June 2023

Specification of the Asset Administration Shell

Part 2: Application Programming Interfaces

SPECIFICATION

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1 Preamble

1.1 Editorial Notes

This document (version 3.0) was produced from November 2021 to May 2023 by the joint sub working group "Asset Administration Shell" of the working group "Reference Architectures, Standards and Norms" of the Plattform Industrie 4.0 and the working group "Open Technology" of the Industrial Digital Twin Association (IDTA). It is the first release published by the Industrial Digital Twin Association.

Earlier versions of this document were release candidates and used the version 1.0. It has been decided in the meantime that this first release will start with version 3.0, in line with the related release of the metamodel.

Version 1.0 RC02 of this document was developed from November 2020 to November 2021 by the joint working groups “Asset Administration Shell” and “Infrastructure of the Asset Administration Shell” of the Plattform Industrie 4.0 working group “Reference Architectures, Standards and Norms“.

Version 1.0 RC01 of this document was developed from December 2019 to November 2020 by the sub working groups “Asset Administration Shell” and “Infrastructure of the Asset Administration Shell” of the Plattform Industrie 4.0 working group “Reference Architectures, Standards and Norms“.

This document is Part 2 of the document series “Specification of the Asset Administration Shell”.

This specification is versioned using Semantic Versioning 2.0.0_ and follows the semver specification [4].

1.2 Metamodel Versions

This document (version 3.0) uses the following parts of the “Specification of the Asset Administration Shell” series:

- Part 1: Metamodel in version 3.0 [1]
- Part 3a: Data Specification – IEC 61360 in version 3.0 [2]
- Part 5: Package File Format (AASX) in version 3.0 [3]

1.3 Scope of this Document

This document specifies the interfaces as well as the APIs in selected technologies for the Asset Administration Shells and its submodels.

1.4 Structure of the Document

Clause 3 gives an introduction to the topic. General topics are discussed in Clause 4. The technology-neutral specification of the interfaces of the Asset Administration Shell can be found in Clauses 5 to 11.

Clause 12 defines the API specification for HTTP/REST. Annex B gives an example for the ValueOnly-serialization of the payload.

Clause 13 provides a summary and outlook.

The tables used to specify operations and interfaces are explained in the annex. Additionally, non-normative examples are given to illustrate in particular the different serialization alternatives.

2 Terms, Definitions and Abbreviations

2.1 Terms and Definitions

Please note: the definitions of terms are only valid in a certain context. This glossary applies only within the context of this document.

If available, definitions were taken from IEC 63278-1 DRAFT, July 2022.

API

specification of the set of operations and events that forms an API in a selected technology

API Operation

specification of the operations (procedures) that may be called through an API

Asset Administration Shell (AAS)

standardized digital representation of an asset

Note: Asset Administration Shell and Administration Shell are used synonymously.

→ [SOURCE: IEC 63278-1, note added]

Interface

defined connection point of a functional unit which can be connected to other functional units

Note 1: “defined” means that the requirements and the assured properties of this connection point are described.
Note 2: the combination of interfaces of function units is also called an interface.
Note 3: in an information system, the defined exchange of information takes place at this point.
Note 4: an interface places certain requirements on the connection that is to be made.
Note 5: an interface demands certain features.

[Source: Glossary Industrie 4.0
DUDEN (modified)
ISO/IEC 13066-1:2011(en), 2.15 (modified)
DIN EN 60870-5-6:2009-11 (modified)
DIN IEC 60625-1:1981-05 (modified)]

Interface Operation

interface operations define interaction patterns via the specified interface

operation

executable realization of a function

Note 1: the term method is synonymous to operation.
Note 2: an operation has a name and a list of parameters [ISO 19119:2005, 4.1.3].

→ [SOURCE: Glossary Industrie 4.0, editorial changes]

service

Demarcated scope of functionality which is offered by an entity or organization via interfaces

Note: one or multiple operations can be assigned to one service.

→ [SOURCE: Glossary Industrie 4.0]

service specification

specification of a service according to the notation, architectural style and constraints of a selected technology

Note: one or multiple API Operations can be assigned to one service specification.

Submodel

representation of an aspect of an asset

→ [SOURCE: IEC 63278-1]

SubmodelElement

element of a Submodel

→ [SOURCE: IEC 63278-1]

2.2 Abbreviations

Abbreviation	Description
AAS	Asset Administration Shell
AASX	Package file format for the AAS
AML	AutomationML
API	Application Programming Interface
BITKOM	Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e. V.
BLOB	Binary Large Object
CDD	Common Data Dictionary
GUID	Globally unique identifier
ID	Identifier
IDTA	Industrial Digital Twin Association
IEC	International Electrotechnical Commission
IRDI	International Registration Data Identifier
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
MIME	Multipurpose Internet Mail Extensions
OPC	Open Packaging Conventions (ECMA-376, ISO/IEC 29500-2)
OPCF	OPC Foundation
OPC UA	OPC Unified Architecture
PDF	Portable Document Format
RAMI4.0	Reference Architecture Model Industrie 4.0
RDF	Resource Description Framework
REST	Representational State Transfer
RFC	Request for Comment
ROA	Resource Oriented Architecture
SOA	Service Oriented Architecture
UML	Unified Modeling Language
URI, URL, URN	Uniform Resource Identifier, Locator, Name
VDE	Verband der Elektrotechnik Elektronik Informationstechnik e. V.
VDI	Verein Deutscher Ingenieure e.V.
VDMA	Verband Deutscher Maschinen- und Anlagenbau e.V.
W3C	World Wide Web Consortium
XML	eXtensible Markup Language
ZIP	archive file format that supports lossless data compression
ZVEI	Zentralverband Elektrotechnik- und Elektronikindustrie e. V.

3 Introduction

This document defines APIs for enabling the access to the information provided by an Asset Administration Shell. The underlying information model is as defined in [1].

Since an API can be specified in different technologies like HTTP/REST, MQTT and OPC UA, the specification offers a technology-neutral specification of the interfaces.

While Part 5 of the specification series of the Asset Administration Shell [3] mainly considered file exchange, this specification focuses on the API that allows online access to information provided by the AAS (see Figure 1).

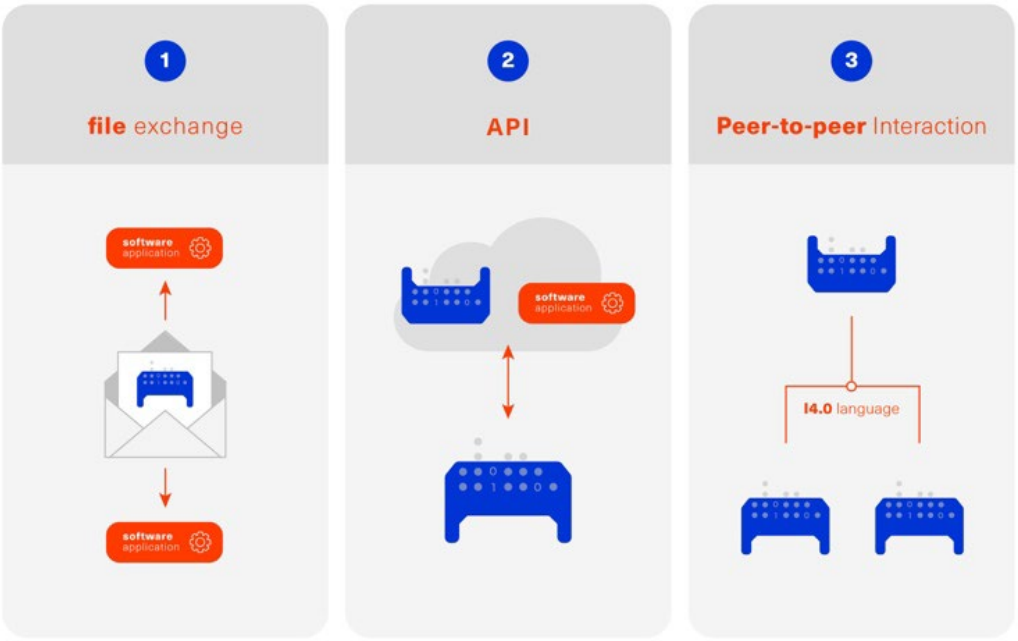


Figure 1 Types of Information Exchange via Asset Administration Shells

4 General

4.1 Services, Interfaces and Interface Operations

This document uses the Industrie 4.0 Service Model illustrated in

Figure 2 for a uniform understanding and naming. It basically distinguishes between associated concepts on several levels (from left to right):

- technology-neutral level: concepts that are independent from selected technologies;
- technology-specific level: concepts that are instantiated for a given technology and/or architectural style (e.g. HTTP/REST, OPC UA, MQTT);
- implementation level: concepts that are related to an implementation architecture that comprises one or more technologies (e. g. C#, C++, Java, Python);
- runtime level: concepts that are related to identifiable components in an operational Industry 4.0 system.

This document deals with the concepts of the technology-neutral and technology-specific level. However, to avoid terminological and conceptual misunderstandings, the whole Industrie 4.0 Service Model is provided here.

The technology-neutral level comprises the following concepts:

- **Service**: a service describes a demarcated scope of functionality (including its informational and non-functional aspects), which is offered by an entity or organization via interfaces.
- **Interface**: this is the most important concept as it is understood to be the unit of reusability across services and the unit of standardization when mapped to application programming interfaces (API) in the technology-specific level. One interface may be mapped to several APIs depending on the technology and architectural style used, e.g. HTTP/REST or OPC UA, whereby these API mappings also need to be standardized for the sake of interoperability.
- **Interface-Operation**: interface operations define interaction patterns via the specified interface.

The technology-specific level comprises the following concepts:

- **Service Specification**: specification of a service according to the notation, architectural style, and constraints of a selected technology. Among others, it comprises and refers to the list of APIs that forms this service specification. These may be I4.0-defined standard APIs but also other, proprietary APIs.

Note: such a technology-specific service specification may be but does not have to be derived from the “service” described in the technology-neutral form. It is up to the system architect and service engineer to tailor the technology-specific service according to the needs of the use cases.

- **API**: specification of the set of operations and events that forms an API in a selected technology. It is derived from the interface description on the technology-neutral level. Hence, if there are several selected technologies, one interface may be mapped to several APIs.
- **API-Operation**: specification of the operations (procedures) that may be called through an API. It is derived from the interface operation description on the technology-neutral level. When selecting technologies, one interface operation may be mapped to several API-operations; several interface operations may also be mapped to the same API-operation.

The implementation level comprises the following concepts:

- **Service-Implementation**: service realized in a selected implementation language following the specification in the Service Specification description on the technology-specific level.

- **API-Implementation**: set of operations realized in a selected implementation language following the specification in the API description on the technology-specific level.
- **API-Operation-Implementation**: concrete realization of an operation in a selected implementation language following the specification in the API-Operation description on the technology-specific level.

The runtime level comprises the following concepts:

- **Service-Instance**: instance of a Service-Implementation including its API-Instances for communication. Additionally, it has an identifier to be identifiable within a given context.
- **API-Instance**: instance of an API-Implementation which has an endpoint to get the information about this instance and the related operations.
- **API-Operation-Instance**: instance of an API-Operation-Implementation which has an endpoint to get invoked.

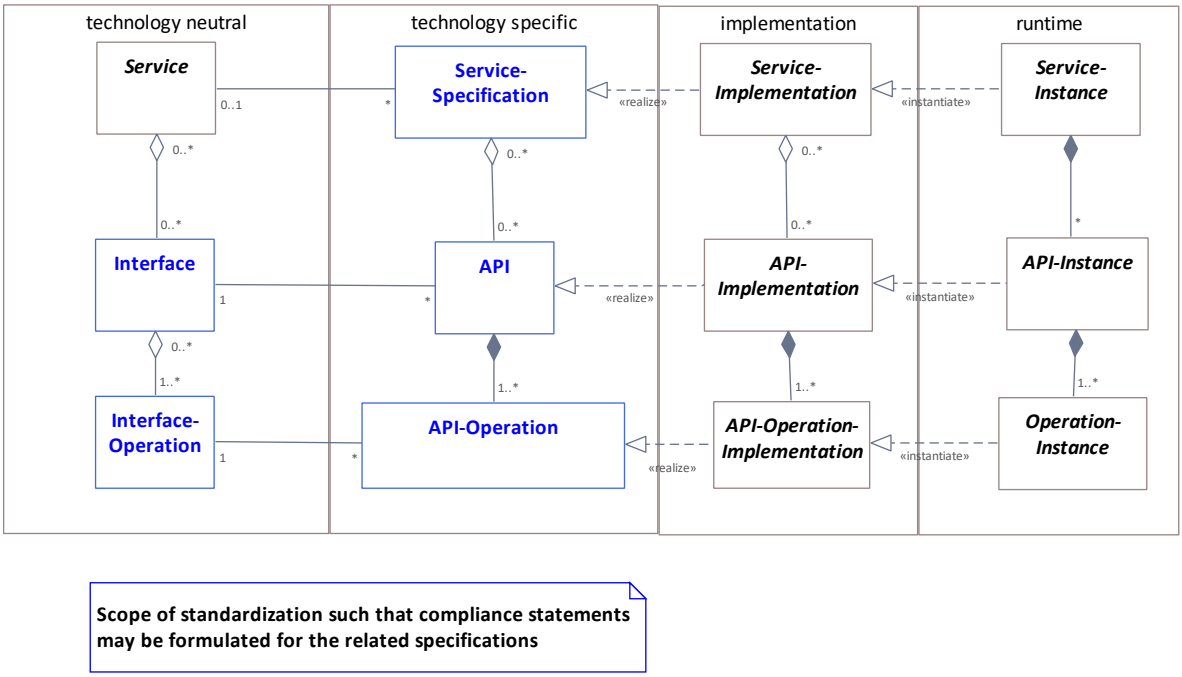


Figure 2 Services, Interfaces & APIs and Operations

One important message from the Industrie 4.0 Service Model is that it is the level of the interface (mapped to technology-specific APIs) that

- provides the unit of reusability,
- is the foundation for interoperable services, and
- provides the reference unit for compliance statements.

Therefore, this document defines the interfaces and operations which are needed for interaction regarding the elements of the Asset Administration Shell metamodel starting with Clause 5.

4.2 Design Principles

The operations of the interfaces follow a resource-oriented approach which is close to general REST principles but not as strict in every situation. The approach consists of the three main agreements:

- Stateless: the API is stateless. Each operation is independent. The server is always consistent after each operation.

- Resources (nouns): each resource is a clearly defined noun. This means that it has a specific name and its relation to other nouns is defined. The nouns and the relationships between them are taken from the list of referable objects of “Specification of the Asset Administration Shell Part 1” and their relationships. Clause 10.2 gives an additional list of resources.
- Methods (verbs): a small set of standard REST methods (GET, POST, PUT, DELETE) is used to describe the semantic of the most common operations. There are only a few exceptions for situations where the standard methods do not fit (e.g. GETALL, SET, INVOKE).

The methods are:

- GET: a GET returns a single resource based on the resource identifier which is the identifier [1] for identifiables and the idShortPath for referables.
- GETALL: returns a list of resources based on optionally available parameters such as filters.
- POST: creates a new resource. The identifier of the resource is part of the resource description. This is necessary because the id of identifiables is globally unique and should be the identifier for the object in every system. This implies that the creation of an identifiable is idempotent. There shall never be more than one identifiable with the same ID in one system. For example, trying to post the same AAS object twice will not create two AAS resources.
- PUT: replaces an existing resource.
- PATCH: updates an existing resource. The content to be replaced will be defined by the given SerializationModifiers, e.g. content=value provides the ValueOnly-serialization to update all values in the existing resource. The structure of the existing resource on the server and of the content given by the PATCH must be the same.

Note: values remain unchanged with content=metadata.

- DELETE: deletes a resource based on a given identifier.
- SET: sets the value of an object, e.g. the value of a Property.
- INVOKE: invokes an operation at a specified path.

Note: these methods are intended for the naming of interfaces as described in Figure 2. They shall not be interpreted as new protocol methods, e.g. on HTTP level.

Naming rules for operations:

The following rules shall apply for the operation names in Asset Administration Shell Interface, Submodel Interface, Shell Repository Interface, Submodel Repository Interface, Concept Description Repository Interface:

```
<Interface Operation>    ::=  <Method Verb><Model Element Name>[<Modifier>]
                              ["By"<By-Qualifier>]

<Method Verb>            ::=  "Get" | "GetAll" | "Put" | "Post" | "Patch" |
                              "Delete" | "Set" | "Invoke"

<Model Element Name>     ::=  "AssetAdministrationShell"["s"] | "SubmodelReference"
                              ["s"] |
                              "AssetInformation" | "Submodel"["s"] |
                              "SubmodelElement"["s"] | "ConceptDescription"["s"]

<Modifier>               ::=  "Value" | "IdShortPath" | "Reference"

<By-Qualifier>           ::=  "Id" | "SemanticId" | "ParentPathAndSemanticId" |
                              "Path" | "AssetId" | "IdShort" | "IsCaseOf" |
                              "DataSpecificationReference"
```

Examples:

GetSubmodel has method verb “Get” and element name “Submodel”.

GetAllSubmodelElementsByPath has method verb “GetAll” and element name “SubmodelElements” plus a by-qualifier “Path”.

4.3 Semantic References for Operations

The operations of this document need unique identifiers to reach a common understanding and allow all involved parties to reference the same things. These identifiers need to be globally unique and understandable by the community and implementing systems. Furthermore, the identifiers need to support a versioning scheme for future updates and extensions of the metamodel. The identifiers defined in this document are reused in related resources, for instance REST API operations or in self-descriptions of implementing services.

Internationalized Resource Identifiers (IRIs), Uniform Resource Identifiers (URIs) [5] in particular, and the requirements of DIN SPEC 91406 [6], serve as the basic format. Further design decisions include ‘https’ as the URI scheme, and the controlled domain name ‘admin-shell.io’ as the chosen authority. Both decisions guarantee the interoperability of the identifiers and their durability, since URIs are generally well-known and proven, while the domain is controlled and served through the Plattform Industrie 4.0. All identifiers included in the ‘admin-shell.io’ domain are described in a lightweight catalogue in the form of markdown documents; they are continuously maintained and updated[1]. The catalogue itself is structured in several sub-namespaces specified by the first path parameter. All URIs of this document reflect entities of the core metamodel, which are contained in the sub-namespace identified with the ‘/aas/API’ path.

The described identifiers appear mainly in the semanticId field of every class and operation. They are required since the class name is not necessarily constant over time. The respective semanticIds, however, guarantee the unique and certain relation between a reference and the referenced class or operation. The URIs are constructed as follows (compare to Clause Semantic Identifiers for Metamodel and Data Specifications in Part 1 [1]).

Note 1: version information is explicitly included in each identifier.
Note 2: even though the usage of the ‘https’ scheme might indicate URLs, all identifiers are regarded as URI look ups; dereferencing them cannot be expected.

The following grammar is used to create valid identifiers:

```
<Identifier>    ::= <Namespace>"/aas/API/"<OperationName>"/"<Version>

<Namespace>     ::= "https://admin-shell.io

<OperationName> ::= {<Character>}+

<Version>    ::= {<Digit>}+"/"{<Digit>}+["/"{<Character>}+]

<Digit>      ::= "0" | "1" | "2" | "3" | "4" | "5" | "6" | "7" | "8" | "9"

<Character>     ::= an unreserved character permitted by DIN SPEC 91406


?       ::= zero or one

+       ::= one or more
```

[1] https://github.com/admin-shell-io/id

Examples for valid identifiers:

- https://admin-shell.io/aas/API/GetSubmodel/1/23
- https://admin-shell.io/aas/API/GetAllSubmodelElements/1/0/RC03
- https://admin-shell.io/aas/API/GetAllSubmodelElements/3/0

Examples for invalid identifiers:

- http://admin-shell.io/API/GetSubmodel/1/0
  The scheme is different to 'https', and the 'aas' path segment is missing
- https://admin-shell.io/aas/API/GetSubmodel
  Version information is missing
- https://admin-shell.io/aas/API/GetSubmodel/1/0#0173-%20ABC#001
  The URI includes DIN SPEC 91406-reserved (#) and impermissible (%) characters

4.4 References and Keys

The concept of references is introduced in Part 1 of the series " Specification of the Asset Administration Shell" [1].

When defining interfaces, a distinction is made between relative references and absolute references.

Absolute references require a global unique id as starting point of the reference to be resolvable. In this case the type "Reference" is used.

Relative references do not start with a global unique id. Instead, it is assumed that the context is given and unique. In this case, the key list only contains keys with *Key/type* that references a non-identifiable referable (e.g. a Property, a Range, a RelationshipElement, etc.).

4.5 Special Parameters

The following table describes special parameters used for consistency throughout the document.

Table 1 Special Parameters

Parameter	Description
path	IdShort-Path via relative Reference/Keys to a submodel element
OperationHandle	The returned handle of an operation's asynchronous invocation used to request the current state of the operation's execution
OperationResult	The returned result of an operation's invocation
SerializationModifier	Defines the format of the input or the output of an operation
SerializationFormat	Determines the format of serialization, i.e. JSON, XML, RDF, AML, etc.
ShellDescriptor	Object containing the Asset Administration Shell's identification and endpoint information
SubmodelDescriptor	Object containing the Submodel's identification and endpoint information
SpecificAssetId	The name of the specific asset identifier or the predefined name "*globalAssetId*" that would refer to the *AssetInformation/globalAssetId*
SemanticId	Identifier of the semantic definition

4.6 Relation of Interfaces

The following chapters define several interfaces, which work together as a system and support different deployment scenarios.

There are three major components of the overall system:

1. Repositories store the data of Asset Administration Shells, Submodels, and Concept Descriptions,
2. Registries are “directories” which store AAS-IDs and Submodel-IDs together with the related endpoints (typically a URL-path into a repository or to a single AAS/Submodel),
3. discovery (servers) supports a fast search and only store copies of essential information, i.e. key value pairs to find IDs by other IDs.

