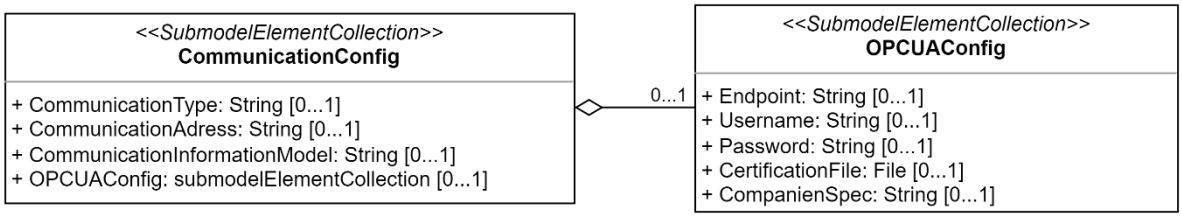


Table 13: Properties of SMC "OPCUAConfig”

idShort	OPCUAConfig *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	CommunicationConfig		
Explanation	The SMC “OPCUAConfig” is a collection of OPCUA server access configuration information.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] Endpoint	Endpoint to the OPCUA server if one exists	[String]	[0…1]
[Property] Username	Username to enter the OPCUA server	[String]	[0…1]
[Property] Password	Password to enter the OPCUA server	[String]	[0…1]
[File] CertificationFile	Certification file to enter the OPCUA server	n/a	[0…1]
[Property] CompanionSpec	Companion specification of the server	[String]	[0…1]
[Ref] OPCUAServerDataSheet	Coming soon (if available replace this SMC - CommunicationConfig		

3.13 Properties of the SMC “Tools”

Figure 16: UML-diagram for the SMC "Tools"

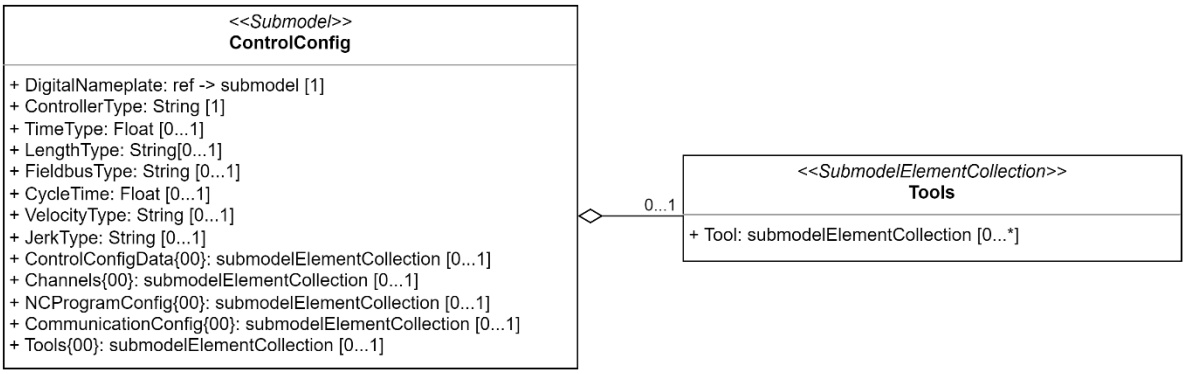


Table 14: Properties of SMC "Tools”

idShort	Tools *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Controller		
Explanation	The SMC “Tools” is a collection of tools of the CNC controller.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] Tool	Collection of Tools which are used by the control	n/a	[0…*]

3.14 Properties of the SMC “Tool”

Figure 17: UML-diagram for the SMC "Tool"

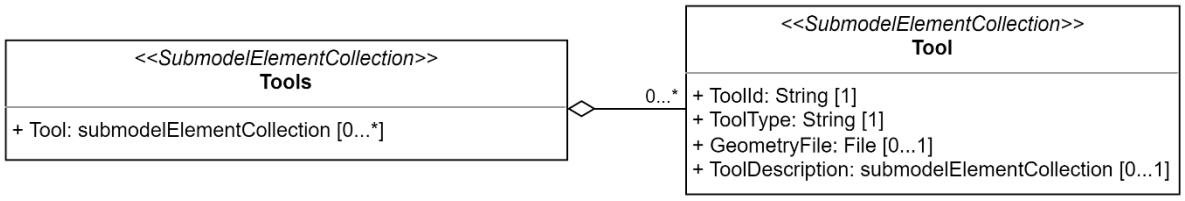


Table 15: Properties of SMC "Tool”

idShort	Tool *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Tools		
Explanation	The SMC “Tool” is a collection of tool configuration information.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] ToolId	Identification number of the tool.	[String]	[1]
[Property] ToolType	Type of the specific tool.	[String] End milling	[1]
[File] GeometryFile	Geometry file of the tool, with a drawing and the dimensions. Can be standardized with gdx standard.	n/a	[0…1]
[SMC] ToolConfig	Collection of tool information to be parametrized by the CNC control, if no standard is defined	n/a	[0…1]