Figure 3 shows a typical sequence. Discovery finds the AAS-ID for a given Asset-ID. A Registry provides the endpoint for a given AAS-ID. Such an endpoint for an AAS and the related Submodel-IDs make the submodels with their submodelElements accessible.

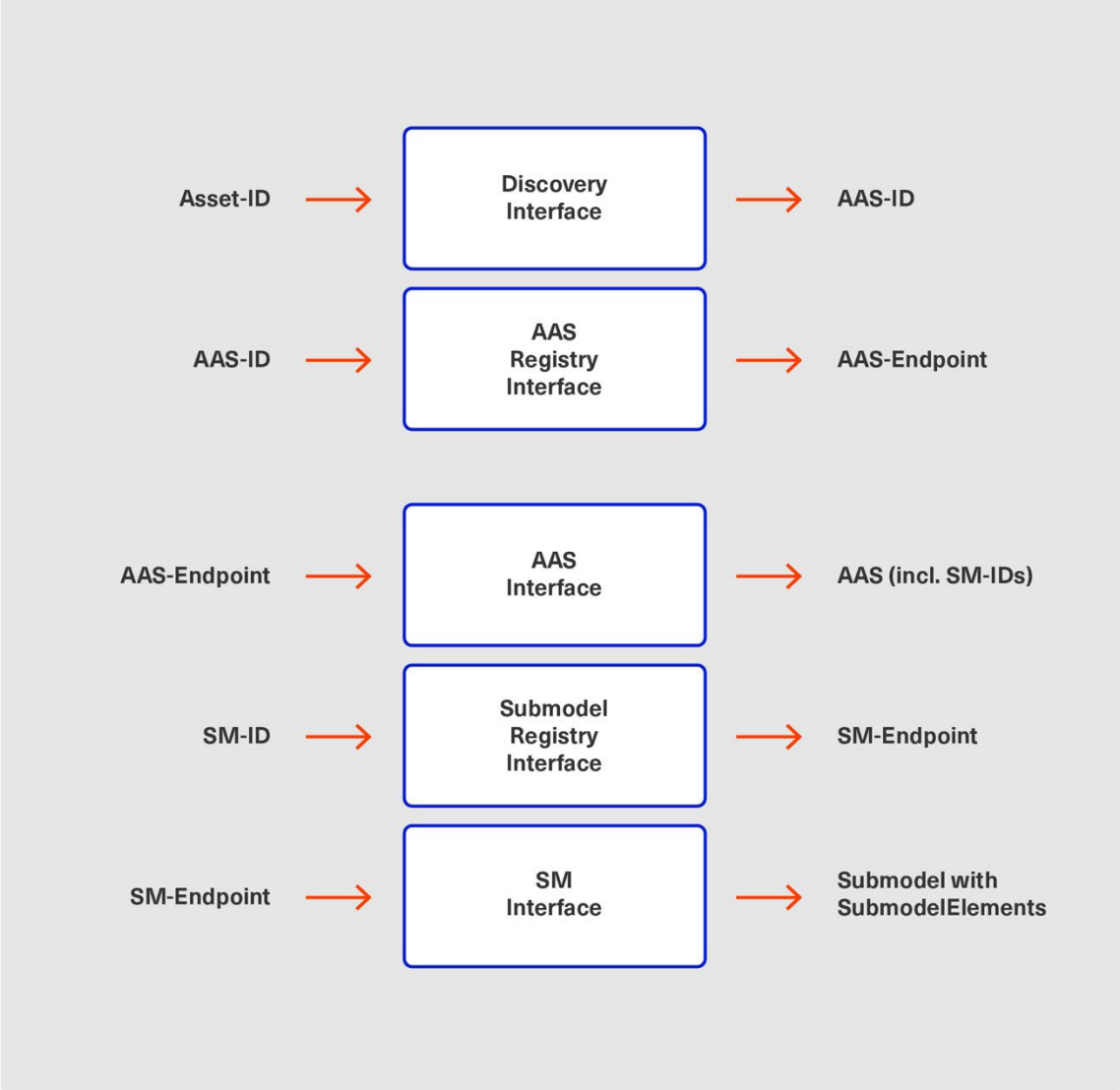


Figure 3 Retrieval of Asset-related Information by AAS and Submodels

The Asset Administration Shell model is an asset-oriented model.

An Asset-ID may be retrieved e.g. by a QRCODE on the asset, by an RFID for the asset, from the firmware of the asset or from an asset database. IEC 61406 (formerly DIN SPEC 91406) defines the format of such Asset-IDs.

The “Administration Shell Basic Discovery Interface” may be used with an Asset-ID to get the related AAS-IDs (“GetAllAssetAdministrationShellIdsByAssetLink”).

The “Asset Administration Shell Registry Interface” may be used with an AAS-ID to retrieve the related descriptor for an AAS (“GetAssetAdministrationShellDescriptorById”). The retrieved AAS Descriptor includes the endpoint for the “Asset Administration Shell Interface”.

The “Asset Administration Shell Interface” makes the information about the AAS itself and the references to the related submodels available.

The related submodels of an AAS are retrieved by “GetAllSubmodelReferences”. Such a reference includes the SM-ID of a related submodel.

Similarly to the AAS above, the “Submodel Registry Interface” may be used to retrieve the related descriptor for a submodel (“GetSubmodelDescriptorById”) with a specific SM-ID. The retrieved Submodel Descriptor includes the endpoint for the “Submodel Interface”.

The “Submodel Interface” makes the information about the submodel itself and all its included submodel elements available.

Asset Administration Shells and submodels may be deployed on different endpoints in different ways.

One example is the deployment of an AAS on a device. In this case, the AAS might be fixed and might not be changed or deleted. In a cloud scenario, a single AAS may also be deployed as a single container (e.g. docker container).

Another example is the deployment of many Asset Administration Shells in an AAS Repository. In this case, the “Asset Administration Shell Repository Interface” may allow to create and manage multiple AAS in the repository.

The separate interfaces of the HTTP/REST API allow many ways to support different deployments.

For an AAS repository, the combination “Asset Administration Shell Repository Interface”, “Asset Administration Shell Interface”, “Submodel Interface”, “Serialization Interface”, and “Self-Description Interface” is proposed.
This will result in the following HTTP/REST paths as described in a combined OpenAPI file (https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellRepositoryServiceSpecification/V3.0.1_SSP-001)[2]:

/shells
/shells/{aas-identifier}
/shells/{aas-identifier}/asset-information
/shells/{aas-identifier}/asset-information/thumbnail
/shells/{aas-identifier}/submodel-refs
/shells/{aas-identifier}/submodel-refs/{submodel-identifier}
/shells/{aas-identifier}/submodels/{submodel-identifier}
/shells/{aas-identifier}/submodels/{submodel-identifier}/submodel-elements
/shells/{aas-identifier}/submodels/{submodel-identifier}/submodel-elements/{idShortPath}
/shells/{aas-identifier}/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/attachment
/shells/{aas-identifier}/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/invoke
/shells/{aas-identifier}/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/invoke-async
/shells/{aas-identifier}/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/operation-status/{handleId}
/shells/{aas-identifier}/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/operation-results/{handleId}
/serialization
/description

[2] For easier reading only the standard paths are shown in the following: $metadata, $value, $reference and $path parameter paths are additionally contained in the OpenAPI file.

If the repository also supports AASX Packages, it shall be extended by additionally supporting a “AASX File Server” Profile[3].

The example of a device or container containing one AAS with its related submodels will result in the following HTTP/REST paths as described in the related OpenAPI file (https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellServiceSpecification/V3.0.1_SSP-001)[2]:

/aas
/aas/asset-information
/aas/asset-information/thumbnail
/aas/submodel-refs
/aas/submodel-refs/{submodel-identifier}
/aas/submodels/{submodel-identifier}
/aas/submodels/{submodel-identifier}/submodel-elements
/aas/submodels/{submodel-identifier}/submodel-elements/{idShortPath}
/aas/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/attachment
/aas/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/invoke
/aas/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/invoke-async
/aas/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/operation-status/{handleId}
/aas/submodels/{submodel-identifier}/submodel-elements/{idShortPath}/operation-results/{handleId}
/serialization
/description

Note: identifiers are base64url-encoded in the API, i.e. {aas-identifier} and {submodel-identifier}. The {idShortPath} is URL-encoded in the API.

[3] Related OpenAPI file:
https://app.swaggerhub.com/apis/Plattform_i40/AasxFileServerServiceSpecification/V3.0.1_SSP-001

5 Asset Administration Shell Interfaces

5.1 General

These interfaces make it possible to access the elements of Asset Administration Shells or Submodels.

The AASX File Server Interface enables management of AASX packages on a server. A list of available packages can be retrieved. Each package in the list can be downloaded, uploaded, or deleted. New packages can also be added.

AASX packages are stored and managed independently from instantiated Asset Administration Shells or submodels on a server. The server documentation shall contain a description of when and how AASX packages are handled, e.g. if Asset Administration Shells or Submodels in AASX packages are instantiated at startup of the server and/or if they are also instantiated when an AASX package is changed by an API operation.

5.2 Asset Administration Shell Interface and Operations

5.2.1 Asset Administration Shell Interface

Interface: Asset Administration Shell	
Operation Name	**Description**
GetAssetAdministrationShell	Returns the Asset Administration Shell
PutAssetAdministrationShell	Replaces the current Asset Administration Shell
GetAllSubmodelReferences	Returns all Submodel References
PostSubmodelReference	Creates a Submodel Reference at the Asset Administration Shell
DeleteSubmodelReference	Deletes a specific Submodel Reference from the Asset Administration Shell
GetAssetInformation	Returns the Asset Information
PutAssetInformation	Replaces the Asset Information
GetThumbnail	Returns the thumbnail file
PutThumbnail	Replaces the thumbnail file
DeleteThumbnail	Deletes the thumbnail

5.2.2 Operation GetAssetAdministrationShell

Operation Name	GetAssetAdministrationShell			
Explanation	Returns the Asset Administration Shell			
semanticId	https://admin-shell.io/aas/API/GetAssetAdministrationShell/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the response	no	SerializationModifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Asset Administration Shell	yes	AssetAdministrationShell	1

5.2.3 Operation PutAssetAdministrationShell

Operation Name	PutAssetAdministrationShell			
Explanation	Replaces the Asset Administration Shell			
semanticId	https://admin-shell.io/aas/API/PutAssetAdministrationShell/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aas	AssetAdministrationShell	yes	Asset Administration Shell object	1
Output Parameter				
statusCode	StatusCode	yes	Status code	1
payload	AssetAdministrationShell	yes	Replaced Asset Administration Shell	1

5.2.4 Operation GetAllSubmodelReferences

Operation Name	GetAllSubmodelReferences			
Explanation	Returns all Submodel References			
semanticId	https://admin-shell.io/aas/API/GetAllSubmodelReferences/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Submodel References	yes	Reference	0..*

5.2.5 Operation PostSubmodelReference

Operation Name	PostSubmodelReference			
Explanation	Creates a Submodel Reference at the Asset Administration Shell			
semanticId	https://admin-shell.io/aas/API/PostSubmodelReference/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodelRef	Reference to the Submodel	yes	Reference	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created Submodel Reference	yes	Reference	1

5.2.6 Operation DeleteSubmodelReference

Operation Name	DeleteSubmodelReference			
Explanation	Deletes the Submodel Reference from the Asset Administration Shell			
semanticId	https://admin-shell.io/aas/API/DeleteSubmodelReference/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodelId	The unique id of the Submodel for the reference to be deleted	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.2.7 Operation GetAssetInformation

Operation Name	GetAssetInformation			
Explanation	Returns the Asset Information			
semanticId	https://admin-shell.io/aas/API/GetAssetInformation/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Asset Information	yes	AssetInformation	1

5.2.8 Operation PutAssetInformation

Operation Name	PutAssetInformation			
Explanation	Replaces the Asset Information			
semanticId	https://admin-shell.io/aas/API/PutAssetInformation/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
assetInfo	Asset Information object	yes	AssetInformation	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.2.9 Operation GetThumbnail

Operation Name	GetThumbnail			
Explanation	Returns the thumbnail file			
semanticId	https://admin-shell.io/aas/API/GetThumbnail/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested thumbnail file	yes	File Content	1

5.2.10 Operation PutThumbnail

Operation Name	PutThumbnail			
Explanation	Replaces the thumbnail file			
semanticId	https://admin-shell.io/aas/API/PutThumbnail/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
file	Thumbnail file	yes	File Content	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.2.11 Operation DeleteThumbnail

Operation Name	DeleteThumbnail			
Explanation	Deletes the thumbnail file			
semanticId	https://admin-shell.io/aas/API/DeleteThumbnail/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.3 Submodel Interface and Operations

5.3.1 Submodel Interface

Interface: Submodel	
Operation Name	**Description**
GetSubmodel	Returns the Submodel
GetAllSubmodelElements	Returns all submodel elements including their hierarchy
GetSubmodelElementByPath	Returns a specific submodel element from the Submodel at a specified path
GetFileByPath	Returns a specific file from the Submodel at a specified path
PutFileByPath	Replaces the file of an existing submodel element at a specified path within the submodel element hierarchy
DeleteFileByPath	Deletes the file of an existing submodel element at a specified path within the submodel element hierarchy
PutSubmodel	Replaces the Submodel
PatchSubmodel	Updates the Submodel
PostSubmodelElement	Creates a new submodel element as a child of the submodel. The idShort of the the new submodel element must be set in the payload.
PostSubmodelElementByPath	Creates a new submodel element at a specified path within the submodel elements hierarchy. The idShort of the the new submodel element must be set in the payload.
PutSubmodelElementByPath	Replaces an existing submodel element at a specified path within the submodel element hierarchy
PatchSubmodelElementByPath	Updates an existing submodel element at a specified path within the submodel element hierarchy
GetSubmodelElementValueByPath	Returns the value of the submodel element at a specified path according to the protocol-specific RAW-value payload
DeleteSubmodelElementByPath	Deletes a submodel element at a specified path within submodel element hierarchy
InvokeOperationSync	Synchronously invokes an Operation at a specified path with a client timeout in ms
InvokeOperationAsync	Asynchronously invokes an Operation at a specified path with a client timeout in ms

Interface: Submodel	
Operation Name	**Description**
GetOperationAsyncStatus	Returns the current status of an asynchronously invoked operation
GetOperationAsyncResult	Returns the OperationResult of an asynchronously invoked operation

5.3.2 Operation GetSubmodel

Operation Name	GetSubmodel			
Explanation	Returns the Submodel			
semanticId	https://admin-shell.io/aas/API/GetSubmodel/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the response	no	SerializationModifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Submodel	yes	Submodel	1

5.3.3 Operation GetAllSubmodelElements

Operation Name	GetAllSubmodelElements			
Explanation	Returns all submodel elements including their hierarchy			
semanticId	https://admin-shell.io/aas/API/GetAllSubmodelElements/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the response	no	SerializationModifier	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested submodel elements	yes	SubmodelElement	0..*

5.3.4 Operation GetSubmodelElementByPath

Operation Name	GetSubmodelElementByPath			
Explanation	Returns a specific submodel element from the Submodel at a specified path			
semanticId	https://admin-shell.io/aas/API/GetSubmodelElementByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
serializationModifier	Defines the format of the response	no	SerializationModifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested submodel element	yes	SubmodelElement	0..1

5.3.5 Operation GetFileByPath

Operation Name	GetFileByPath			
Explanation	Returns a specific file from the Submodel at a specified path			
semanticId	https://admin-shell.io/aas/API/GetFileByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested file	yes	File Content	0..1

5.3.6 Operation PutFileByPath

Operation Name	PutFileByPath			
Explanation	Replaces the file of an existing submodel element at a specified path within the submodel element hierarchy			
semanticId	https://admin-shell.io/aas/API/PutFileByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
payload	Replacing file	yes	File Content	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.3.7 Operation DeleteFileByPath

Operation Name	DeleteFileByPath			
Explanation	Deletes the file of an existing submodel element at a specified path within the submodel element hierarchy			
semanticId	https://admin-shell.io/aas/API/DeleteFileByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.3.8 Operation PutSubmodel

Operation Name	PutSubmodel			
Explanation	Replaces the Submodel			
semanticId	https://admin-shell.io/aas/API/PutSubmodel/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodel	Submodel object	yes	Submodel	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Replaced submodel	yes	Submodel	1

5.3.9 Operation PatchSubmodel

Operation Name	PatchSubmodel			
Explanation	Updates the Submodel			
semanticId	https://admin-shell.io/aas/API/PatchSubmodel/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the input Note: values remain unchanged with content=metadata.	no	SerializationModifier	1
submodel	Submodel object	yes	Submodel	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Updated submodel	yes	Submodel	1

5.3.10 Operation PostSubmodelElement

Operation Name	PostSubmodelElement			
Explanation	Creates a new submodel element as a child of the submodel. The idShort of the new submodel element must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.			
semanticId	https://admin-shell.io/aas/API/PostSubmodelElement/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodelElement	Submodel element object	yes	SubmodelElement	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created submodel element	yes	SubmodelElement	1

5.3.11 Operation PostSubmodelElementByPath

Operation Name	PostSubmodelElementByPath			
Explanation	Creates a new submodel element at a specified path within the submodel element hierarchy. The idShort of the new submodel element must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.			
semanticId	https://admin-shell.io/aas/API/PostSubmodelElementByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	The IdShortPath to the SubmodelElement under which the new SubmodelElement shall be addedIdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
submodelElement	Submodel element object	yes	SubmodelElement	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created submodel element	yes	SubmodelElement	1

Note: if the PostSubmodelElementByPath is executed towards a SubmodelElementList, the new SubmodelElement is added to the end of the list.

5.3.12 Operation PutSubmodelElementByPath

Operation Name	PutSubmodelElementByPath			
Explanation	Replaces an existing submodel element at a specified path within the submodel element hierarchy			
semanticId	https://admin-shell.io/aas/API/PutSubmodelElementByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	The IdShortPath to the SubmodelElement which shall be replacedIdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
submodelElement	Submodel element object	yes	SubmodelElement	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Replaced submodel element	yes	SubmodelElement	1

5.3.13 Operation PatchSubmodelElementByPath

Operation Name	PatchSubmodelElementByPath			
Explanation	Updates an existing submodel element at a specified path within the submodel element hierarchy			
semanticId	https://admin-shell.io/aas/API/PatchSubmodelElementByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the input Note: values remain unchanged with content=metadata.	no	SerializationModifier	1
path	IdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
submodelElement	Submodel element object	yes	SubmodelElement	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Updated submodel element	yes	SubmodelElement	1

5.3.14 Operation GetSubmodelElementValueByPath

Operation Name	GetSubmodelElementValueByPath			
Explanation	Returns a specific submodel element value from the Submodel at a specified path according to the ValueOnly-serialization as defined in clause 11.4.1			
semanticId	https://admin-shell.io/aas/API/GetSubmodelElementValueByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel elementhort-Path via relative Reference/Keys to a submodel element	yesIdShort-Path via relative Reference/Keys to a submodel	Key	1..*

		element		
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested submodel element value	yes	SubmodelElement	1

5.3.15 Operation PatchSubmodelElementValueByPath

Operation Name	PatchSubmodelElementValueByPath			
Explanation	Sets the value of the submodel element at a specified path according to the ValueOnly-serialization as defined in clause 11.4.1			
semanticId	https://admin-shell.io/aas/API/PatchSubmodelElementValueByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel elementIdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
payload	The new value of the submodel element	yes	SubmodelElement	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.3.16 Operation DeleteSubmodelElementByPath

Operation Name	DeleteSubmodelElementByPath			
Explanation	Deletes a submodel element at a specified path within the submodel elements hierarchy			
semanticId	https://admin-shell.io/aas/API/DeleteSubmodelElementByPath/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				

Operation Name	DeleteSubmodelElementByPath			
path	IdShort-Path via relative Reference/Keys to a submodel element	yes	Key	1..*
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.3.17 Operation InvokeOperationSync

Operation Name	InvokeOperationSync			
Explanation	Synchronously invokes an Operation at a specified path			
semanticId	https://admin-shell.io/aas/API/InvokeOperationSync/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel element, in this case an operation	yes	Key	1..*
inputArgument	Input argument	no	OperationVariable	1..*
inoutputArgument	Inoutput argument	no	OperationVariable	1..*
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	The Operation Result	yes	OperationResult	1

5.3.18 Operation InvokeOperationAsync

Operation Name	InvokeOperationAsync			
Explanation	Asynchronously invokes an Operation at a specified path			
semanticId	https://admin-shell.io/aas/API/InvokeOperationAsync/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
path	IdShort-Path via relative Reference/Keys to a submodel element, in this case an operation	yes	Key	1..*
inputArgument	Input argument	no	OperationVariable	1..*
inoutputArgument	Inoutput argument	no	OperationVariable	1..*
clientTimeoutDuration	Timestamp indicating when the client expects the server to have finished execution of the invoked operation	yes	duration	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	The returned handle of an operation's asynchronous invocation used to request the current state of the operation's execution	yes	OperationHandle	1

5.3.19 Operation GetOperationAsyncStatus

Operation Name	GetOperationAsyncStatus			
Explanation	Returns the current status of an asynchronously invoked operation			
semanticId	https://admin-shell.io/aas/API/GetOperationAsnycStatus/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
operationHandle	The returned handle of an operation's asynchronous invocation used to request the current state of the operation's execution	yes	OperationHandle	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Execution state of the operation	yes	OperationResult	1

5.3.20 Operation GetOperationAsyncResult

Operation Name	GetOperationAsyncResult			
Explanation	Returns the OperationResult of an asynchronously invoked operation			
semanticId	https://admin-shell.io/aas/API/GetOperationAsnycResult/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
operationHandle	The returned handle of an operation's asynchronous invocation used to request the current state of the operation's execution	yes	OperationHandle	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Operation Result	yes	OperationResult	1

5.4 Serialization Interface and Operations

5.4.1 Serialization Interface

Interface: Serialization	
Operation Name	**Description**
GenerateSerializationByIds	Returns an appropriate serialization based on the specified format (see SerializationFormat).

5.4.2 Operation GenerateSerializationByIds

Operation Name	GenerateSerializationByIds			
Explanation	Returns an appropriate serialization based on the specified format (see SerializationFormat).			
semanticId	https://admin-shell.io/aas/API/GenerateSerializationByIds/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasIds	The unique ids of the Asset Administration Shells to be contained in the serialization	no	Identifier	1..*
submodelIds	The unique ids of the Submodels to be contained in the serialization	no	Identifier	1..*
includeConceptDescriptions	Include concept descriptions	no	boolean	1
serializationFormat	Denotes in which serialization format the requested content shall be delivered	no	SerializationFormat	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Serialization of the requested Asset Administration Shells and/or Submodels with or without ConceptDescriptions in specified SerializationFormat.	yes	Environment	1

Enumeration:	SerializationFormat
Explanation:	Determines the format of serialization, i.e. JSON, XML, RDF, AML, etc.RFC 6838, IANA Media Types, and defined custom content types; additional elements may be added in future versions
Set of:	--
Literal	**Explanation**
application/json	JSON serialization of the requested data object inside an AAS Environment structure
application/xml	XML serialization of the requested data object inside an AAS Environment structure (default)
application/asset-administration-shell-package+xml	AASX-Package (binary data) containing the requested data object

5.5 AASX File Server Interface and Operations

5.5.1 AASX File Server Interface

Interface: AASX File Server	
Operation Name	**Description**
GetAllAASXPackageIds	Returns a list of available AASX packages at the server
GetAASXByPackageId	Returns a specific AASX package from the server
PostAASXPackage	Creates an AASX package at the server
PutAASXByPackageId	Replaces the AASX package at the server
DeleteAASXByPackageId	Deletes a specific AASX package

5.5.2 Operation GetAllAASXPackageIds

Operation Name	GetAllAASXPackageIds			
Explanation	Returns a list of available AASX packages at the server			
semanticId	https://admin-shell.io/aas/API/GetAllAASXPackageIds/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasId	Identifier of the AAS which must exist in each matching AASX package	no	Identifier	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Matching package list; the PackageDescription includes all Asset Administration Shell identifiers, also those which may have not been requested through the aasId input parameter	yes	PackageDescription	0..*

5.5.3 Operation GetAASXByPackageId

Operation Name	GetAASXByPackageId			
Explanation	Returns a specific AASX package from the server			
semanticId	https://admin-shell.io/aas/API/GetAASXByPackageId/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
packageId	Requested package ID from the package list	yes	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
filename	Filename of the AASX package	yes	string	1
payload	Requested AASX package	yes	AASX Package	1

5.5.4 Operation PostAASXPackage

Operation Name	PostAASXPackage			
Explanation	Creates an AASX package at the server			
semanticId	https://admin-shell.io/aas/API/PostAASXPackage/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasIds	Included AAS Ids Note: it is not mandatory for servers to read and parse AASX packages. Servers may simply store the AASX files with their related given aasIds.	no	Identifier	0..*
file	New AASX package	yes	AASX package	1
filename	Filename of the AASX package	yes	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
packageId	New Package ID	yes	string	1

5.5.5 Operation PutAASXPackageById

Operation Name	PutAASXPackageById			
Explanation	Replaces the AASX package at the server			
semanticId	https://admin-shell.io/aas/API/PutAASXPackageById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
packageId	Package ID from the package list	yes	string	1
aasIds	Included AAS Ids Note: it is not mandatory for servers to read and parse AASX packages. Servers may simply store the AASX files with their related given aasIds.	no	Identifier	0..*
file	New AASX package	yes	AASX package	1
filename	Filename of the AASX package	yes	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

5.5.6 Operation DeleteAASXPackageById

Operation Name	DeleteAASXPackageById			
Explanation	Deletes a specific AASX package from the server			
semanticId	https://admin-shell.io/aas/API/DeleteAASXPackageById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
packageId	Package ID from the package list	yes	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

6 Registration Interfaces

6.1 General

These interfaces allow to register and unregister descriptors of administration shells or submodels. The descriptors contain the information needed to access the interfaces of the corresponding element. This required information includes the endpoint in the dedicated environment.

Lookup interfaces provide access to the registered descriptors by identifiers (Asset Administration Shell and Submodel ID). These identifiers may be discovered through the interfaces described in Clause 7.

6.2 Asset Administration Shell Registry Interface and Operations

6.2.1 Asset Administration Shell Registry Interface

Interface: Asset Administration Shell Registry	
Operation Name	**Description**
GetAllAssetAdministrationShellDescriptors	Returns all Asset Administration Shell Descriptors
GetAssetAdministrationShellDescriptorById	Returns a specific Asset Administration Shell Descriptor
PostAssetAdministrationShellDescriptor	Creates a new Asset Administration Shell Descriptor, i.e. registers an AAS
PutAssetAdministrationShellDescriptorById	Replaces an existing Asset Administration Shell Descriptor, i.e. replaces registration information
DeleteAssetAdministrationShellDescriptorById	Deletes an Asset Administration Shell Descriptor, i.e. de-registers an AAS

6.2.2 Operation GetAllAssetAdministrationShellDescriptors

Operation Name	GetAllAssetAdministrationShellDescriptors			
Explanation	Returns all Asset Administration Shell Descriptors			
semanticId	https://admin-shell.io/aas/API/GetAllAssetAdministrationShellDescriptors/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
assetKind	The kind of the assets to retrieve (Type, Instance)	Yes	AssetKind	1
assetType	The type of the assets to retrieve, encoded as unique id	Yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	List of Asset Administration Shell Descriptors	no	AssetAdministrationShellDescriptor	1..*

6.2.3 Operation GetAssetAdministrationShellDescriptorById

Operation Name	GetAssetAdministrationShellDescriptorById			
Explanation	Returns a specific Asset Administration Shell Descriptor			
semanticId	https://admin-shell.io/aas/API/GetAssetAdministrationShellDescriptorById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasIdentifier	The Asset Administration Shell’s unique id	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Asset Administration Shell Descriptor	yes	AssetAdministrationShellDescriptor	1

6.2.4 Operation PostAssetAdministrationShellDescriptor

Operation Name	PostAssetAdministrationShellDescriptor			
Explanation	Creates a new Asset Administration Shell Descriptor, i.e. registers an AAS			
semanticId	https://admin-shell.io/aas/API/PostAssetAdministrationShellDescriptor/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
shellDescriptor	Object containing the Asset Administration Shell's identification and endpoint informationntaining the Asset Administration Shell's identification and endpoint information	yes	AssetAdministrationShellDescriptor	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created Asset Administration Shell Descriptor	yes	AssetAdministrationShellDescriptor	1

6.2.5 Operation PutAssetAdministrationShellDescriptorById

Operation Name	PutAssetAdministrationShellDescriptorById			
Explanation	Replaces an existing Asset Administration Shell Descriptor, i.e. replaces registration information			
semanticId	https://admin-shell.io/aas/API/PutAssetAdministrationShellDescriptorById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
shellDescriptor	Object containing the Asset Administration Shell's identification and endpoint informationcontaining the Asset Administration Shell's identification and endpoint information	yes	AssetAdministrationShellDescriptor	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Replaced Asset Administration Shell Descriptor	yes	AssetAdministrationShellDescriptor	1

6.2.6 Operation DeleteAssetAdministrationShellDescriptorById

Operation Name	DeleteAssetAdministrationShellDescriptorById			
Explanation	Deletes an Asset Administration Shell Descriptor, i.e. de-registers an AAS			
semanticId	https://admin-shell.io/aas/API/DeleteAssetAdministrationShellDescriptorById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasIdentifier	The Asset Administration Shell's unique id	yes	Identifer	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

6.3 Submodel Registry Interface and Operations

6.3.1 Submodel Registry Interface

Interface:Submodel Registry	
Operation Name	**Description**
GetAllSubmodelDescriptors	Returns all submodel descriptors
GetSubmodelDescriptorById	Returns a specific submodel descriptor
PostSubmodelDescriptor	Creates a new submodel descriptor, i.e. registers a submodel
PutSubmodelDescriptorById	Replaces an existing submodel descriptor, i.e. replaces registration information
DeleteSubmodelDescriptorById	Deletes a submodel descriptor, i.e. de-registers a submodel

6.3.2 Operation GetAllSubmodelDescriptors

Operation Name	GetAllSubmodelDescriptors			
Explanation	Returns all submodel descriptors			
semanticId	https://admin-shell.io/aas/API/GetAllSubmodelDescriptors/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	The maximum size of the result set	yes	StatusCode	1
payload	The position from which to resume a result listing	no	SubmodelDescriptor	1..*

6.3.3 Operation GetSubmodelDescriptorById

Operation Name	GetSubmodelDescriptorById			
Explanation	Returns a specific Submodel Descriptor			
semanticId	https://admin-shell.io/aas/API/GetSubmodelDescriptorById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodelIdentifier	The Submodel's unique id	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested submodel descriptor	yes	SubmodelDescriptor	1

6.3.4 Operation PostSubmodelDescriptor

Operation Name	PostSubmodelDescriptor			
Explanation	Creates a new submodel descriptor, i.e. registers a submodel			
semanticId	https://admin-shell.io/aas/API/PostSubmodelDescriptor/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodel Descriptor	Object containing the Submodel's identification and endpoint information	yes	SubmodelDescriptor	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created submodel descriptor	yes	SubmodelDescriptor	1

6.3.5 Operation PutSubmodelDescriptorById

Operation Name	PutSubmodelDescriptorById			
Explanation	Replaces an existing submodel descriptor, i.e. replaces registration information			
semanticId	https://admin-shell.io/aas/API/PutSubmodelDescriptorById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodel Descriptor	Object containing the Submodel's identification and endpoint information	yes	SubmodelDescriptor	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Replaced submodel descriptor	yes	SubmodelDescriptor	1

6.3.6 Operation DeleteSubmodelDescriptorById

Operation Name	DeleteSubmodelDescriptorById			
Explanation	Deletes a Submodel Descriptor, i.e. de-registers a submodel			
semanticId	https://admin-shell.io/aas/API/DeleteSubmodelDescriptorById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodelIdentifier	The Submodel's unique id	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

7 Repository Interfaces

7.1 General

These interfaces allow to manage Asset Administration Shells, Submodels, and Concept Descriptions. They further provide access to the data of these elements through interfaces described in Clause . A repository can host multiple entities. These entities can be stored in individual repositories of a decentral system. The endpoints of the entities managed by one repository shall be resolved by subsequent calls to discover (Clause 6) and lookup (Clause 8) interfaces to such decentralized systems.

Sometimes, these kinds of services are also classified as Asset Administration Shell management services.

The interfaces that provide access to the entities (Asset Administration Shells, Submodels, Concept Descriptions) themselves are convenience interfaces that provide access in a system where the services are managed by central repositories.

7.2 Asset Administration Shell Repository Interface and Operations

7.2.1 Asset Administration Shell Repository Interface

Interface: Asset Administration Shell Registry	
Operation Name	**Description**
GetAllAssetAdministrationShells	Returns all Asset Administration Shells
GetAssetAdministrationShellById	Returns a specific Asset Administration Shell
GetAllAssetAdministrationShellsByAssetId	Returns all Asset Administration Shells that are linked to a globally unique asset identifier or to specific asset ids
GetAllAssetAdministrationShellsByIdShort	Returns all Asset Administration Shells with a specific idShort
PostAssetAdministrationShell	Creates a new Asset Administration Shell. The id of the new Asset Administration Shell must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.
PutAssetAdministrationShellById	Replaces an existing Asset Administration Shell
DeleteAssetAdministrationShellById	Deletes an Asset Administration Shell

7.2.2 Operation GetAllAssetAdministrationShells

Operation Name	GetAllAssetAdministrationShells			
Explanation	Returns all Asset Administration Shells			
semanticId	https://admin-shell.io/aas/API/GetAllAssetAdministrationShells/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	List of Asset Administration Shells	no	AssetAdministrationShell	1

7.2.3 Operation GetAssetAdministrationShellById

Operation Name	GetAssetAdministrationShellById			
Explanation	Returns a specific Asset Administration Shell			
semanticId	https://admin-shell.io/aas/API/GetAssetAdministrationShellById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
id	The Asset Administration Shell’s unique id	yes	Identifier	1
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Asset Administration Shell	yes	AssetAdministrationShell	1

7.2.4 Operation GetAllAssetAdministrationShellsByAssetId

Operation Name	GetAllAssetAdministrationShellsByAssetId			
Explanation	Returns all Asset Administration Shells that are linked to a globally unique asset identifier or to specific asset ids			
semanticId	https://admin-shell.io/aas/API/GetAllAssetAdministrationShellsByAssetId/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
key	The key of the AssetId The name of the specific asset identifier or the predefined name “*globalAssetId*” that would refer to the *AssetInformation/globalAssetId*	yes	string	1
keyIdentifier	The key identifier object	yes	string	1
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	1
limit	The maximum size of the result set	yes	nonNegativeInteger	1
cursor	The position from which to resume a result listing	yes	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Asset Administration Shells	no	AssetAdministrationShell	1..*

7.2.5 Operation GetAllAssetAdministrationShellsByIdShort

Operation Name	GetAllAssetAdministrationShellsByIdShort			
Explanation	Returns all Asset Administration Shells with a specific *idShort*			
semanticId	https://admin-shell.io/aas/API/GetAllAssetAdministrationShellsByIdShort/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
idShort	The Asset Administration Shell's idShort	yes	NameType	
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Asset Administration Shells	no	AssetAdministrationShell	1

7.2.6 Operation PostAssetAdministrationShell

Operation Name	PostAssetAdministrationShell			
Explanation	Creates a new Asset Administration Shell. The id of the new Asset Administration Shell must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.			
semanticId	https://admin-shell.io/aas/API/PostAssetAdministrationShell/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aas	Asset Administration Shell object	yes	AssetAdministrationShell	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created Asset Administration Shell	yes	AssetAdministrationShell	1

7.2.7 Operation PutAssetAdministrationShellById

Operation Name	PutAssetAdministrationShellById			
Explanation	Replaces an existing Asset Administration Shell			
semanticId	https://admin-shell.io/aas/API/PutAssetAdministrationShellById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aas	Asset Administration Shell object	yes	AssetAdministrationShell	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Replaced Asset Administration Shell	yes	AssetAdministrationShell	1

7.2.8 Operation DeleteAssetAdministrationShellById

Operation Name	DeleteAssetAdministrationShellById			
Explanation	Deletes an Asset Administration Shell			
semanticId	https://admin-shell.io/aas/API/DeleteAssetAdministrationShellById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
id	The Asset Administration Shell's unique id	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

7.3 Submodel Repository Interface and Operations

7.3.1 Submodel Repository Interface

Interface: Submodel Repository	
Operation Name	**Description**
GetAllSubmodels	Returns all Submodels
GetSubmodelById	Returns a specific Submodel
GetAllSubmodelsBySemanticId	Returns all Submodels with a specific SemanticId or SupplementalSemanticId
GetAllSubmodelsByIdShort	Returns all Submodels with a specific *idShort*
PostSubmodel	Creates a new Submodel. The id of the new submodel must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.
PutSubmodelById	Replaces an existing Submodel
PatchSubmodelById	Updates an existing submodel
DeleteSubmodelById	Deletes a Submodel

7.3.2 Operation GetAllSubmodels

Operation Name	GetAllSubmodels			
Explanation	Returns all Submodels			
semanticId	https://admin-shell.io/aas/API/GetAllSubmodels/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	List of Submodels	no	Submodel	1..*

7.3.3 Operation GetSubmodelById

Operation Name	GetSubmodelById			
Explanation	Returns a specific Submodel			
semanticId	https://admin-shell.io/aas/API/GetSubmodelById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
id	The Submodel’s unique id	yes	Identifier	1
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Submodel	yes	Submodel	1

7.3.4 Operation GetAllSubmodelsBySemanticId

Operation Name	GetAllSubmodelsBySemanticId			
Explanation	Returns all Submodels with a specific SemanticId or SupplementalSemanticId. If either the semanticId fits to the input parameter or at least one of the SupplementalSemanticIds, the submodel is returned.			
semanticId	https://admin-shell.io/aas/API/GetAllSubmodelsBySemanticId/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
semanticId	Identifier of the semantic definition	yes	Reference	1
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Submodels	no	Submodel	1..*

7.3.5 Operation GetAllSubmodelsByIdShort

Operation Name	GetAllSubmodelsByIdShort			
Explanation	Returns all Submodels with a specific *idShort*			
semanticId	https://admin-shell.io/aas/API/GetAllSubmodelsByIdShort/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
idShort	The Submodel's idShort	yes	NameType	1
serializationModifier	Defines the format of the input or the output of an operation	yes	SerializationModifier	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Submodels	no	Submodel	1..*

7.3.6 Operation PostSubmodel

Operation Name	PostSubmodel			
Explanation	Creates a new Submodel. The id of the new submodel must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.			
semanticId	https://admin-shell.io/aas/API/PostSubmodel/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodel	Submodel object	yes	Submodel	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created Submodel	yes	Submodel	1

7.3.7 Operation PutSubmodelById

Operation Name	PutSubmodelById			
Explanation	Replaces an existing Submodel			
semanticId	https://admin-shell.io/aas/API/PutSubmodelById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
submodel	Submodel object	yes	Submodel	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Replaced Submodel	yes	Submodel	1

7.3.8 Operation PatchSubmodelById

Operation Name	PatchSubmodelById			
Explanation	Updates an existing Submodel			
semanticId	https://admin-shell.io/aas/API/PatchSubmodelById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
serializationModifier	Defines the format of the input or the output of an operation Note: values remain unchanged with content=metadata.	yes	SerializationModifier	1
submodel	Submodel object	yes	Submodel	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Updated submodel	yes	Submodel	1

7.3.9 Operation DeleteSubmodelById

Operation Name	DeleteSubmodelById			
Explanation	Deletes a Submodel			
semanticId	https://admin-shell.io/aas/API/DeleteSubmodelById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
id	The Submodel’s unique id	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

7.4 Concept Description Repository Interface and Operations

7.4.1 Concept Description Repository Interface

Interface: Concept Description Repository	
Operation Name	**Description**
GetAllConceptDescriptions	Returns all Concept Descriptions
GetConceptDescriptionById	Returns a specific Concept Description
GetAllConceptDescriptionsByIdShort	Returns all Concept Descriptions with a specific *idShort*
GetAllConceptDescriptionsByIsCaseOf	Returns all Concept Descriptions with a specific *IsCaseOf*-reference
GetAllConceptDescriptionsByDataSpecificationReference	Returns all Concept Descriptions with a specific *dataSpecification* reference
PostConceptDescription	Creates a new Concept Description. The id of the the new Concept Description must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.
PutConceptDescriptionById	Replaces an existing Concept Description
DeleteConceptDescriptionById	Deletes a Concept Description

7.4.2 Operation GetAllConceptDescriptions

Operation Name	GetAllConceptDescriptions			
Explanation	Returns all Concept Descriptions			
semanticId	https://admin-shell.io/aas/API/GetAllConceptDescriptions/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
limit	The maximum size of the result set	No	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	String	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	List of Concept Descriptions	no	ConceptDescription	1..*

7.4.3 Operation GetConceptDescriptionById

Operation Name	GetConceptDescriptionById			
Explanation	Returns a specific Concept Description			
semanticId	https://admin-shell.io/aas/API/GetConceptDescriptionById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
id	The Concept Description’s unique id	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Concept Description	yes	ConceptDescription	1

7.4.4 Operation GetAllConceptDescriptionsByIdShort

Operation Name	GetAllConceptDescriptionsByIdShort			
Explanation	Returns all Concept Descriptions with a specific *idShort*			
semanticId	https://admin-shell.io/aas/API/GetAllConceptDescriptionsByIdShort/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
idShort	The Concept Description's idShort	yes	NameType	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Concept Descriptions	no	ConceptDescription	1..*

7.4.5 Operation GetAllConceptDescriptionsByIsCaseOf

Operation Name	GetAllConceptDescriptionsByIsCaseOf			
Explanation	Returns all Concept Descriptions with a specific *IsCaseOf* reference			
semanticId	https://admin-shell.io/aas/API/GetAllConceptDescriptionsByIsCaseOf/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
isCaseOf	IsCaseOf reference	yes	Reference	1
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Concept Descriptions	no	ConceptDescription	1..*

7.4.6 Operation GetAllConceptDescriptionsByDataSpecificationReference

Operation Name	GetAllConceptDescriptionsByDataSpecificationReference			
Explanation	Returns all Concept Descriptions with a specific *dataSpecification* reference			
semanticId	https://admin-shell.io/aas/API/GetAllConceptDescriptionsByDataSpecificationReference/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
dataSpecification-Reference	*DataSpecification* reference	yes	Reference	*1*
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested Concept Descriptions	no	ConceptDescription	1..*

7.4.7 Operation PostConceptDescription

Operation Name	PostConceptDescription			
Explanation	Creates a new Concept Description. The id of the new Concept Description must be set in the payload. Note: the creation of the idShort is out of scope and must be handled in a proprietary way.			
semanticId	https://admin-shell.io/aas/API/PostConceptDescription/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
conceptDescription	Concept Description object	yes	ConceptDescription	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Created Concept Description	yes	ConceptDescription	1

7.4.8 Operation PutConceptDescriptionById

Operation Name	PutConceptDescriptionById			
Explanation	Replaces an existing Concept Description			
semanticId	https://admin-shell.io/aas/API/PutConceptDescriptionById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
conceptDescription	Concept Description object	yes	ConceptDescription	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Replaced Concept Description	yes	ConceptDescription	1

7.4.9 Operation DeleteConceptDescriptionById

Operation Name	DeleteConceptDescriptionById			
Explanation	Deletes a Concept Description			
semanticId	https://admin-shell.io/aas/API/DeleteConceptDescriptionById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
cdIdentifier	The Concept Description's unique id	yes	Identifier	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

8 Publish and Discovery Interfaces

8.1 General

These interfaces allow to publish information about Asset Administration Shells that enable a search for asset IDs of the corresponding Asset Administration Shells in a subsequent discovery interface call.