3.15 Properties of the SMC “ToolConfig”

Figure 18: UML-diagram for the SMC "ToolConfig"

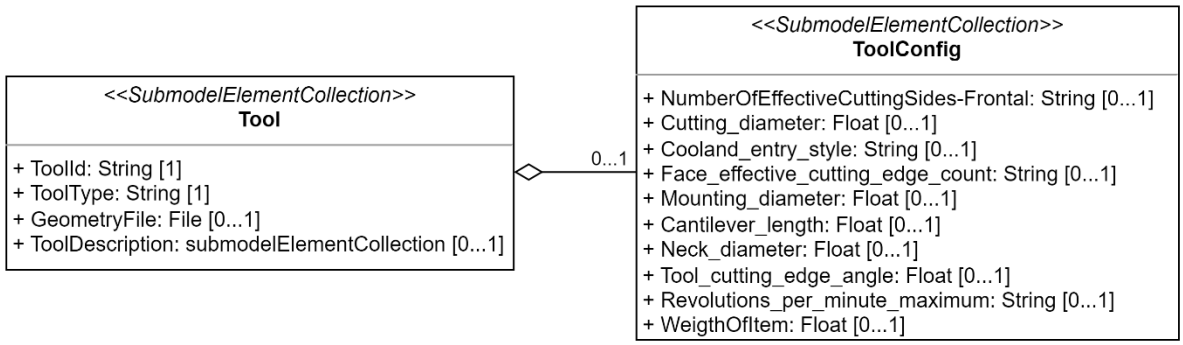


Table 16: Properties of SMC "ToolConfig”

idShort	ToolConfig *Note: the above idShort shall always be as stated.*		
Class	SubmodelElementCollection		
semanticId			
isCaseOf			
AllowDuplicates	True		
Parent	Tool		
Explanation	The SMC “ToolConfig” is a collection of tool configuration description. The tool description is still work in progress.		
[SME type]	**semanticity = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] NumberOfEffectiveCuttingSides-Frontal		[String]	[0…1]
[Property] Cutting_diameter		[Float]	[0…1]
[Property] Coolant_entry_style		[String]	[0…1]
[Property] Face_effective_cutting_edge_count		[String]	[0…1]
[Property] Mounting_diameter		[Float]	[0…1]
[Property]		[Float]	[0…1]

Cantilever_length			
[Property] Neck_diameter		[Float]	[0…1]
[Property] Tool_cutting_edge_angle		[Float]	[0…1]
[Property] Revolutions_per_minute_maximum		[String]	[0…1]
[Property] WeightOfItem		[Float]	[0…1]

4 Usage as SubmodelElementCollection

4.1 Properties of the Submodel “Control configuration and parametrization for NC/CNC machines”

Due to the fact that xy can be re-used in various contexts beside service issues, the specified SMC “XY” in section 3 can be used within other Submodels. In this way the parent Submodel can utilize standardized means of …

Dieses Submodel kann als SMC verwendet werden, wenn in einer Produktionsanlage mehrere CNC Steuerungen verbaut sind. Dadurch kann jedes CNC „Asset“ seine eigene Konfiguration erhalten.

Annex A: Explanations on used table formats

General
The used tables in this document try to outline information as concise as possible. They do not convey all information on Submodels and SubmodelElements. For this purpose, the definitive definitions are given by a separate file in form of an AASX file of the Submodel template and its elements.

Tables on Submodels and SubmodelElements
For clarity and brevity, a set of rules is used for the tables for describing Submodels and SubmodelElements.

- The tables follow in principle the same conventions as in [5].
- The table heads abbreviate 'cardinality' with 'card'.
- The tables often place two informations in different rows of the same table cell. In this case, the first information is marked out by sharp brackets [] form the second information. A special case are the semanticIds, which are marked out by the format: (type)(local)[idType]value.
- The types of SubmodelElements are abbreviated: SME

SME type Submodel	**Element type**
Property	Property
MLP	MultiLanguageProperty
Range	Range
File	File
Blob	Blob
Ref	ReferenceElement
Rel	RelationshipElement
SMC	SubmodelElementCollection

- If an idShort ends with '{00}', this indicates a suffix of the respective length (here: 2) of decimal digits, in order to make the idShort unique. A different idShort might be choosen, as long as it is unique in the parent’s context.
- The Keys of semanticId in the main section feature only idType and value, such as: [IRI]https://admin-shell.io/vdi/2770/1/0/DocumentId/Id. The attributes "type" and "local" (typically "ConceptDescription" and "(local)" or "GlobalReference" and (no-local)") need to be set accordingly; see [6].
- If a table does not contain a column with "parent" heading, all represented attributes share the same parent. This parent is denoted in the head of the table.
- Multi-language strings are represented by the text value, followed by '@'-character and the ISO 639 language code: example@de.
- The [valueType] is only given for Properties.

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