8.2 Asset Administration Shell Basic Discovery Interface and Operations

8.2.1 Asset Administration Shell Basic Discovery Interface

Interface: Asset Administration Shell Basic Discovery	
Operation Name	**Description**
GetAllAssetAdministrationShellIdsByAssetLink	Returns a list of Asset Administration Shell ids based on asset identifier key-value-pairs
GetAllAssetLinksById	Returns a list of asset identifier key-value-pairs based on a given Asset Administration Shell id
PostAllAssetLinksById	Creates or replaces all asset identifier key-value-pairs linked to an Asset Administration Shell to edit discoverable content
DeleteAllAssetLinksById	Deletes all asset identifier key-value-pair linked to an Asset Administration Shell

8.2.2 Operation GetAllAssetAdministrationShellIdsByAssetLink

Operation Name	GetAllAssetAdministrationShellIdsByAssetLink			
Explanation	Returns a list of Asset Administration Shell ids based on asset identifier key-value-pairs			
semanticId	https://admin-shell.io/aas/API/GetAllAssetAdministrationShellIdsByAssetLink/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
assetIds	The specific assetId of an asset identifier, which could be the globalAssetId or specificAssetIds. Note: The key of the asset identifier key-value-pair for the globalAssetId is defined in Clause 4.5. It is the predefined key "*globalAssetId*" that would refer to the *AssetInformation/globalAssetId*.	yes	SpecificAssetId	1..*
limit	The maximum size of the result set	no	nonNegativeInteger	1
cursor	The position from which to resume a result listing	no	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Identifiers of all Asset Administration Shells which contain all asset identifier key-value-pairs in their asset information, i.e. AND-match of key-value-pairs per Asset Administration Shell	yes	Identifier	1..*

8.2.3 Operation GetAllAssetLinksById

Operation Name	GetAllAssetLinksById			
Explanation	Returns a list of asset identifier key-value-pairs based on an Asset Administration Shell id to edit discoverable content			
semanticId	https://admin-shell.io/aas/API/GetAllAssetLinksById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasIdentifier	The Asset Administration Shell's unique id	yes	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Requested asset identifier, which could be the globalAssetId or specificAssetIds. Note: the name of the SpecificAssetId for the globalAssetId is defined in Clause 4.5. It is the predefined name "*globalAssetId*" that would refer to the *AssetInformation/globalAssetId*.	no	SpecificAssetId	1..*

8.2.4 Operation PostAllAssetLinksById

Operation Name	PostAllAssetLinksById			
Explanation	Creates new asset identifier key-value-pairs linked to an Asset Administration Shell for discoverable content. The existing content might have to be deleted first.			
semanticId	https://admin-shell.io/aas/API/PostAllAssetLinksById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasIdentifier	The Asset Administration Shell's unique id	yes	string	1
assetLinks	Asset identifier, which could be the globalAssetId or specificAssetIds. Note: the name for the globalAssetId is defined in Clause 4.5. It is the predefined key "*globalAssetId*" that would refer to the *AssetInformation/globalAssetId*.	yes	SpecificAssetId	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1
payload	Asset identifier created successfully	yes	SpecificAssetId	1

8.2.5 Operation DeleteAllAssetLinksById

Operation Name	DeleteAllAssetLinksById			
Explanation	Deletes all asset identifier key-value-pairs linked to an Asset Administration Shell to edit discoverable content			
semanticId	https://admin-shell.io/aas/API/DeleteAllAssetLinksById/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
aasIdentifier	The Asset Administration Shell's unique id	yes	string	1
Output Parameter				
statusCode	Status code	yes	StatusCode	1

9 Description Interface

9.1.1 Self-Description Interface

Interface: Self-Description	
Operation Name	**Description**
GetSelfDescription	Returns a description object containing the capabilities and supported features of the server.

9.1.2 Operation GetSelfDescription

Operation Name	GetSelfDescription			
Explanation	Returns a description object containing the capabilities and supported features of the server.			
semanticId	https://admin-shell.io/aas/API/GetSelfDescription/3/0			
Name	**Description**	**Mand.**	**Type**	**Card.**
Output Parameter				
statusCode	Status code	yes	StatusCode	1
description	Key-value-pairs that describe the capabilities of the providing server	yes	ServiceDescription	1

Note 1: a server implementing more than one service specification profile, e.g. hosting a repository and a registry at the same time, adds both ServiceSpecificationProfileEnum items in the profiles list.
Note 2: a profile value must only be used if the related API is implemented at the path where the API Operation “GetDescription” is published, or child paths.

10 Data Types for Payload

10.1 General

For metamodel elements like AssetAdministrationShell, Submodel, Identifier, etc. that are specified in Part 1, please refer to the specification in [1]. The AAS package format and the AAS Package type are defined in Part 5 [3]. This clause only defines additional classes that are needed for communication with the API.

10.2 Metamodel Specification Details

The following type definitions are used to describe specific metamodel elements like Asset Administration Shells and submodels regarding their network and deployment configuration. They use certain attributes copied from the model element itself to describe it – hence the name *Descriptor*.

10.2.1 Descriptor

Class Name	Descriptor		
Explanation	The self-describing information of a network resource. This class is not part of the metamodel.		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/Descriptor/3/0		
Attribute	**Explanation**	**Type**	**Card.**
description	Description or comments on the element The description can be provided in several languages	MultiLanguageTextType	0..1
displayName	Display name; can be provided in several languages	MultiLanguageNameType	0..1
extension	An extension of the element	Extension	0..*

10.2.2 AssetAdministrationShellDescriptor

Class Name	AssetAdministrationShellDescriptor		
Explanation	Descriptor of an Asset Administration Shell		
Inherits from	Descriptor		
semanticId	https://admin-shell.io/aas/API/DataTypes/AssetAdministrationShellDescriptor/3/0		
Attribute	**Explanation**	**Type**	**Card.**
administration	Administrative information of the Asset Administration Shell	AdministrativeInformation	0..1
assetKind	Denotes whether the asset of the described Asset Administration Shell is of kind “Type” or “Instance”	AssetKind	0..1
assetType	The type of the asset described by the Asset Administration Shell of this Descriptor. See AssetInformation/assetType for further information.	Identifier	0..1
endpoint	Endpoint of the network resource	Endpoint	0..*
globalAssetId	Global reference to the asset the AAS is representing	Identifier	0..1
idShort	Short name of the Asset Administration Shell	NameType	0..1
id	Globally unique identification of the Asset Administration Shell	Identifier	1
specificAssetId	Specific asset identifier	SpecificAssetId	0..*
submodelDescriptor	Descriptor of a submodel of the Asset Administration Shell	SubmodelDescriptor	0..*

Note: the cardinality restriction for AssetAdministrationShellDescriptor/endpoint (optional: 0..*) allows a provider to skip the declaration of the location of an AssetAdministrationShell and directly point to the endpoints of the contained Submodels through the path AssetAdministrationShellDescriptor/submodelDescriptor-> SubmodelDescriptor/endpoint. A client, therefore, might decide to skip the lookup on the AssetAdministrationShell. Nevertheless, in case the information contained in the AssetAdministrationShellDescriptor deviates from the related AssetAdministrationShell, or attributes are missing, the AssetAdministrationShell is always the source of truth.

10.2.3 SubmodelDescriptor

Class Name	SubmodelDescriptor		
Explanation	A descriptor of a submodel		
Inherits from	Descriptor		
semanticId	https://admin-shell.io/aas/API/DataTypes/SubmodelDescriptor/3/0		
Attribute	**Explanation**	**Type**	**Card.**
administration	Administrative information of the Submodel	AdministrativeInformation	0..1
endpoint	Endpoint of the network resource	Endpoint	1..*
idShort	Short name of the Submodel	NameType	0..1
id	Globally unique identification of the Submodel	Identifier	1
semanticId	Identifier of the semantic definition of the Submodel	Reference	0..1
supplementalSemanticId	Identifier of a supplemental semantic definition of the element called supplemental semantic ID of the element	Reference	0..*

10.2.4 Endpoint

Class Name	Endpoint		
Explanation	The endpoint description of a network resource. This class is not part of the metamodel.		
Inherits from	-		
semanticId	https://admin-shell.io/aas/API/DataTypes/Endpoint/3/0		
Attribute	**Explanation**	**Type**	**Card.**
protocolInformation	Protocol information of the network resource endpoint	ProtocolInformation	1
interface	Name of the offered interface at the endpoint	ShortIdType	1

The following names will be used for the interfaces:

Interface	interface-shortName
Asset Administration Shell Interface	AAS
Submodel Interface	SUBMODEL
Serialization Interface	SERIALIZE
Description Interface	DESCRIPTION
AASX File Server Interface	AASX-FILE
Asset Administration Shell Registry Interface	AAS-REGISTRY
Submodel Registry Interface	SUBMODEL-REGISTRY
Asset Administration Shell Repository Interface	AAS-REPOSITORY
Submodel Repository Interface	SUBMODEL-REPOSITORY
Concept Description Repository Interface	CD-REPOSITORY
Asset Administration Shell Basic Discovery Interface	AAS-DISCOVERY

The value for the interface attribute is “{interface-shortName}-{interface-version}”.

The interface-version of this specification is “3.0”, e.g. the entry for the Asset Administration Shell Interface is “AAS-3.0”.

10.2.5 ProtocolInformation

Class Name	ProtocolInformation		
Explanation	The protocol information of a network resource endpoint will be defined in DIN SPEC 16593-2. After the release of DIN SPEC 16593-2, any required updates will be made. This class is not part of the metamodel. The information in this table is a 1:1 copy from DIN SPEC 16593-2. Required changes need to be made by the related DIN working group.		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/ProtocolInformation/3/0		
Attribute	**Explanation**	**Type**	**Card.**
href	The endpoint address as an URL	String 2048	1
endpointProtocol	Either scheme of endpointAdress or scheme + further information. Scheme denotes the highest level of doubtless transmission.	ShortIdType	0..1
endpointProtocolVersion	Array of strings, each entry represents one supported version at this very endpoint, the entry shall be formatted according to the regulations of the protocol specified in the href	ShortIdType	0..*
subprotocol	Allows for referencing sub-protocols that may be used in the context of that endpoint	ShortIdType	0..1
subprotocolBody	If the sub-protocol field is present, a subprotocolBody might be given to hold extra information	ShortIdType	0..1
subprotocolBodyEncoding	If subprotocolBody is present, the encoding might be explicitly defined, otherwise it shall default to subprotocols encoding scheme	ShortIdType	0..1
securityAttributes	Array of securityAttribute objects, each attribute has 3 properties: { **type** = Enum security type or standard: • 'NONE', • 'RFC_TLSA' - TLSA according to rfc6698 • 'W3C_DID' - W3C DID document , **key** = security attribute key according to standard definitions of the security type, **value** = security attribute value e.g. DANE TLSA Ressource Record } The securityAttribute objects are treated as possible alternatives (logical "or")	SecurityAttributeObject	1..*

Class Name	SecurityAttributeObject		
Explanation	Security attributes as defined by DIN SPEC 16593-2. After the release of DIN SPEC 16593-2, any required updates will be made. This class is not part of the metamodel. The information in this table is derived from DIN SPEC 16593-2. Required changes need to be made by the related DIN working group.		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/SecurityAttributeObject/3/0		
Attribute	**Explanation**	**Type**	**Card.**
type	Enum security type or standard	SecurityTypeEnum	1
key	Security attribute key according to standard definitions of the security type	string	1
value	Security attribute value e.g. DANE TLSA Ressource Record	string	1

Enumeration	SecurityTypeEnum
Explanation	The security types as defined by DIN SPEC 16593-2. After the release of DIN SPEC 16593-2, any required updates will be made. This class is not part of the metamodel. The information in this table is derived from DIN SPEC 16593-2. Required changes need to be made by the related DIN working group.
semanticId	https://admin-shell.io/aas/API/DataTypes/SecurityTypeEnum/3/0
Literal	**Explanation**
NONE	No predefined security type available
RFC_TLSA	TLSA according to RFC 6698
W3C_DID	Decentralized Identifiers according to the W3C Recommendation [7]

10.2.6 ServiceDescription

Class Name	ServiceDescription		
Explanation	The self-describing information of an API Implementation. It enables servers to present their capabilities to the clients, in particular which profiles they implement. At least one defined profile is required. Additional, proprietary attributes might be included. Nevertheless, the server must not expect that a regular client understands them. This class is not part of the metamodel.		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/ServiceDescription/3/0		
Attribute	**Explanation**	**Type**	**Card.**
profiles	List of implemented server specification profiles.	ServiceSpecificationProfileEnum	1..*

Enumeration	ServiceSpecificationProfileEnum
Explanation	The identifiers of the standardized service specification profiles. See also clause 12.12 for further details.
semanticId	https://admin-shell.io/aas/API/DataTypes/ServiceSpecificationProfileEnum/3/0
Literal	**Explanation**
https://admin-shell.io/aas/API/3/0/AssetAdministrationShellServiceSpecification/SSP-001	Indicates that the server implemented all features of the Asset Administration Shell Service Specification Full Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/AssetAdministrationShellServiceSpecification/SSP-002	Indicates that the server implemented all features of the Asset Administration Shell Service Specification Read Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelServiceSpecification/SSP-001	Indicates that the server implemented all features of the Submodel Service Specification Full Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelServiceSpecification/SSP-002	Indicates that the server implemented all features of the Submodel Service Specification Value Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelServiceSpecification/SSP-003	Indicates that the server implemented all features of the Submodel Service Specification Read Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/AasxFileServerServiceSpecification/SSP-001	Indicates that the server implemented all details of the AASX File Server Service Specification Full Profile in version 3.0.

https://admin-shell.io/aas/API/3/0/AssetAdministrationShellRegistryServiceSpecification/SSP-001	Indicates that the server implemented all details of the Asset Administration Shell Registry Service Specification Full Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/AssetAdministrationShellRegistryServiceSpecification/SSP-002	Indicates that the server implemented all details of the Asset Administration Shell Registry Service Specification Read Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelRegistryServiceSpecification/SSP-001	Indicates that the server implemented all details of the Submodel Registry Service Specification Full Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelRegistryServiceSpecification/SSP-002	Indicates that the server implemented all details of the Submodel Registry Service Specification Read Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/DiscoveryServiceSpecification/SSP-001	Indicates that the server implemented all details of the Discovery Service Specification Full Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/AssetAdministrationShellRepositoryServiceSpecification/SSP-001	Indicates that the server implemented all details of the Asset Administration Shell Repository Service Specification Full Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/AssetAdministrationShellRepositoryServiceSpecification/SSP-002	Indicates that the server implemented all details of the Asset Administration Shell Repository Service Specification Read Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelRepositoryServiceSpecification/SSP-001	Indicates that the server implemented all details of the Submodel Service Specification Full Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelRepositoryServiceSpecification/SSP-002	Indicates that the server implemented all details of the Submodel Service Specification Read Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelRepositoryServiceSpecification/SSP-003	Indicates that the server implemented all details of the Submodel Service Specification Template Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/SubmodelRepositoryServiceSpecification/SSP-004	Indicates that the server implemented all details of the Submodel Service Specification Template Read Profile in version 3.0.
https://admin-shell.io/aas/API/3/0/ConceptDescriptionServiceSpecification/SSP-001	Indicates that the server implemented all details of the Concept Description Service Specification Read Template Profile in version 3.0.

An example ServiceDescription object might look like the following, indicating that the server supports two profiles at the same time (see Clause 12.12 for further details on service specifications and profiles):

```
{
    "profiles": [
       "https://admin-shell.io/aas/API/3/0/DiscoveryServiceSpecification/SSP-
          001",
       "https://admin-shell.io/aas/API/3/0/RegistryServiceSpecification/SSP-
          002"
    ]
}
```

10.2.7 Simple Data Types

All simple data types from Part 1 [1] apply also to the specifications described in this document. Additional data types are defined in Table 2.

Table 2 Simple Data Types used for API-specific Classes

Primitive	Definition	Value Examples
NonNegativeInteger	The *nonNegativeInteger* datatype as defined by XML Schema Part 2 in version 1.0[4]	0 42

10.2.8 Primitive Data Types

All primitive data types from Part 1 version 3.0 apply also to the specifications described in this document. All constraints and spelling patterns apply as well. In addition, the following data types are defined.

Table 3 Primitive Data Types used for the API-specific Classes

Primitive	Definition	Value Examples
CodeType	*string* with max 32 and min 1 characters	“409” “Bad_UserAccessDenied”
ShortIdType	same as *NameType* Note: ShortIdType is *not* the data type of idShort attributes but for IDs which shall be shorter than the identifier type.	“02063059-b81c-482b-97d1-d29cbe382ef6” “my-random-id”

[4] https://www.w3.org/TR/xmlschema-2/

10.2.9 Status Code, Error Handling & Result Messages

This clause deals with the error and result handling of an operation's execution in a technology-independent manner.

The first clause covers generic status codes that are returned on each request, independent of the operation's success or failure. The subsequent clause describes the result object that is returned in case of failure.

10.2.9.1 Generic Status Codes

Successful operations return one of the success status codes and their respective payload. Unsuccessful operations return one of the failure status codes and a result object as defined in Clause 10.2.9.2.

Table 4 shows generic status codes returned to the requester. Additionally, the table indicates whether a specific status code comes with a result object in the returned payload.

Table 4 Status Codes

Generic Status Code	Meaning	Has Result Object
Success	Success	No
SuccessCreated	Successful creation of a new resource	No
SuccessAccepted	The reception of the request was successful	No
SuccessNoContent	Success with explicitly no content in the payload	No
ClientErrorBadRequest	Bad or malformed request	Yes
ClientNotAuthorized	Wrong or missing authorization credentials	Yes
ClientForbidden	Authorization has been refused	Yes
ClientMethodNotAllowed	Operation request is not allowed	Yes
ClientErrorResourceNotFound	Resource not found	Yes
ClientResourceConflict	Conflict-creating resource (resource already exists)	Yes
ServerInternalError	Unexpected error	Yes
ServerErrorBadGateway	Bad gateway	Yes

10.2.9.2 General Result Object

In case of a failed operation execution, a result object shall be returned containing more information about the reasons why the operation failed to execute.

Class Name	Result		
Explanation	The result object		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/Result/3/0		
Attribute	**Explanation**	**Type**	**Card.**
message	Additional message containing information for the requester	Message	0..*

Class Name	Message		
Explanation	A message containing more information for the requester about a certain happening in the backend		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/Message/3/0		
Attribute	**Explanation**	**Type**	**Card.**
messageType	The message type	MessageTypeEnum	1
text	The message text	string	1
code	Technology-dependent status or error code	CodeType	0..1
correlationId	Identifier to relate several result messages throughout several systems	ShortIdType	0..1
timestamp	Timestamp of the message	dateTime	0..1

Enumeration	MessageTypeEnum
Explanation	The message type
semanticId	https://admin-shell.io/aas/API/DataTypes/MessageTypeEnum/3/0
Literal	**Explanation**
Info	Used to inform the user about a certain fact
Warning	Used for warnings; warnings may lead to errors in the subsequent execution
Error	Used for handling errors
Exception	Used in case of an internal and/or unhandled exception

10.2.9.3 Operation Objects

The following type definitions are used to call and handle the requests and responses while performing synchronous or asynchronous operation invocation.

10.2.9.3.1 OPERATIONREQUEST

Class Name	OperationRequest		
Explanation	The operation request object		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/OperationRequest/3/0		
Attribute	**Explanation**	**Type**	**Card.**
inputArguments	Input argument	OperationVariable	0..*
inoutputArguments	InOutput argument	OperationVariable	0..*
clientTimeoutDuration	Duration indicating when the client expects the server to have finished execution of the invoked operation	duration	0..1

10.2.9.3.2 OPERATIONRESULT

Class Name	OperationResult		
Explanation	The operation's invocation result object		
Inherits from	Result		
semanticId	https://admin-shell.io/aas/API/DataTypes/OperationResult/3/0		
Attribute (* = mandatory)	**Explanation**	**Type**	**Card.**
outputArguments	Output argument	OperationVariable	0..*
inoutputArguments	InOutput argument	OperationVariable	0..*
executionState	Execution state	ExecutionState	1
success	Flag indicating whether the business operation behind the operation was successful (true) or not (false)	boolean	0..1

10.2.9.3.3 ENUMERATION EXECUTIONSTATE

Enumeration	ExecutionState
Explanation	The operation's invocation result state
semanticId	https://admin-shell.io/aas/API/DataTypes/ExecutionState/3/0
Literal	**Explanation**
Initiated	The operation is ready to be executed (initial state)
Running	The operation is running
Completed	The operation is completed
Canceled	The operation was cancelled externally
Failed	The operation failed
Timeout	The operation has timed out due to given client or server timeout

10.2.9.3.4 OPERATIONHANDLE

Class Name	OperationHandle		
Explanation	The returned handle of an operation’s asynchronous invocation used to request the current state of the operation’s execution		
Inherits from	--		
semanticId	https://admin-shell.io/aas/API/DataTypes/OperationHandle/3/0		
Attribute	**Explanation**	**Type**	**Card.**
handleId	Handle id	ShortIdType	1

10.2.10 File Content

The “File Content” type of the operations mentioned above is seen as “arbitrary binary data” according to RFC 2046 and is as such defined as byte-array in UTF8-encoding. If a content type is required, “application/octet-stream” must be used as defined in RFC 2046.

11 Basic Operation Parameters

11.1 General

This clause specifies the parameters for API operations.

11.2 SerializationModifiers in Operations

Definition

For GET operations, a SerializationModifier indicates the requester's expected or desired response content. For PUT and PATCH operations, a SerializationModifier indicates the input content. The SerializationModifier comprises three orthogonal enumerations. When combined, these enumerations influence the input or response content of the requested operation.

Note: values remain unchanged with content=metadata.

1. Enumeration: Level

The first enumeration *Level* indicates the depth of the structure of the response or input content.

Table 5 Level Parameters

Value	Explanation
Deep (Default)	All elements of a requested hierarchy level and all children on all sublevels are returned. Children in this sense are SubmodelElements which are contained at the 'submodelElements' field of Submodels, the 'value' field of SubmodelElementCollections or SubmodelElementLists, the 'statements' field of Entities, or the 'annotations' field of AnnotatedRelationshipElements.
Core	Only elements of a requested hierarchy level as well as direct children are returned. By this, a client can iterate the hierarchy step by step.

Note: level parameters are mapped to the query parameter "?level" in the HTTP/REST APIs, see also Clause 12.8.

2. Enumeration: Content

The second enumeration *Content* indicates the kind of serialization of the response or input content.

For Content equal to Value see Clause 11.4.2 for details.

Table 6 Content Parameters

Value	Explanation
Normal (Default)	The standard serialization of the model element or child elements is applied.
Metadata	Only metadata of an element or child elements is returned; the value is not .
Value	Only the raw value of the model element or child elements is returned; it is commonly referred to as *ValueOnly*-serialization.
Reference	Only applicable to Referables. Only the reference to the found element is returned; potential child elements are ignored.

Path	Returns the idShort of the requested element and a list of *idShort* paths to child elements if the requested element is a Submodel, a SubmodelElementCollection, a SubmodelElementList, a AnnotatedRelationshipElement, or an Entity.

Note: level parameters are mapped to path suffixes "/$<content>" in the HTTP/REST APIs, see also Clause 12.8.

3. Enumeration: Extent

The third enumeration *Extent* indicates to which extent the response or input content is being serialized. At this stage, the listed values could also be represented as binary values on BLOB-elements. They are, however, kept as generic extent values for the sake of extension.

Table 7 Extent Parameters

Value	Explanation
WithoutBLOBValue (Default)	Only applicable to BLOB-elements; the BLOB content is not returned.
WithBLOBValue	Only applicable to BLOB-elements; the BLOB content is returned as *base64*-encoded string.

Note: level parameters are mapped to the query parameter "?extent" in the HTTP/REST APIs, see also Clause 12.8.

11.3 Applicability of SerializationModifiers

The defined SerializationModifiers are only valid for specific operations due to their generic nature. Also, the applicability depends on the kind of the accessed resource. The following list defines the applicability of the modifiers to the resources.

GET and PATCH operations may combine all SerializationModifiers as listed below. PUT operations may only use the Extent Modifier. POST operations do not use SerializationModifiers.

Table 8 Applicability of SerializationModifiers

Resource Name	Level Modifier	Content Modifier	Extent Modifier
Asset Administration Shell	No	Normal/Reference	No
Submodel Reference	No	No	No
Submodel	Deep/Core	Normal/ Metadata/Value/Reference/Path	WithoutBLOBValue/ WithBLOBValue
SubmodelElements			
SubmodelElementCollection	Deep/Core	Normal/ Metadata/Value/Reference/Path	WithoutBLOBValue/ WithBLOBValue
SubmodelElementList	Deep/Core	Normal/ Metadata/Value/Reference/Path	WithoutBLOBValue/ WithBLOBValue

Resource Name	Level Modifier	Content Modifier	Extent Modifier
Entity	Deep/Core	Normal/ Metadata/Value/Reference/Path	WithoutBLOBValue/ WithBLOBValue
BasicEventElement	No	Normal/ Metadata/Value/Reference	No
Capability	No	Normal/Reference	No
Operation	No	Normal/Reference	No
DataElements			
Property	No	Normal/ Metadata/Value/Reference	No
MultilanguageProperty	No	Normal/ Metadata/Value/Reference	No
Range	No	Normal/ Metadata/Value/Reference	No
ReferenceElement	No	Normal/ Metadata/Value/Reference	No
RelationshipElement	No	Normal/ Metadata/Value/Reference	No
AnnotatedRelationshipElement	No	Normal/ Metadata/Value/Reference	No
Blob	No	Normal/ Metadata/Value/Reference	WithoutBLOBValue/ WithBLOBValue
File	No	Normal/ Metadata/Value/Reference	No

Note: EventPayload defines the necessary information of an event instance sent out or received. It is, however not part of the AAS and submodel hierarchical structure.

11.4 Serialization in Specified Formats (SerializationModifier *Content*)

11.4.1 General

If the SerializationModifier *Content* is set to **Value**, the ValueOnly-Serialization is used as described below.

Note: to date, only the serialization in JSON has been specified. Other serialization formats (e.g. XML, RDF, etc.) will be defined in future versions of this document.

11.4.2 ValueOnly-Serialization in JSON

Note: this clause explains how to return the submodel element's value only if the SerializationModifier *Content* is set to *Value*.

In many cases, applications using data from Asset Administration Shells already know the Submodel regarding its structure, attributes, and semantics. Consequently, there is not always a need to receive the entire model information, which can be requested separately via *Content* modifier set to *Metadata*, in each request since it is constant most of the time. Instead, applications are most likely only interested in the values of the modelled data. Furthermore, having limited processing power or limited bandwidth, one use case of this SerializationModifier is to transfer data as efficiently as possible. Semantics and data might be split into two separate architecture building blocks. For example, a database would suit the needs for querying semantics, while a device would only provide the data at runtime. Two separate requests make it possible to build up a user interface (UI) and show new upcoming values highly efficiently.

Values are only available for

- All subtypes of abstract type *DataElement*,
- SubmodelElementList and SubmodelElementCollection resp. for their included SubmodelElements,
- ReferenceElement,
- RelationshipElement + AnnotatedRelationshipElement,
- Entity,
- BasicEventElement.

Capabilities are excluded from the SerializationModifier's scope since only data containing elements are in the focus. They are consequently omitted in the serialization.

The following rules shall be adhered to when serializing a submodel with the SerializationModifier *Value*:

- A submodel is serialized as an unnamed JSON object.
- A submodel element is considered a leaf submodel element if it does not contain other submodel elements. A leaf submodel element follows the rules for the different submodel elements considered in the serialization, as described below. If it is not a leaf element, the serialization rules must be transitively followed until the value is a leaf submodel element.
- For each submodel element:

    - *Property* is serialized as `${Property/idShort}: ${Property/value}` where `${Property/value}` is the JSON serialization of the respective property's value in accordance with the data type to value mapping (see table after this section).

    - *MultiLanguageProperty* is serialized as named JSON object with `${MultiLanguageProperty/idShort}` as the name of the containing JSON property. The JSON object contains an array of JSON objects for each language of the *MultiLanguageProperty* with the language as name and the corresponding localized string as value of the respective JSON property. The language name is defined as two chars according to ISO 639-1.

    - *Range* is serialized as named JSON object with `${Range/idShort}` as the name of the containing JSON property. The JSON object contains two JSON properties. The first is named "min". The second is named "max". Their corresponding values are `${Range/min}` and `${Range/max}`.

- *File* and *Blob* are serialized as named JSON objects with `${File/idShort}` or `${Blob/idShort}`as the name of the containing JSON property. The JSON object contains two JSON properties. The first refers to the content type named `${File/contentType}` resp. `${Blob/contentType}`. The latter refers to the value named “value” `${File/value}` resp. `${Blob/value}`. The resulting ValueOnly object is indistinguishable whether it contains File or Blob attributes. Therefore, the receiver needs to take the type of the target resource into account. Since the receiver knows in advance if a File or a Blob SubmodelElement shall be manipulated, it can parse the transferred ValueOnly object accordingly as a File or Blob object.

- *SubmodelElementCollection* is serialized as named JSON object with `${SubmodelElementCollection/idShort}` as the name of the containing JSON property. The elements contained within the struct are serialized according to their respective type with `${SubmodelElement/idShort}` as the name of the containing JSON property.

- *SubmodelElementList* is serialized as a JSON array with the index of the contained SubmodelElement in the list as the position in the JSON array. The elements contained within the list are serialized according to their respective type.

- *ReferenceElement* is serialized as `${ReferenceElement/idShort}`: `${ReferenceElement/value}` where `${ReferenceElement/value}` is the serialization of the *Reference* class.

- *RelationshipElement* is serialized as named JSON object with `${RelationshipElement/idShort}` as the name of the containing JSON property. The JSON object contains two JSON properties. The first is named “first”. The second is named “second”. Their corresponding values are `${RelationshipElement/first}` resp. `${Relationship/second}`. The values are serialized according to the serialization of a *ReferenceElement* (see above).

- *AnnotatedRelationshipElement* is serialized according to the serialization of a *ReleationshipElement* (see above). Additionally, a third named JSON object is introduced with “annotations” as the name of the containing JSON property. The value is `${AnnotatedRelationshipElement/annotations}`. The values of the array items are serialized depending on the type of the annotation data element.

- *Entity* is serialized as named JSON object with `${Entity/idShort}` as the name of the containing JSON property. The JSON object contains three JSON properties. The first is named “statements” `${Entity/statements}` and contains an array of the serialized submodel elements according to their respective serialization mentioned in this clause. The second is named either “globalAssetId” or “specificAssetId” and contains either a *Reference* (see above) or a *SpecificAssetId*. The third property is named “entityType” and contains a string representation of `${Entity/entityType}`. *SpecificAssetId* is serialized as named JSON object with the values of the properties “name” for the JSON key and “value” for the JSON value.

- *BasicEventElement* is serialized as named JSON object with `${BasicEventElement/idShort}` as the name of the containing JSON property. The JSON object contains one JSON property named “observed” with the corresponding value of $`{BasicEventElement/observed}` as the standard serialization of the *Reference* class.

- Submodel elements defined in the submodel other than the ones mentioned above are not subject to serialization of that SerializationModifier.

Data type to value mapping[5]

The serialization of submodel element values is described in the following table. The left column “Data Type” shows the data types which can be used for submodel element values. The data types are defined according to the W3C XML Schema (https://www.w3.org/TR/xmlschema-2/#built-in-datatypes and https://www.w3.org/TR/xmlschema-2/#built-in-derived). “Value Range” further explains the possible range of data values for this data type. The right column comprises related examples of the serialization of submodel element values.

Table 9 Mapping of Data Types in ValueOnly-Serialization

	Data Type	JSON Type	Value Range	Sample Values
Core Types	xs:string	string	Character string	"Hello world", "Καλημέρα κόσμε", "コンニチハ"
	xs:boolean	boolean	true, false	true, false
	xs:decimal	number	Arbitrary-precision decimal numbers	-1.23, 126789672374892739424.543233, 100000.00, 210
	xs:integer	number	Arbitrary-size integer numbers	-1, 0, 126789675432332938792837429837429837429, 100000
IEEE-floating-point numbers	xs:double	number	64-bit floating point numbers	-1.0, -0.0, 0.0, 234.567e8, 234.567e+8, 234.567e-8
	xs:float	number	32-bit floating point numbers	-1.0, -0.0, 0.0, 234.567e8, 234.567e+8, 234.567e-8
Time and data	xs:date	string	Dates (yyyy-mm-dd) with or without time zone	"2000-01-01","2000-01-01Z", "2000-01-01+12:05"
	xs:time	string	Times (hh:mm:ss.sss…) with or without time zone	"14:23:00", "14:23:00.527634Z", "14:23:00+03:00"
	xs:dateTime	string	Date and time with or without time zone	"2000-01-01T14:23:00", "2000-01-01T14:23:00.66372+14:00"
	xs:dateTimeStamp	string	Date and time with required time zone	"2000-01-01T14:23:00.66372+14:00"
Recurring and partial dates	xs:gYear	string	Gregorian calendar year	"2000", "2000+03:00"
	xs:gMonth	string	Gregorian calendar month	"--04", "--04+03:00"
	xs:gDay	string	Gregorian calendar day of the month	"---04", "---04+03:00"
	xs:gYearMonth	string	Gregorian calendar year and month	"2000-01", "2000-01+03:00"

[5] cf. https://openmanufacturingplatform.github.io/sds-documentation/bamm-specification/2.0.0/datatypes.html

	xs:gMonthDay	string	Gregorian calendar month and day	"--01-01", "--01-01+03:00"
	xs:duration	string	Duration of time	"P30D", "-P1Y2M3DT1H", "PT1H5M0S"
	xs:yearMonthDuration	string	Duration of time (months and years only)	"P10M", 'P5Y2M"
	xs:dayTimeDuration	string	Duration of time (days, hours, minutes, seconds only)	"P30D", 'P1DT5H", 'PT1H5M0S"
Limited-range integer numbers	xs:byte	number	-128…+127 (8 bit)	-1, 0, 127
	xs:short	number	-32768…+32767 (16 bit)	-1, 0, 32767
	xs:int	number	2147483648…+2147483647 (32 bit)	-1, 0, 2147483647
	xs:long	number	-9223372036854775808…+9223372036854775807 (64 bit)	-1, 0, 9223372036854775807
	xs:unsignedByte	number	0…255 (8 bit)	0, 1, 255
	xs:unsignedShort	number	0…65535 (16 bit)	0, 1, 65535
	xs:unsignedInt	number	0…4294967295 (32 bit)	0, 1, 4294967295
	xs:unsignedLong	number	0…18446744073709551615 (64 bit)	0, 1, 18446744073709551615
	xs:positiveInteger	number	Integer numbers >0	1, 73456837465783648573684756 38745
	xs:nonNegativeInteger	number	Integer numbers ≥0	0, 1, 73456837465783648573684756 38745
	xs:negativeInteger	number	Integer numbers <0	-1, -23487263847628376482736487 263847
	xs:nonPositiveInteger	number	Integer numbers ≤0	-1, 0, -93845837498573987498798987 394
Encoded binary data	xs:hexBinary	string	Hex-encoded binary data	"6b756d6f77617368657265"
	xs:base64Binary	string	base64-encoded binary data	"a3Vtb3dhc2hlcmU="
Miscellaneous types	xs:anyURI	string	Absolute or relative URIs and IRIs	"http://customer.com/demo/aas/1/1/1234859590", "urn:example:company:1.0.0"
	rdf:langString	string	Strings with language tags	"'Hello'@en", "'Hallo'@de" Note: the examples are written in RDF/Turtle syntax, and only "Hello" and "Hallo" are the actual values.

The following types defined by the XSD and RDF specifications are explicitly omitted for serialization:

xs:language, xs:normalizedString, xs:token, xs:NMTOKEN, xs:Name, xs:NCName, xs:QName, xs:ENTITY, xs:ID, xs:IDREF, xs:NOTATION, xs:IDREFS, xs:ENTITIES, xs:NMTOKENS, rdf:HTML and rdf:XMLLiteral.

Note 1: due to the limits in the representation of numbers in JSON, the maximum integer number that can be used without losing precision is 2^{53}-1 (defined as Number.MAX_SAFE_INTEGER). Even if the used data type would allow higher or lower values, they cannot be used if they cannot be represented in JSON. Affected data types are unbounded numeric types `xs:decimal`, `xs:integer`, `xs:positiveInteger`, `xs:nonNegativeInteger`, `xs:negativeInteger`, `xs:nonPositiveInteger` and the bounded type `xs:unsignedLong`. Other numeric types are not affected.[6]

Note 2: the ValueOnly-serialization uses JSON native data types, AAS in general uses XML Schema Built-in Datatypes for Simple Data Types and ValueDataType. In case of booleans, JSON accepts only literals true and false, whereas xs:boolean also accepts 1 and 0, respectively. In case of double, JSON number is used in ValueOnly, but JSON number does not support INF/-INF (positive Infinity/negative), which is supported by xs:double. Furthermore, NaN (Not a Number) is also not supported.
(See https://datatracker.ietf.org/doc/html/rfc8259#section-6)

Note 3: language-tagged strings (rdf:langString) containing single quotes (‘) or double quotes (“) are not supported.

Examples conformant to [1]:

Full serialization of single submodel element *Property*:

```
{
    "idShort": "MaxRotationSpeed",
    "category": "PARAMETER",
    "kind": "Instance",
    "semanticId": {
        "type": "ModelReference",
        "keys": [{
            "type": "ConceptDescription",
            "value": "0173-1#02-BAA120#008",
        }]
    },
    "modelType": "Property",
    "valueType": "xs:int",
    "value": "5000"
}
```

With the SerializationModifier set to *Value,* the payload is minimized to the following:

```
{
    "MaxRotationSpeed" : 5000
}
```

For a *SubmodelElementCollection,* the struct is serialized as objects denoted by curly brackets:

```
{
    "NamesOfFamilyMembers": {
        "NameOfMother": "Martha ExampleFamily",
        "NameOfFather": "Jonathan ExampleFamily",
        "NameOfSon": "Clark ExampleFamily"
    }
}
```

For a *SubmodelElementList,* the struct is serialized as array denoted by square brackets:

[6] cf. https://openmanufacturingplatform.github.io/sds-documentation/bamm-specification/v1.0.0/datatypes.html (with adjustments for +/-INF, NaN, and language-typed literal support)

```
{
    "NamesOfFamilyMembers": [
        "Martha ExampleFamily",
        "Jonathan ExampleFamily",
        "Clark ExampleFamily"
    ]
}
```

For a *MultiLanguageProperty* named “Label”, the payload is minimized to the following:

```
{
    "Label": [
        { "de": "Das ist ein deutscher Bezeichner" },
        { "en": "That's an English label" }
    ]
}
```

Note: in accordance with IETF RFC 5646, the language names match the following regular expression:
`^[a-z]{2,4}(-[A-Z][a-z]{3})?(-([A-Z]{2}|[0-9]{3}))?$`

For a *Range* named “TorqueRange”, the payload is minimized to the following:

```
{
    "TorqueRange": {
        "min": 3,
        "max": 15
    }
}
```

For a *ReferenceElement* named “MaxRotationSpeedReference”, the payload is minimized to the following:

```
{
    "MaxRotationSpeedReference":
    {
        "type": "ModelReference",
        "keys": [
            {
                "type": "Submodel",
                "value": "http://customer.com/demo/aas/1/1/1234859590"
            },
            {
                "type": "Property",
                "value": "MaxRotationSpeed"
            }
        ]
    }
}
```

For the same *ReferenceElement,* the payload is minimized to the following in case the *Reference* is of subtype *GlobalReference*:

```
{
    "MaxRotationSpeedReference":
    {
        "type": "ExternalReference",
        "keys": [
            {
                "type": "GlobalReference",
                "value": "0173-1#02-BAA120#008"
            }
        ]
    }
}
```

For a *File* named “Document”, the payload is minimized to the following:

```
{
    "Document": {
        "contentType": "application/pdf",
        "value": "SafetyInstructions.pdf"
    }
}
```

For a *Blob* named “Library”, the payload is minimized to the following if the SerializationModifier *Extent* is set to ***WithoutBLOBValue***

```
{
    "Library": {
        "contentType": "application/octet-stream"
    }
}
```

If the SerializationModifier Extent is set to ***WithBlobValue***, there is an additional attribute containing the base64-encoded value:

```
{
    "Library": {
        "contentType": "application/octet-stream",
        "value": "VGhpcyBpcyBteSBibG9i"
    }
}
```

For a *RelationshipElement* named “CurrentFlowsFrom”, the payload is minimized to the following:


```
{
    "CurrentFlowsFrom": {
        "first": {
            "type": "ModelReference",
            "keys": [
                {
                    "type": "Submodel",
                    "value": "http://customer.com/demo/aas/1/1/1234859590"
                },
                {
                    "type": "Property",
                    "value": "PlusPole"
                }
            ]
        },
        "second": {
            "type": "ModelReference",
            "keys": [
                {
                    "type": "Submodel",
                    "value": "http://customer.com/demo/aas/1/0/1234859123490"
                },
                {
                    "type": "Property",
                    "value": "MinusPole"
                }
            ]
        }
    }
}
```


For an *AnnotatedRelationshipElement* named “CurrentFlowFrom”, with an annotated *Property*-DataElement “AppliedRule”, the payload is minimized to the following:

```
{
    "CurrentFlowsFrom": {
        "first": {
            "type": "ModelReference",
            "keys": [
                {
                    "type": "Submodel",
                    "value": "http://customer.com/demo/aas/1/1/1234859590"
                },
                {
                    "type": "Property",
                    "value": "PlusPole"
                }
            ]
        },
        "second": {
            "type": "ModelReference",
            "keys": [
                {
                    "type": "Submodel",
                    "value": "http://customer.com/demo/aas/1/0/1234859123490"
                },
                {
                    "type": "Property",
                    "value": "MinusPole"
                }
            ]
        },
        "annotation": [
            {
                "AppliedRule": "TechnicalCurrentFlowDirection"
            }
        ]
    }
}
```


For an *Entity* named “MySubAssetEntity”, the payload is minimized to the following:


```
{
    "MySubAssetEntity": {
        "statements": {
            "MaxRotationSpeed": 5000
        },
        "entityType": "SelfManagedEntity",
        "globalAssetId": "http://customer.com/demo/asset/1/1/MySubAsset"
    }
}
```

For a BasicEventElement named “MyBasicEvent”, the payload is minimized to the following:

```
{
    "MyBasicEvent": {
        "observed": {
            "type": "ModelReference",
            "keys": [
                {
                    "type": "Submodel",
                    "value": "http://customer.com/demo/aas/1/1/1234859590"
                },
                {
                    "type": "Property",
                    "value": "CurrentValue"
                }
            ]
        }
    }
}
```

11.4.3 JSON-Schema for the ValueOnly-Serialization

The following JSON-Schema represents the validation schema for the ValueOnly-Serialization of submodel elements. This holds true for all submodel elements mentioned in the previous clause except for *SubmodelElementCollections*. Since *SubmodelElementCollections* are treated as objects containing submodel elements of any kind, the integration into the same validation schema would result in a circular reference or ambiguous results ignoring the actual validation of submodel elements other than *SubmodelElementCollections*. Hence, the same validation schema must be applied for each *SubmodelElementCollection* within a submodel element hierarchy. In this case, it may be necessary to create a specific JSON-Schema for the individual use case. The *SubmodelElementCollection* is added to the following schema for completeness and clarity. It is, however, not referenced from the *SubmodelElementValue*-oneOf-Enumeration due to the reasons mentioned above.
See Annex B for an example that validates against this schema.

```
{
  "$schema": "https://json-schema.org/draft/2019-09/schema",
  "title": "ValueOnly-Serialization-Schema",
  "$id": "https://admin-shell.io/schema/valueonly/json/V3.0",
  "definitions": {
    "AnnotatedRelationshipElementValue": {
      "type": "object",
      "properties": {
        "first": {
          "$ref": "#/definitions/ReferenceValue"
        },
        "second": {
          "$ref": "#/definitions/ReferenceValue"
        },
        "annotation": {
          "type": "array",
          "items": {
            "$ref": "#/definitions/ValueOnly"
          }
        }
      },
      "required": [
        "first",
        "second",
        "annotation"
      ],
      "additionalProperties": false
    },
    "BasicEventElementValue": {
```

```
      "type": "object",
      "properties": {
        "observed": {
          "$ref": "#/definitions/ReferenceValue"
        }
      },
      "required": [
        "observed"
      ],
      "additionalProperties": false
    },
    "BlobValue": {
      "type": "object",
      "properties": {
        "contentType": {
          "type": "string",
          "minLength": "1",
          "maxLength": "100"
        },
        "value": {
          "type": "string"
        }
      },
      "required": [
        "contentType",
        "value"
      ],
      "additionalProperties": false
    },
    "BooleanValue": {
      "type": "boolean",
      "additionalProperties": false
    },
    "EntityValue": {
      "type": "object",
      "properties": {
        "statements": {
          "$ref": "#/definitions/ValueOnly"
        },
        "entityType": {
          "enum": [
            "SelfManagedEntity",
            "CoManagedEntity"
          ]
        },
        "globalAssetId": {
          "type": "string"
        },
        "specificAssetIds": {
          "type": "array",
          "items": {
            "$ref": "#/definitions/SpecificAssetIdValue"
          }
        }
      },
      "required": [
        "statements",
        "entityType"
      ],
      "additionalProperties": false
    },
    "FileValue": {
      "type": "object",
      "properties": {
```

```
        "contentType": {
          "type": "string",
          "minLength": "1",
          "maxLength": "100"
        },
        "value": {
          "type": "string",
          "minLength": "1",
          "maxLength": "200"
        }
      },
      "required": [
        "contentType",
        "value"
      ],
      "additionalProperties": false
    },
    "Identifier": {
      "type": "string"
    },
    "Key": {
      "type": "object",
      "properties": {
        "type": {
          "type": "string"
        },
        "value": {
          "type": "string"
        }
      },
      "required": [
        "type",
        "value"
      ],
      "additionalProperties": false
    },
    "LangString": {
      "type": "object",
      "patternProperties": {
        "^[a-z]{2,4}(-[A-Z][a-z]{3})?(-([A-Z]{2}|[0-9]{3}))?$": {
          "type": "string"
        }
      },
      "additionalProperties": false
    },
    "MultiLanguagePropertyValue": {
      "type": "array",
      "items": {
        "$ref": "#/definitions/LangString"
      },
      "additionalProperties": false
    },
    "NumberValue": {
      "type": "number",
      "additionalProperties": false
    },
    "OperationRequestValueOnly": {
      "inoutputArguments": {
        "$ref": "#/definitions/ValueOnly"
      },
      "inputArguments": {
        "$ref": "#/definitions/ValueOnly"
      },
      "timestamp": {
```

```
        "type": "string",
        "pattern": "^-?(([1-9][0-9][0-9][0-9]+)|(0[0-9][0-9][0-9]))-((0[1-
9])|(1[0-2]))-((0[1-9])|([12][0-9])|(3[01]))T((([01][0-9])|(2[0-3])):[0-
5][0-9]:([0-5][0-9])(\\.[0-9]+)?)|24:00:00(\\.0+)?)(Z|\\+00:00|-00:00)$"
      },
      "additionalProperties": false
    },
    "OperationResultValueOnly": {
      "executionState": {
        "type": "string",
        "enum": ["Initiated", "Running", "Completed", "Canceled", "string",
                 "Failed", "Timeout"]
      },
      "inoutputArguments": {
        "$ref": "#/definitions/ValueOnly"
      },
      "outputArguments": {
        "$ref": "#/definitions/ValueOnly"
      },
      "additionalProperties": false
    },
    "PropertyValue": {
      "oneOf": [
        {
          "$ref": "#/definitions/StringValue"
        },
        {
          "$ref": "#/definitions/NumberValue"
        },
        {
          "$ref": "#/definitions/BooleanValue"
        }
      ]
    },
    "RangeValue": {
      "type": "object",
      "properties": {
        "min": {
          "type": "number"
        },
        "max": {
          "type": "number"
        }
      },
      "required": [
        "min",
        "max"
      ],
      "additionalProperties": false
    },
    "ReferenceElementValue": {
      "$ref": "#/definitions/ReferenceValue"
    },
    "ReferenceValue": {
      "type": "object",
      "properties": {
        "type": {
          "type": "string",
          "enum": ["ModelReference", "ExternalReference"]
        },
        "keys": {
          "type": "array",
          "items": {
            "$ref": "#/definitions/Key"
```

```
          }
        }
      },
      "additionalProperties": false
    },
    "RelationshipElementValue": {
      "type": "object",
      "properties": {
        "first": {
          "$ref": "#/definitions/ReferenceValue"
        },
        "second": {
          "$ref": "#/definitions/ReferenceValue"
        }
      },
      "required": [
        "first",
        "second"
      ],
      "additionalProperties": false
    },
    "SpecificAssetIdValue": {
      "type": "object",
      "patternProperties": {
        "(.*?)": {
          "type": "string"
        }
      }
    },
    "StringValue": {
      "type": "string",
      "additionalProperties": false
    },
    "SubmodelElementCollectionValue": {
      "$ref": "#/definitions/ValueOnly"
    },
    "SubmodelElementListValue": {
      "type": "array",
      "items": {
        "$ref": "#/definitions/SubmodelElementValue"
      }
    },
    "SubmodelElementValue": {
      "oneOf": [
        {
          "$ref": "#/definitions/BasicEventElementValue"
        },
        {
          "$ref": "#/definitions/RangeValue"
        },
        {
          "$ref": "#/definitions/MultiLanguagePropertyValue"
        },
        {
          "$ref": "#/definitions/FileBlobValue"
        },
        {
          "$ref": "#/definitions/ReferenceElementValue"
        },
        {
          "$ref": "#/definitions/RelationshipElementValue"
        },
        {
          "$ref": "#/definitions/AnnotatedRelationshipElementValue"
```

```
          },
          {
            "$ref": "#/definitions/EntityValue"
          },
          {
            "$ref": "#/definitions/PropertyValue"
          },
          {
            "$ref": "#/definitions/SubmodelElementListValue"
          }
        ]
      },
      "ValueOnly": {
        "propertyNames": {
          "pattern": "^[A-Za-z_][A-Za-z0-9_-]*$"
        },
        "patternProperties": {
          "^[A-Za-z_][A-Za-z0-9_-]*$": {
            "$ref": "#/definitions/SubmodelElementValue"
          }
        },
        "additionalProperties": false
      }
    }
}
```

11.4.4 IdShortPath Serialization

To get only the idShort paths of a submodel element hierarchy, the serialization format is specified in terms of an idShortPath notation to be returned in an unnamed JSON-array. The notation differs depending on whether a SubmodelElementCollection or a SubmodelElementList is used. In the first case, the submodel element's idShort is separated by "." (dot) from top level down to child level. In the second case, square brackets with an index "[<<index>>]" are appended after the idShort of the containing SubmodelElementList.

In the following example, where a request for idShort paths starts at *MySubmodelElementCollection* with SerializationModifier level = deep, the list of idShort paths is returned as follows:

Submodel: MySubmodel

- ⇨ Property: MyTopLevelProperty
- ⇨ SMC: MySubmodelElementCollection
  - Property: MySubProperty1
  - Property: MySubProperty2
  - SMC: MySubSubmodelElementCollection
    - Property: MySubSubProperty1
    - Property: MySubSubProperty2
  - SML: MySubSubmodelElementList1
    - Property: "MySubTestValue1",
    - Property: "MySubTestValue2",
  - SML: MySubSubmodelElementList2
    - SML
      - Property: "MySubTestValue3"

```
[
    "MySubmodelElementCollection",
    "MySubmodelElementCollection.MySubProperty1",
    "MySubmodelElementCollection.MySubProperty2",
    "MySubmodelElementCollection.MySubSubmodelElementCollection",
    "MySubmodelElementCollection.MySubSubmodelElementCollection.MySubSubProp-
erty1",
    "MySubmodelElementCollection.MySubSubmodelElementCollection.MySubSubProp-
erty2",
    "MySubmodelElementCollection.MySubSubmodelElementList1",
    "MySubmodelElementCollection.MySubSubmodelElementList1[0]",
    "MySubmodelElementCollection.MySubSubmodelElementList1[1]",
    "MySubmodelElementCollection.MySubSubmodelElementList2",
    "MySubmodelElementCollection.MySubSubmodelElementList2[0]",
    "MySubmodelElementCollection.MySubSubmodelElementList2[0][0]"
]
```

12 HTTP/REST API

12.1 General

This clause describes the technology mapping to HTTP/REST APIs.

The OpenAPI specification of the HTTP/REST APIs can be found at SwaggerHub.

To clearly separate the different parts of the AAS model, the model has been split into several HTTP/REST APIs. Combinations then form service specifications and profiles, each materialized as an individual OpenAPI document.

The schema for the metamodel of Part 1 is available at:
https://app.swaggerhub.com/domains/Plattform_i40/Part1-MetaModel-Schemas/V3.0.1
This schema includes general objects, which are used in the further defined APIs.

Additional objects are needed for Part 2, e.g. for the ValueOnly-Serialization or the descriptors for the registry. The related schema of Part 2 objects is available at:
https://app.swaggerhub.com/domains/Plattform_i40/Part2-API-Schemas/V3.0.1
This schema includes general objects, which are used in the further defined APIs.

The definition of endpoints is based on DIN SPEC 16593. The related schema for DIN SPEC 16593 is available at: https://app.swaggerhub.com/domains/Plattform_i40/DINSPEC16593-Schemas/V3.0.1
This schema includes general objects, which are used in the further defined APIs. These objects are the basis for the definition of Part 2 APIs.

The Asset Administration Shell Service Specification including the Asset Administration Shell API, the Submodel API, the Serialization API, and the Self-Description API is available at:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellServiceSpecification/V3.0.1_SSP-001
This is a combination of APIs, which forms a service specification according to the Industrie 4.0 Service Model in Clause 4.1.

The Submodel Service Specification I including the Submodel API, the Serialization API, and the Self-Description API is available at:
https://app.swaggerhub.com/apis/Plattform_i40/SubmodelServiceSpecification/V3.0.1_SSP-001
This is a combination of APIs, which forms a service specification according to the Industrie 4.0 Service Model in Clause 4.1.

The Asset Administration Shell Repository Service Specification including the Asset Administration Shell Repository API, the Asset Administration Shell API, the Submodel API, the Submodel Repository API, the Serialization API, and the Self-Description API is available at:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellRepositoryServiceSpecification/V3.0.1_SSP-001
This is a combination of APIs, which forms a service specification according to the Industrie 4.0 Service Model in Clause 4.1.

The Submodel Repository Service Specification including the Submodel Repository API, the Submodel Repository API, the Serialization API, and the Self-Description API is available at:
https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRepositoryServiceSpecification/V3.0.1_SSP-001
This is a combination of APIs, which forms a service specification according to the Industrie 4.0 Service Model in Clause 4.1.

The Registry and Discovery APIs are independent from the other APIs. An Asset Administration Shell Registry Service Specification including the Asset Administration Shell Registry API, the Submodel Registry API through superpaths, and the Self-Description API is available at:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellRegistryServiceSpecification/V3.0.1_SSP-001
The sole Submodel Registry Service Specification including the Submodel Registry API itself and the Self-

Description API is available at:
https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRegistryServiceSpecification/V3.0.1_SSP-001

The Discovery Service Specification including the Self-Description API and the Self-Description API is available at:
https://app.swaggerhub.com/apis/Plattform_i40/DiscoveryServiceSpecification/V3.0.1_SSP-001
Both are a combination of APIs, which form a service specification according to the Industrie 4.0 Service Model in Clause 4.1.

This clause gives an overview of the HTTP/REST API and describes general design decisions.

12.2 Design Decisions

The following design decisions and constraints hold for the HTTP/REST API:

- OpenAPI and Swaggerhub shall be used for specification. This leads to the constraint that one operation can only provide one type of a resulting payload.
- This document assumes version 1.1 of HTTP.
- An endpoint of the HTTP/REST API shall always use HTTPS (Port 443) with an up-to-date level of encryption.
- The SerializationModifier “content” changes the type the of payload for inputs or results. To ensure type-safe APIs, this parameter is mapped to the path suffixes “/$value”, “/$metadata”, “/$reference”, and “/$path”. “content=normal” is mapped to the path without any “/$<content>” suffix.
- Generic SerializationModifiers changing the size of payload for input or result have been mapped to corresponding query parameters, e.g. ”?level=” or “?extent=”.
- Query parameters are also used when the type of a resulting payload is a list of objects and the type remains the same, while the query parameter filters the content of the list, e.g. GetAllSubmodels with optional query parameters “?semanticId=” or “?idShort=”.
- Complete objects are provided as requested payloads, e.g. a complete submodel. This corresponds to the generic SerializationModifier content=”normal”. Reduced objects can be requested by the path suffix “/$<content>”. See Clause 12.5 for further details. Exceptions to this rule are API Operations requiring pagination and error cases.
- By default, blobs are not part of the payload. Using ?extent=WithBLOBValue includes blobs for submodel elements of kind BLOB.
- Submodels define a hierarchical structure. Certain operations use an idShort-path to access deeper parts in the hierarchy. To easily support this in the REST API, “.” or “[index]” is used as a delimiter in the idShort-paths. Please see Clause 12.3. Since an idShort-path could include square brackets like “[index]”, the idShort-path must be URL-encoded.
- Identifiers of Identifiables are base64url-encoded to be passed to the HTTP/REST API (see https://www.base64url.com/). These may be identifiers for Asset Administration Shells, Submodels, or Concept Descriptions.
  Identifiers may also be passed as base64url-encoded query parameters, e.g. for semanticId or assetId. Such query parameters are typically used when a list of objects may be retrieved in the resulting payload. A list of base64url-encoded ids is simply passed as comma-separated query parameters.
- Please note that base64url-encoding differs slightly from base64-encoding and has been specifically defined for passing URLs. An appropriate base64url implementation needs to be used for encoding/decoding. See RFC 4648 for further details.
- When base64url or base64-encoding is mentioned in connection with string values (e.g. Identifiers), the UTF-8 decoded byte array representation of that string is used for the base64url or base64-encoding.
- When retrieving AssetAdministrationShells (/shells, /lookup/shells), a query parameter “?assetids=” can be specified. Such assetId may be a globalAssetId or specificAssetId. The corresponding key-value-pair is first serialized to JSON and then base64url-encoded. The resulting encoded string is the value of “?assetids=”.
- In some operations, references are part of the query parameters e.g. “?semanticId=”. The corresponding reference is first serialized to JSON and then base64url-encoded. The resulting encoded string is the value of “?semanticId=”.
- Even though the metamodel of the AAS distinguishes between the attributes “semanticId” and “supplementalSemanticId”, the query parameter “?semanticId” targets both.
- This encoding (serialize to JSON + base64url) is also used for SpecificAssetIds, i.e. for GetAllAssetAdministrationShellIdsByAssetLink (/lookup/shells). For the example “[{"key": "globalAssetId","value": "http://example.company/myAsset"},{"key": "myOwnInternalAssetId","value": "12345ABC"}]”, the resulting base64url-encoded value of the query parameter is

"?assetIds=W3sia2V5IjogImdsb2JhbEFzc2V0SWQiLCJ2YWx1ZSI6ICJodHRwOi8vZXhhbXBsZS5jb21wYW55L215QXNzZXQifSx7ImtleSI6ICJteU93bkludGVybmFsQXNzZXRJZCIsInZhbHVlIjogIjEyMzQ1QUJDIn1d".
If several key-value-pairs are included, all must be part of the key-value-pairs on the server.

- Comparisons of idShort are made case-sensitive in the HTTP/REST API to avoid repeating toupper()/tolower() conversions.

Note: this is conformant to the change made in Part 1 V3.0 [1].

- GetAll…-API Operations will retrieve a list of objects as the resulting payload, e.g. GetAllSubmodelElements.
- The splitting of big result sets into smaller pieces, commonly referred to as "pagination", is executed using the cursor query parameter. Therefore, result objects for GetAll…-API Operations and others requiring pagination return their content inside a Result structure. See Clause 12.6 for further explanations.
- In general, only GET, POST, PUT, PATCH and DELETE are used. POST is used to create new objects and to invoke operations.
- Some interfaces may be combined in a so-called "superpaths", e.g. the Asset Administration Shell Repository Interface may be combined with the AAS Interface and the Submodel Interface. This results in a complete path like "/shells/{aas-identifier}/submodels/{submodel-identifier}/*". This is especially useful when all data is hosted in the same repository. Superpaths are defined as part of the service specifications and profiles.
- The attribute AssetAdministrationShell/submodels (array of References) maps to the path segment "/submodel-refs" to distinguish it from the superpath segment "/submodels" (array of Submodels).
- Each interface includes a "/description" operation for self-discovery to provide detailed information about the interface. A server supporting the HTTP/REST API may also provide a server global "/description" to provide the information about all available profiles on that server.
- The recursive nature of the reference class (Reference/referredSemanticId points to Reference again) cannot be represented in SwaggerHub due to a bug in the SwaggerUI code. Therefore, the additional class "ReferenceParent" has been added. "ReferenceParent" shall not be used in productive operations and is only a placeholder for "Reference". When implementing generated code originating from the SwaggerHub schemas, please delete "ReferenceParent" and add its attributes to "Reference".

12.3 API Versioning

API versioning provides a way to deal with different versions of the same API at the same time. This way, older versions may still be accessible on the same server to provide services to legacy clients without breaking existing functionality.

There are different solutions regarding API versioning involving URL-based versioning, query parameter-based versioning, as well as HTTP header-oriented solutions using custom or standard headers.
As different solutions also provide different advantages and disadvantages, **URL-based versioning** has been selected as the most suitable method for the AAS API. Among other advantages, implementation complexity on clients as well as servers is rather low and different versions can be easily accessed through browsers without the need for specific development tools or extensions.

Figure 4 - Generic URL Scheme for AAS API Versioning

Upcoming implementations of AAS related servers need to implement the version prefix “**api/v<X.Y>/**” to provide information of the specific major version regarding AAS Part 2 version, where <X> denotes the implemented major version and <Y> denotes the minor version, e.g. “api/v3.0/” (see Figure 4).

Note: all URLs mentioned in this document regarding the REST mapping of the AAS APIs have to be understood with this prefix in mind.

The versioning scheme for AAS API related services follows semantic versioning[7]. Very briefly, this defines version numbers as a format following: <MAJOR>.<MINOR>.<PATCH>.

The major version changes in case of breaking or incompatible changes that need to be addressed by clients. Minor versions add (new) functionality in a backwards compatible way and allow clients with lower minor versions to keep their existing functionality. Patch versions only include backwards compatible bug fixes.

AAS API versioning uses the major and minor version as described above. A specific AAS API version uses specific related versions of the metamodel as defined in Clause 1.2. AAS API versions with the same major version must remain compatible, i.e. a client written for an older or a newer minor version must still work. This requires corresponding testing of clients and servers.

Additionally, “Release candidates” are variants of the implementation of the denoted major version. For example, “3.1.0 RC2” should be interpreted as the second (alternative) release candidate for version 3.1.0. This will still result in the version prefix “/api/v3.1/”.

As multiple versions will be supported in the future, an AAS ecosystem consisting of Registry / Discovery services as well as AAS Repository, Submodel (standalone), or AAS (standalone) services should share a consistent version. Therefore, a consistent interface description in the form of OpenAPI documents shall be provided with each major version.

Upcoming compatibility constraints regarding newer versions will be elaborated in further iterations of this document and related technical descriptions (OpenAPI specification).

Finally, it is recommended to include an additional "/description” endpoint into each service to further denote information about APIs / servers capabilities. This endpoint provides further information about the API and its supported profiles. The “/description” will be extended with additional information in later versions.

12.4 Addressing Resources

The API allows to address each referable element, either by its global identifier or by its idShort-path depending on the object type.

If the referable element is an identifiable, it can only be addressed by the global identifier of the object. All other referable elements are addressable by the idShort-path.
The idShort-path is a chain of idShorts or SubmodelElementList-indexes, which points to an element within a hierarchy of elements. The root of the idShort-path is always a submodel and the first element in an idShort-path is always an idShort of a first level SubmodelElement within a Submodel. Technically, the idShort path is a string and the idShorts are separated by a dot while the SubmodelElementList-indexes are written in brackets.

[7] http://semver.org

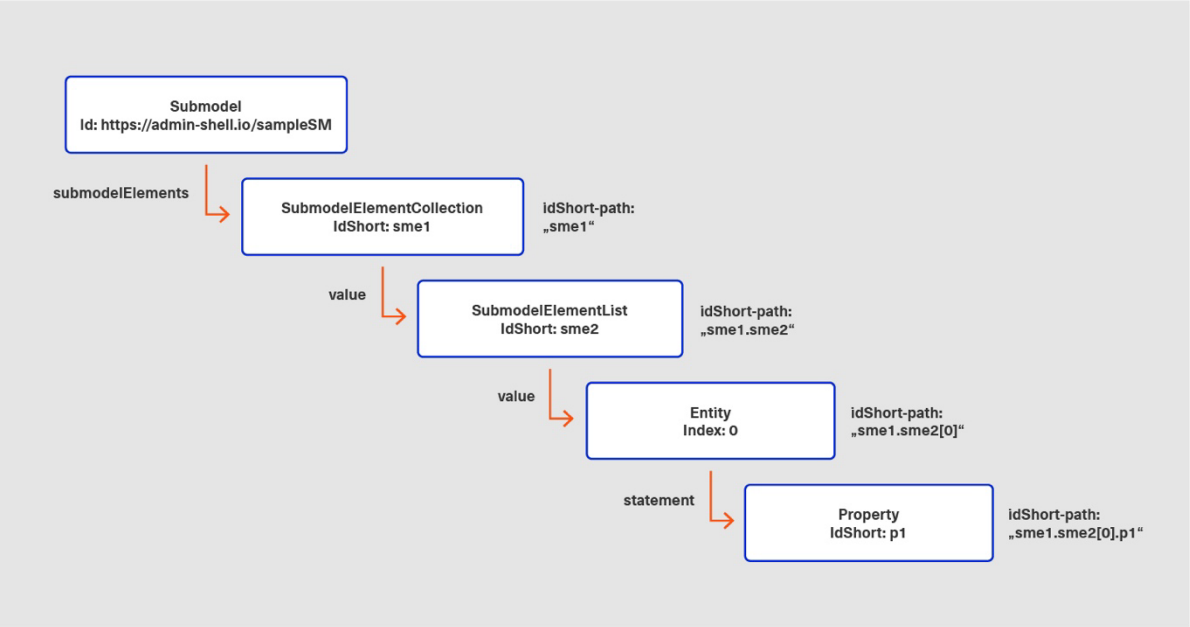


Figure 5 Example Hierarchy of Submodel Elements

The example hierarchy in Figure 5 shows a Submodel with a hierarchical structure of SubmodelElements. The submodel can be addressed by its global identifier “https://admin-shell.io/sampleSM”. The other elements in the figure do not have a global identifier; they are, however, uniquely identifiable and addressable by the submodel identifier and the idShort-path. The idShort-path in this example pointing to the Property p1 is “sme1.sme2[0].p1”. The hierarchy is built on parent-child relations between the elements. There are four elements which can aggregate SubmodelElements and create deeper hierarchal structures. The elements are Submodel, SubmodelElementCollection, SubmodelElementList, and Entity. The fields used to navigate to a deeper level of the hierarchy can be seen in the following table.

Table 10 Children of certain objects

Element Name	Child aggregation field name
Submodel	SubmodelElement
SubmodelElementCollection	value
SubmodelElementList	value
AnnotatedRelationshipElement	annotations
Entity	statements

Example requests:

GET /submodels/aHR0cHM6Ly9hZG1pbi1zaGVsbC5pby9zYW1wbGVTTQ/submodel/submodelElements/sme1.sme2%5B0%5D.p1

Add a new Property to the Entity statements:

POST /submodels/aHR0cHM6Ly9hZG1pbi1zaGVsbC5pby9zYW1wbGVTTQ/submodel/submodelElements/sme1.sme2%5B0%5D

Note 1: to avoid problems with IRI values in URLs, the identifiers shall be base64url-encoded before using them as parameters in the HTTP-APIs. IdshortPaths are base64url-encoded to also allow square brackets.
Note 2: in the example above, “aHR0cHM6Ly9hZG1pbi1zaGVsbC5pby9zYW1wbGVTTQ” is the base64url-encoding of “https://admin-shell.io/sampleSM”, “sme1.sme2%5B0%5D.p1” is the URL-encoding of “sme1.sme2[0].p1”, and “sme1.sme2%5B0%5D” is the URL-encoding of “sme1.sme2[0]”.

12.5 Metadata Objects

Metadata objects are defined for scenarios where a client only wants to access the metadata of an object, but not the value. **Metadata objects are only part of HTTP/REST and do not change the metamodel.** Metadata objects are used to reduce the payload response to a minimum and to avoid the recursive traversing through the data model when not needed. In many cases, a client is not interested in each child element or value of a resource, but only in the resource itself.

A metadata object does not contain any additional fields in relation to its full object representation, only some fields are left off. The left off fields are fields which could be requested by an own API call and may consist of a recursive or potentially large substructure. The serialization of a metadata object is the same as for the original full object, but without the left off fields.

Table 11 Metadata Attributes

Class Name	Fields not available in metadata representation
Identifiables	
AssetAdministrationShell	assetInformation, submodels
Submodel	submodelElements
SubmodelElements	
SubmodelElementCollection	value
SubmodelElementList	value
Entity	statements, globalAssetId, specificAssetId
BasicEventElement	observed
Capability	--
Operation	--
DataElements	
Property	value, valueId
MultilanguageProperty	value, valueId
Range	min, max
ReferenceElement	value
RelationshipElement	first, second
AnnotatedRelationshipElement	first, second, annotations
Blob	value, contentType
File	value, contentType

Example

The example shows a JSON serialization of an AssetAdministrationShell object in its full representation and how it looks like in a metadata representation.

Note: for editorial reasons, some fields which are the same for both representations are omitted.

Table 12 AssetAdministrationShell JSON Serialization Example

```
{
    "idShort": "TestAssetAdministrationShell",
    "description": […],
    "id": {…},

     ...

    "derivedFrom": {…}
    "assetInformation": {…},
    "submodels": […]
}
```

Table 13 AssetAdministrationShell Metadata JSON Serialization Example

```
{
    "idShort": "TestAssetAdministrationShell",
    "description": […],
    "id": {…}

    ...

    "derivedFrom": {…}
    }
}
```

12.6 Pagination

Pagination is a commonly used pattern to break down potentially long result lists into smaller pieces for a better control of the network and computational load on both the server and the client side. For instance, the OData protocol [8] provides guidelines for parameters and behavior on the client and server side. In addition, the proposals of the RFC 8977[8] present a best practice for web APIs. In the scope of the AAS HTTP/REST API, the query parameter “cursor” controls, which part of a longer result set is returned.

The AAS client may decide on the appropriate size of the result list through the limit parameter. If it is not specified, the server must comply to the default value or explicitly indicate it in the response object.

Pagination is currently only defined for the HTTP/REST API. Other APIs might introduce different patterns to control the response content.

[8] see Chapter 2.4 of RFC 8977

Pagination is controlled by the client via the query parameters “cursor” and “limit”. They can be combined with all other query parameters as defined in this document and listed in the following table:

Table 14 Parameters for Pagination

Parameter	Values	Default	Explanation
Cursor	string	-	The position from which to resume a result listing. The value may be base64url-encoded and contain additional information which helps the server to respond more efficiently. However, the client must not expect any meaning and treat the cursor value as an arbitrary character sequence. The server must interpret a missing cursor as if the client wants to retrieve the first part of the result set.
Limit	nonNegativeInteger	100	The maximum size of the result list.

Constraint AASa-001: The value of the cursor query parameter must not be empty. If the client does not know the cursor value, it must omit the whole query parameter in the request.

Note 1: this constraint prohibits that an empty cursor value is sent by the client, e.g. *…?cursor=""*.
Note 2: if the client sends a request without a cursor query parameter, the server must interpret it as if the client wants to retrieve the results from the very beginning. A client may send the query parameter “limit" without any cursor. In that case, the server must return at max the specified number of result items from the beginning.

Pagination requires a defined and consistent sorting. The server implementation must ensure a deterministic ordering of the result set. For instance, a server must not return an element A before another element C and in any later request return C before A. This applies in particular if any attribute of either A or C has been changed between the two requests. However, in case a new element B was created (or deleted), the client must expect that B and then C are returned after A.

Nevertheless, the inherent order of the result set must stay the same. Implementations may maintain an internal sorting attribute to ensure this behavior or implement it in any other appropriate manner. The server is not obligated to inform the client about its ordering schema.

The server informs the client about pagination attributes through the Result object in the request response. In particular, the Result contains the cursor value for the next page. Additional information, e.g. the overall number of result items, may also be part of it.

Class Name	Result		
Explanation	An object connecting the actual list of returned items with metadata information to, e.g. fetch the next part of the result set.		
Inherits from	--		
Attribute	**Explanation**	**Type**	**Card.**
result	List of returned items. Any kind of Referables is possible, depending on the endpoint which has been requested.	Referable	0..*
paging_metadata	Additional information for the client to, e.g. fetch the next part of the result set.	PagingMetadata	1

Class Name	PagingMetadata		
Explanation	Additional information for the client to, e.g. fetch the next part of the result set. Note: more attributes may be added to this class in future versions.		
Inherits from	--		
Attribute	**Explanation**	**Type**	**Card.**
cursor	The cursor for the next part of the result set. No cursor attribute means that the end of the result set has been reached.	string	0..1

12.7 Payload

The payload is generated from the technology-neutral specification as described in Part 1 of the Asset Administration Shell Series for JSON [1].

The serialization of JSON values is described in Clause 11.4.2.

Additional classes needed for payload of the HTTP/REST API specification can be found in Clause 10.2.

12.8 Modifier Constraints

To use metadata objects as described in Clause 12.5., modifiers are implemented as HTTP query parameters or path suffixes. For example, a request for a specific submodel may look like:
GET /submodel/$value?level=deep&extent=withBlobValue

The following constraints apply for the combination of modifiers:

- If Level=Core and Content=Value, only the requested object and the direct children without their value (empty value) will be returned in value serialization. If a direct child is a SubmodelElementCollection, `"<SubmodelElementCollection/idShort>": {}` will be returned. If a direct child is a SubmodelElementList, `"<SubmodelElementList/idShort>": []` will be returned.
- The combination of Content=Metadata and Extent=WithBLOBValue is not allowed.
- The combination of Level=Deep and Content=Reference is not allowed.
- Modifiers cannot be used for POST operations.

In addition, the modifiers can also be used for PUT operations. They define how the request content is delivered and have the same semantics as in the related GET operation. Only Content=Reference and Content=Path are not possible for PUT.

12.9 Mapping of Operations

The following

Table 15 shows the mapping of the generic operations to the HTTP/REST API.

The black entries correspond to the corresponding generic operations.

The blue entries are operations which only exist in the HTTP/REST API.

Table 15 Mapping of the generic Interface Operations to HTTP API Operations

Operation Name	HTTP Verb	REST-Path	Comment (e.g. optional query parameters)
Asset Administration Shell Interface			
GetAssetAdministrationShell	GET	/aas	content-suffix: $reference
PutAssetAdministrationShell	PUT		
GetAllSubmodelReferences	GET	/aas/submodel-refs	Pagination
PostSubmodelReference	POST	/aas/submodel-refs	Location header in the response contains the link to the new resource
DeleteSubmodelReference	DELETE	/aas/submodel-refs/{submodelIdentifier}	use base64url-encoded identifier
GetAssetInformation	GET	/aas/asset-information	
PutAssetInformation	PUT	/aas/asset-information	
GetThumbnail	GET	/aas/asset-information/thumbnail	
PutThumbnail	PUT	/aas/asset-information/thumbnail	
DeleteThumbnail	DELETE	/aas/asset-information/thumbnail	
	*	/aas/submodels/{submodel-identifier}/*	superpath as defined in service specification or profile
Submodel Interface			
GetSubmodel	GET	/submodel	?level=deep/core path-suffix= $metadata/$value/$reference/$path or no suffix for normal ?extent=WithoutBLOBValue/WithBLOBValue
PutSubmodel	PUT	/submodel	
PatchSubmodel	PATCH	/submodel	path-suffix=$metadata/$value or no path for normal
GetAllSubmodelElements	GET	/submodel/submodel-elements	?level=deep/core path-suffix= $metadata/$value/$reference/$path or no suffix for nomal ?extent=WithoutBLOBValue/WithBLOBValue Pagination
GetSubmodelElementByPath	GET	/submodel/submodel-elements/{idShortPath}	use separated idshort path of this element ?level=deep/core path-suffix= $metadata/$value/$reference/$path or no suffix for nomal ?extent=WithoutBLOBValue/WithBLOBValue URL-encoded IdShortPath
GetFileByPath	GET	/submodel/submodel-elements/{idShortPath}/attachment	use separated idShort path of this element URL-encoded IdShortPath
PutFileByPath	PUT	/submodel/submodel-elements/{idShortPath}/attachment	use separated idShort path of this element URL-encoded IdShortPath
DeleteFileByPath	DELETE	/submodel/submodel-elements/{idShortPath}/attachment	use separated idShort path of this element URL-encoded IdShortPath

PostSubmodelElement	POST	/submodel/submodel-elements	SerializationModifiers are not used with POST Location header in the response contains the link to the new resource
PostSubmodelElementByPath	POST	/submodel/submodel-elements/{idShortPath}	use separated idShort path of the parent element SerializationModifiers are not used with POST Location header in the response contains the link to the new resource
PutSubmodelElementByPath	PUT	/submodel/submodel-elements/{idShortPath}	use separated idShort path of this element URL-encoded IdShortPath
PatchSubmodelElementByPath	PATCH	/submodel/submodel-elements/{idShortPath}	use separated idShort path of this element path-suffix=$metadata/$value or no suffix for normal URL-encoded IdShortPath Note: values remain unchanged with content=metadata
PatchSubmodelElementValueByPath	PATCH	/submodel/submodel-elements/{idShortPath}/$value	use separated idShort path of this element; see Clause 11.4.2 for values path-suffix=$value URL-encoded IdShortPath
DeleteSubmodelElementByPath	DELETE	/submodel/submodel-elements/{idShortPath}	use separated idshort path of this element URL-encoded IdShortPath
InvokeOperationSync	POST	/submodel/submodel-elements/{idShortPath}/invoke	path-suffix=$value or no suffix for normal URL-encoded IdShortPath
InvokeOperationAsync	POST	/submodel/submodel-elements/{idShortPath}/invoke-async	get operationHandle path-suffix=$value or no suffix for normal URL-encoded IdShortPath
GetOperationAsyncResult	GET	/submodel/submodel-elements/{idShortPath}/operation-results/{handleId}	handleId=operationHandle path-suffix=$value or no suffix for normal URL-encoded IdShortPath
Shell Repository Interface			
GetAllAssetAdministrationShells	GET	/shells	path-suffix=$reference or no suffix normal Pagination
GetAllAssetAdministrationShellsByAssetId	GET	/shells	base64url-encoded JSON-serialized key-value-pairs ?assetids=… Pagination
GetAllAssetAdministrationShellsByIdShort	GET	/shells	Pagination ?idShort=<idShort to query for>
GetAssetAdministrationShellById	GET	/shells/{aasIdentifier}	base64url-encoded identifier path-suffix=$reference or no suffix normal
PostAssetAdministrationShell	POST	/shells	Location header in the response contains the link to the new resource
PutAssetAdministrationShellById	PUT	/shells/{aasIdentifier}	base64url-encoded identifier
DeleteAssetAdministrationShellById	DELETE	/shells/{aasIdentifier}	base64url-encoded identifier
AasInterface	*	/shells/{aasIdentifier}/*	superpath as defined in Service Specification or Profile
Submodel Repository Interface			

GetAllSubmodels	GET	/submodels	path-suffix= $metadata/$value/$reference/$path or no suffix for normal Pagination
GetAllSubmodelsBySemanticId	GET	/submodels	?semanticId=<base64url-encoded value of the semanticId> path-suffix= $metadata/$value/$reference/$path or no suffix for normal Constraint AASa-002: The base64url-encoded identifier of the semanticId shall have a length of maximum 3072 characters. Pagination
GetAllSubmodelsByIdShort	GET	/submodels	path-suffix= $metadata/$value/$reference/$path or no suffix for normal Pagination
GetSubmodelById	GET	/submodels/{submodelIdentifier}	path-suffix=$metadata or no suffix for normal base64url-encoded identifier
PostSubmodel	POST	/submodels	Location header in the response contains the link to the new resource
PutSubmodelById	PUT	/submodels/{submodelIdentifier}	base64url-encoded identifier
PatchSubmodelById	PATCH	/submodels/{submodelIdentifier}	path-suffix=$metadata/$value or no suffix for normal
DeleteSubmodelById	DELETE	/submodels/{submodelIdentifier}	base64url-encoded identifier
SubmodelInterface	*	/submodels/{submodelIdentifier}/*	superpath as defined in service specification or profile
Concept Description Repository Interface			
GetAllConceptDescriptions	GET	/concept-descriptions	Pagination
GetConceptDescriptionById	GET	/concept-descriptions/{cdIdentifier}	base64url-encoded identifier Pagination
GetAllConceptDescriptionsByIdShort	GET	/concept-descriptions	Pagination
GetAllConceptDescriptionsByIsCaseOf	GET	/concept-descriptions	base64url-encoded identifier Pagination
GetAllConceptDescriptionsByDataSpecificationReference	GET	/concept-descriptions	base64url-encoded identifier Pagination
PostConceptDescription	POST	/concept-descriptions/	Location header in the response contains the link to the new resource
PutConceptDescriptionById	PUT	/concept-descriptions/{cdIdentifier}	base64url-encoded identifier
DeleteConceptDescriptionById	DELETE	/concept-descriptions/{cdIdentifier}	base64url-encoded identifier
AASX File Server Interface			
GetAllAASXPackageIds	GET	/packages	base64url-encoded identifier Pagination
PostAASXPackage	POST	/packages	Location header in the response contains the link to the new resource
GetAASXByPackageId	GET	/packages/{packageId}	base64url-encoded identifier
PutAASXByPackageId	PUT	/packages/{packageId}	base64url-encoded identifier

DeleteAASXByPackageId	DELETE	/packages/{packageId}	base64url-encoded identifier
Serialization Interface			
GenerateSerializationByIds	GET	/serialization	base64url-encoded identifier; AcceptHeader: application/aasx+xml or application/json oder application/xml
AAS Basic Discovery Interface			
GetAllAssetAdministrationShellIdsByAssetLink	GET	/lookup/shells	base64url-encoded JSON-serialized key-value-pairs ?assetids=… Pagination
GetAllAssetLinksById	GET	/lookup/shells/{aasIdentifier}	base64url-encoded identifier
PostAllAssetLinksById	POST	/lookup/shells/{aasIdentifier}	base64url-encoded identifier
DeleteAllAssetLinksById	DELETE	/lookup/shells/{aasIdentifier}	base64url-encoded identifier
AAS Registry Interface			
GetAllAssetAdministrationShellDescriptors	GET	/shell-descriptors	Pagination assetKind=type|instance assetType= base64url-encoded identifier
GetAssetAdministrationShellDescriptorById	GET	/shell-descriptors/{aasIdentifier}	base64url-encoded identifier
PostAssetAdministrationShellDescriptorById	POST	/shell-descriptors/{aasIdentifier}	base64url-encoded identifier Location header in the response contains the link to the new resource
PutAssetAdministrationShellDescriptorById	PUT	/shell-descriptors/{aasIdentifier}	base64url-encoded identifier
DeleteAssetAdministrationShellDescriptorById	DELETE	/shell-descriptors/{aasIdentifier}	base64url-encoded identifier
Submodel Registry Interface	*	/shell-descriptors/{aasIdentifier}/submodelDescriptors/*	superpath as defined in Service Specification or Profile
Submodel Registry Interface			
GetAllSubmodelDescriptors	GET	/submodel-descriptors	Pagination
GetSubmodelDescriptorById	GET	/submodel-descriptors/{submodelIdentifier}	base64url-encoded identifier
PostSubmodelDescriptor	POST	/submodel-descriptors/{submodelIdentifier}	base64url-encoded identifier Location header in the response contains the link to the new resource
PutSubmodelDescriptorById	PUT	/submodel-descriptors/{submodelIdentifier}	base64url-encoded identifier
DeleteSubmodelDescriptorById	DELETE	/submodel-descriptors/{submodelIdentifier}	base64url-encoded identifier
Descriptor Interface			
GetDescription	GET	/description	Provide additional information on interface endpoint; may also be used at a server

			endpoint to list all descriptions available on that server

12.9.1 Asynchronous Invocation of the SubmodelElement “Operation”

The invocation of the SubmodelElement “Operation” is the only call that can appear either synchronously or asynchronously in the current version of the specification. The expected behavior is therefore explained in detail.

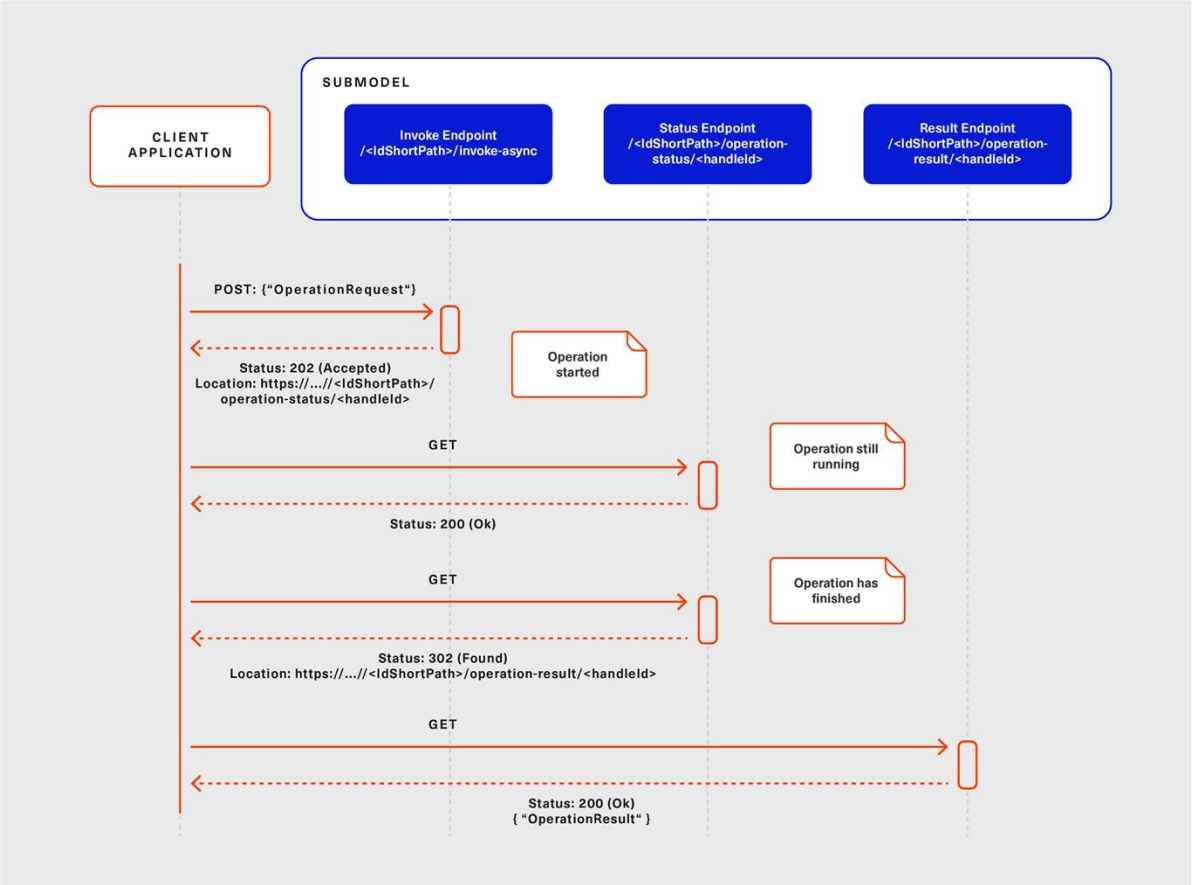


Figure 6 Sequence for asynchronous invocations of the SubmodelElement 'Operation'

The client informs the server whether it is interested in a synchronous (asynchronous) call by targeting the /invoke (/invoke-async) endpoint. In case of a synchronous interaction, the communication channel is kept open until the server has processed the request and responds with an OperationResult object, or a timeout or other kind of error occurs.

In the asynchronous pattern, the server immediately responds with an Accepted (status code: 202) message containing the link to an endpoint where the client can fetch status information about his request (see Figure 6). This status endpoint is also located at the same SubmodelElement “Operation”, followed by the path segments "/operation-status/{handleId}”.

In case the request is incorrect and the server already recognizes it, the server responds directly with the according status code, e.g. 400. If the server can only recognize the error during later processing and not at the time it receives the request, it responds with an Accepted (202) message at first. Hence, a received Accepted message does not guarantee the client that its request is valid in every case.

If the server has not finished processing the request, the status endpoint responds with an BaseOperationResult object with the attribute “executionState” set to “Running”. As soon as the processing is finished, the status endpoints deliver a Found (HTTP status code 302) response with the location of the result in the Location response header. The result is, similar to the status information, provided at the same SubmodelElement “Operation”, followed by the path segments "/operation-result/{handleId}”.

In case incorrect inputs have been provided by the client but the server was only able to recognize this during processing, or if the server perceived any other error during processing, the server must still provide the OperationResult object with status code 200 and set the attribute “executionState” to “Failed”.

Note: the invocation of the SubmodelElement “Operation” may also be conducted in the “ValueOnly” content. In this case, the "/$value” path segment is added to the previously mentioned endpoints.

12.10 Mapping of Status Codes

The following table shows the mapping of the generic status codes to HTTP status codes according to IETF RFC 7231 (see Clause 6.1 https://datatracker.ietf.org/doc/html/rfc7231#section-6)

Table 16 Status Code Mapping for HTTP

Generic status code	Meaning	HTTP status code	Explanation
Success	Success	200 (OK)	Standard response for successful requests
SuccessCreated	Successful creation of a new resource	201 (Created)	Successful request resulting in the creation of a new resource, e.g. SubmodelElement
SuccessAccepted	The reception of the request was successful	202 (Accepted)	The server has accepted the request, but the result will be supplied later
SuccessNoContent	Success with explicitly no content in the payload	204 (No Content)	Successful request with no content in return, e.g. used for updating existing resources
ClientErrorBadRequest	Bad or malformed request	400 (Bad Request)	The server does not / cannot process the request due to a general client error, e.g. a malformed request
ClientNotAuthorized	Wrong or missing authorization credentials	401 (Unauthorized)	The client missed or provided invalid credentials
ClientForbidden	Authorization has been refused	403 (Forbidden)	The request content is basically valid and understood by the server, but the server refuses the action due to certain restrictions, e.g. profiles or roles

ClientErrorResourceNotFound	Resource not found	404 (Not Found)	The requested resource was not found
ClientMethodNotAllowed	Operation request is not allowed	405 (Method Not Allowed)	The server rejected the request for the requested resource, e.g. /invoke only for the operation submodel element
ClientResourceConflict	Conflict-creating resource (resource already exists)	409 (Conflict)	A resource already exists; might occur if a Submodel or SubmodelElement with the same Identifier or ShortId is contained in a POST request.
ServerInternalError	Unexpected error	500 (Internal Server Error)	General server-internal error due to an unexpected condition
ServerNotImplemented	Not implemented	501 (Not Implemented)	The server does not support the functionality to fulfill the request
ServerErrorBadGateway	Bad Gateway	502 (Bad Gateway)	The primarily addressed server that was acting as gateway or proxy received an invalid response from subsequent systems/servers

12.11 Additional Data Types for Payload for HTTP/REST

In addition to the data types used in the technology-neutral specification, the HTTP/REST API uses the data types as defined in this clause.

12.11.1 PackageDescription

Class Name	PackageDescription		
Explanation	The package description consists of a system-wide unique packageId and its corresponding Asset Administration Shell identifiers. The packageId is used to identify the AASX package at the AASX file server. The package description is used to list the Asset Administration Shells in a given AASX package. This class is not part of the metamodel.		
Inherits from	--		
Attribute	**Explanation**	**Type**	**Card.**
packageId	File server specific package id	ShortIdType	1

Class Name	PackageDescription		
aasId	Asset Administration Shell unique identifier	Identifier	0..*

12.12 Service Specifications and Profiles

Figure 2 defines that a service specification contains at least one API and that an API contains at least one API Operation.

The profiles defined in this clause present complete service specifications and their subsets.

For instance, the profile “RepositoryServiceSpecification/SSP-002” contains the API Operation “GetAllSubmodels” but not “PostSubmodelElementByPath”, while the more comprehensive “RepositoryServiceSpecification/SSP-001” contains both. Furthermore, profiles also define which of the SerializationModifiers (content, extent, level) or serialization formats (JSON) can be used or whether pagination or asynchronous operations are available.

Table 17 Overview of Service Specifications and the Contained APIs

Contained APIs: / Service Specifications:	Asset Administration Shell API	Submodel API	AASX File Server API	Asset Administration Shell Registry API	Submodel Registry API	Asset Administration Shell Repository API	Submodel Repository API	Concept Description Repository API	Asset Administration Shell Basic Discovery API	Serialization API	Description API
Asset Administration Shell Service Specification	x	s								x	x
Submodel Service Specification		x								x	x
AASX File Server Service Specification			x								x
Asset Administration Shell Registry Serv. Spec.				x	s						x
Submodel Registry Service Specification					x						x
Discovery Service Specification									x		x
Asset Administration Shell Repository Serv. Spec.	s	s				x	s			x	x
Submodel Repository Service Specification		s					x			x	x
ConceptDescription Repository Service Spec.								x		x	x

x: Service Specification contains API at the root

s: Service Specification contains API through superpaths as introduced in Clause 4.6

12.12.1 Profiles

Service specifications are further refined in profiles, governing which API operations, modifiers, and path combinations are supported. The following clauses describe each service specification and present their predefined profiles. Each profile is unambiguously identified and represented through a normative OpenAPI document. The different OpenAPI profiles of one ServiceSpecification share the same *title* attribute but with different *versions*. The version attribute contains both the major and minor version as well as the profile identifier. A profile identifier is defined as:

https://admin-shell.io/aas/API/3/0/<service specification name>/SSP-<profile number>

The name of the service specification ends with "ServiceSpecification".

The supported service specification or profile can be discovered at the /description endpoint. This endpoint will return the related profile string.

Additional profiles might be introduced in future versions of this document.

Note: in the following, only the last part (<name of service specification>/SSP-<profile number>) is used in the text for better readability, e.g. “AssetAdministrationShellServiceSpecification/SSP-001” instead of “https://admin-shell.io/aas/API/3/0/AssetAdministrationShellServiceSpecification/SSP-001”.

12.12.2 Asset Administration Shell Service Specification

Service Specification / Profiles	Description
AssetAdministrationShellServiceSpecification/SSP-001	Full feature set
AssetAdministrationShellServiceSpecification/SSP-002	Only read operations; is included in the profile AssetAdministrationShellServiceSpecification/SSP-001.

12.12.2.1 Asset Administration Shell Service Specification – Full Profile

The Asset Administration Shell service specification with all its features and endpoints is represented through the profile identifier **AssetAdministrationShellServiceSpecification/SSP-001**:

Name:	AAS Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/AssetAdministrationShellServiceSpecification/SSP-001
Feature	Appearance
APIs and API Operations	*Asset Administration Shell API:* GetAssetAdministrationShell PutAssetAdministrationShell GetAllSubmodelReferences PostSubmodelReference DeleteSubmodelReference GetAssetInformation PutAssetInformation GetThumbnail PutThumbnail DeleteThumbnail *Submodel API as superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath PutFileByPath DeleteFileByPath PutSubmodel PatchSubmodel PostSubmodelElement PostSubmodelElementByPath PutSubmodelElementByPath PatchSubmodelElementByPath DeleteSubmodelElementByPath InvokeOperationSync InvokeOperationAsync GetOperationAsyncStatus GetOperationAsyncResult *Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellServiceSpecification/V3.0.1_SSP-001

12.12.2.2 Asset Administration Shell Service Specification – Read Profile

The Asset Administration Shell Service specification with the minimal feature set is represented through **AssetAdministrationShellServiceSpecification/SSP-002**:

Name:	AAS Read Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/AssetAdministrationShellServiceSpecification/SSP-002
Feature	Appearance
API Operations	*Asset Administration Shell API:* GetAssetAdministrationShell GetAllSubmodelReferences GetAssetInformation GetThumbnail *Submodel API as superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellServiceSpecification/V3.0.1_SSP-002

12.12.3 Submodel Service Specification

Service Specification / Profiles	Description
SubmodelServiceSpecification/SSP-001	Full feature set
SubmodelServiceSpecification/SSP-002	Only reads operations; is included in the profile SubmodelServiceSpecification/SSP-001.
SubmodelServiceSpecification/SSP-003	Limitation on the basic capabilities plus the option to execute synchronous operations and to read the submodel in the ValueOnly-serialization format to reduce required bandwidth; is included in the profile SubmodelServiceSpecification/SSP-001.

12.12.3.1 Submodel Service Specification – Full Profile

The submodel service specification with all its features and endpoints is represented through **SubmodelServiceSpecification/SSP-001**:

Name:	Submodel Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/SubmodelServiceSpecification/SSP-001
Feature	Appearance
APIs and API Operations	*Submodel API:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath PutFileByPath DeleteFileByPath PutSubmodel PatchSubmodel PostSubmodelElement PostSubmodelElementByPath PutSubmodelElementByPath PatchSubmodelElementByPath DeleteSubmodelElementByPath InvokeOperationSync InvokeOperationAsync GetOperationAsyncStatus GetOperationAsyncResult *Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelServiceSpecification/V3.0.1_SSP-001

12.12.3.2 Submodel Service Specification – Read Profile

The submodel service specification with its minimal feature set is represented through **SubmodelServiceSpecification/SSP-002**:

Name:	Submodel Read Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/AssetAdministrationShellServiceSpecification/SSP-002

Feature	Appearance
API and API Operations	*Submodel API:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath *Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelServiceSpecification/V3.0.1_SSP-002

12.12.3.1 Submodel Service Specification – Value Profile

The submodel service specification with a reduced feature set is represented through **SubmodelServiceSpecification/SSP-003**:

Name:	Submodel Value Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/SubmodelServiceSpecification/SSP-003
Feature	Appearance
APIs and API Operations	*Submodel API:* GetSubmodel InvokeOperationSync *Description API:* GetDescription
SerializationModifier	Level: Deep Content: Normal, Value Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	not supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelServiceSpecification/V3.0.1_SSP-003

12.12.4 AASX File Server Service Specification

Service Specification / Profiles	**Description**
AasxFileServerServiceSpecification/SSP-001	The full feature set of the AASX File Server Service Specification

12.12.4.1 AASX File Server Service Specification – Full Profile

Name:	AASX File Server Full Profile
Profile Identifier	https://admin-shell.io /aas/API/3/0/AasxFileServerServiceSpecification/SSP-001
Feature	Appearance
APIs and API Operations	*File Server API:* GetAllAASXPackageIds GetAASXByPackageId PostAASXPackage PutAASXByPackageId DeleteAASXByPackageId

	Description API: GetDescription
SerializationModifier	not applicable
SerializationFormat	JSON for descriptions and error messages AASX for packages
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/AasxFileServerServiceSpecification/V3.0.1_SSP-001

12.12.5 Asset Administration Shell Registry Service Specification

Service Specification / Profiles	Description
AssetAdministrationShellRegistryServiceSpecification/SSP-001	Full profile
AssetAdministrationShellRegistryServiceSpecification/SSP-002	Only reads operations; is included in the profile AssetAdministrationShellRegistryServiceSpecification/SSP-001.

12.12.5.1 Asset Administration Shell Registry Service Specification – Full Profile

Name:	Asset Administration Shell Registry Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/ AssetAdministrationShellRegistryServiceSpecification/SSP-001
Feature	Appearance
APIs and API Operations	*AAS Registry API:* GetAllAssetAdministrationShellDescriptors GetAssetAdministrationShellDescriptorById PostAssetAdministrationShellDescriptor PutAssetAdministrationShellDescriptorById DeleteAssetAdministrationShellDescriptorById *Submodel Registry API as superpath:* GetAllSubmodelDescriptors GetSubmodelDescriptorById PostSubmodelDescriptor PutSubmodelDescriptorById DeleteSubmodelDescriptorById *Description API:* GetDescription
SerializationModifier	not applicable
SerializationFormat	JSON
Pagination	Supported

See:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellRegistryServiceSpecification/V3.0.1_SSP-001

12.12.5.1 Asset Administration Shell Registry Service Specification – Read Profile

Name:	AAS Registry Read Profile
Profile Identifier:	https://admin-shell.io/aas/API/3/0/AssetAdministrationShellRegistryServiceSpecification/SSP-002
Feature	Appearance
APIs and API Operations	*AAS Registry API:* GetAllAssetAdministrationShellDescriptors GetAssetAdministrationShellDescriptorById *Submodel Registry API as superpath:* GetAllSubmodelDescriptors GetSubmodelDescriptorById *Description API:* GetDescription
SerializationModifier	not applicable
SerializationFormat	JSON
Pagination	supported

See:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellRegistryServiceSpecification/V3.0.1_SSP-002

12.12.6 Submodel Registry Service Specification

Service Specification / Profiles	Description
SubmodelRegistryServiceSpecification/SSP-001	Full profile
SubmodelRegistryServiceSpecification/SSP-002	Only reads operations; is included in the profile SubmodelRegistryServiceSpecification/SSP-001.

12.12.6.1 Submodel Registry Service Specification – Full Profile

Name:	Submodel Registry Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/SubmodelRegistryServiceSpecification/SSP-001
Feature	Appearance
APIs and API Operations	*Submodel Registry API:* GetAllSubmodelDescriptors GetSubmodelDescriptorById PostSubmodelDescriptor PutSubmodelDescriptorById DeleteSubmodelDescriptorById *Description API:* GetDescription
SerializationModifier	not applicable
SerializationFormat	JSON
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRegistryServiceSpecification/V3.0.1_SSP-001

12.12.6.2 Submodel Registry Profile – Read Profile

Name:	Submodel Registry Read Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/ SubmodelRegistryServiceSpecification/SSP-002
Feature	Appearance
APIs and API Operations	*Submodel Registry API:* GetAllSubmodelDescriptors GetSubmodelDescriptorById *Description API:* GetDescription
SerializationModifier	not applicable
SerializationFormat	JSON
Pagination	Supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRegistryServiceSpecification/V3.0.1_SSP-002

12.12.7 Discovery Service Specification

Service Specification / Profiles	Description
DiscoveryServiceSpecification/SSP-001	Full feature set

12.12.7.1 Discovery Service Specification – Full Profile

Name:	Discovery Service Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/DiscoveryServiceSpecification/SSP-001
Feature	Appearance
API and API Operations	*AAS Basic Discovery API:* GetAllAssetAdministrationShellIdsByAssetLink GetAllAssetLinksById PostAllAssetLinksById DeleteAllAssetLinksById *Description API:* GetDescription
SerializationModifier	not applicable
SerializationFormat	JSON
Pagination	Not supported

See: https://app.swaggerhub.com/apis/Plattform_i40/DiscoveryServiceSpecification/V3.0.1_SSP-001

12.12.8 Asset Administration Shell Repository Service Specification

Service Specification / Profiles	Description
AssetAdministrationShellRepository ServiceSpecification/SSP-001	Full feature set
AssetAdministrationShellRepository ServiceSpecification/SSP-002	Only read operations; is included in the profile AssetAdministrationShellRepositoryServiceSpecification/SSP-001

12.12.8.1 Asset Administration Shell Repository Service Specification – Full Profile

Name:	AAS Repository Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/AssetAdministrationShellRepositoryServiceSpecification/SSP-001
Feature	Appearance
API and API Operations	*AAS Repository API:* GetAllAssetAdministrationShells GetAssetAdministrationShellById GetAllAssetAdministrationShellsByAssetId GetAllAssetAdministrationShellsByIdShort PostAssetAdministrationShell PutAssetAdministrationShellById DeleteAssetAdministrationShellById *AAS API by superpath:* GetAssetAdministrationShell PutAssetAdministrationShell GetAllSubmodelReferences PostSubmodelReference DeleteSubmodelReference GetAssetInformation PutAssetInformation GetThumbnail PutThumbnail DeleteThumbnail *Submodel Repository API by superpath:* GetAllSubmodels GetSubmodelById GetAllSubmodelsBySemanticId GetAllSubmodelsByIdShort PostSubmodel PutSubmodelById DeleteSubmodelById *Submodel API by superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath PutFileByPath DeleteFileByPath PutSubmodel PatchSubmodel PostSubmodelElement PostSubmodelElementByPath PutSubmodelElementByPath PatchSubmodelElementByPath DeleteSubmodelElementByPath InvokeOperationSync InvokeOperationAsync

	GetOperationAsyncStatus GetOperationAsyncResult *AAS Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellRepositoryServiceSpecification/V3.0.1_SSP-001

12.12.8.2 Asset Administration Shell Repository Service Specification – Read Profile

Name:	AAS Repository Read Profile
Profile Identifier:	https://admin-shell.io/aas/API/3/0/AssetAdministrationShellRepositoryServiceSpecification/SSP-002
Feature	Appearance
API and API Operations	*AAS Repository API:* GetAllAssetAdministrationShells GetAssetAdministrationShellById GetAllAssetAdministrationShellsByAssetId GetAllAssetAdministrationShellsByIdShort *AAS API by superpath:* GetAssetAdministrationShell GetAllSubmodelReferences GetAssetInformation GetThumbnail *Submodel Repository API by superpath:* GetAllSubmodels GetSubmodelById GetAllSubmodelsBySemanticId GetAllSubmodelsByIdShort *Submodel API by superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath *Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See:
https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShellRepositoryServiceSpecification/V3.0.1_SSP-002

12.12.9 Submodel Repository Service Specification

Service Specification / Profiles	Description
SubmodelRepositoryServiceSpecification/SSP-001	Full feature set
SubmodelRepositoryServiceSpecification/SSP-002	Only read operations; is included in the profile SubmodelRepositoryServiceSpecification/SSP-001
SubmodelRepositoryServiceSpecification/SSP-003	Profile for a Submodel Repository which only contains Submodels with kind=Template; is *not* included in the profile SubmodelRepositoryServiceSpecification/SSP-001 or the profile SubmodelRepositoryServiceSpecification/SSP-002
SubmodelRepositoryServiceSpecification/SSP-004	Only read operations for a Submodel Repository which only contains Submodels with kind=Template; is included in the profile SubmodelRepositoryServiceSpecification/SSP-003 but *not* in the profile SubmodelRepositoryServiceSpecification/SSP-001 or the profile SubmodelRepositoryService Specification/SSP-002

12.12.9.1 Submodel Repository - Full Profile

Name:	Submodel Repository Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/SubmodelServiceSpecification/SSP-001
Feature	Appearance
API and API Operations	*Submodel Repository API:* GetAllSubmodels GetSubmodelById GetAllSubmodelsBySemanticId GetAllSubmodelsByIdShort PostSubmodel PutSubmodelById PatchSubmodelById DeleteSubmodelById *Submodel API by superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath PutFileByPath DeleteFileByPath PutSubmodel PatchSubmodel PostSubmodelElement PostSubmodelElementByPath PutSubmodelElementByPath PatchSubmodelElementByPath DeleteSubmodelElementByPath InvokeOperationSync InvokeOperationAsync GetOperationAsyncStatus GetOperationAsyncResult *AAS Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRepositoryServiceSpecification/V3.0.1_SSP-001

12.12.9.2 Submodel Repository – Read Profile

Name:	Submodel Repository Read Profile
Profile Identifier	https://admin-shell.io /aas/API/3/0/SubmodelServiceSpecification/SSP-002
Feature	Appearance
API and API Operations	*Submodel Repository API:* GetAllSubmodels GetSubmodelById GetAllSubmodelsBySemanticId GetAllSubmodelsByIdShort *Submodel API by superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath *Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata, Value, Reference, Path Extent: WithBLOBValue, WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRepositoryServiceSpecification/V3.0.1_SSP-002

12.12.9.3 Submodel Repository - Template Profile

The Submodel Repository service specification that only provides and manages Submodel Templates is represented through the profile identifier **SubmodelRepositoryServiceSpecification/SSP-003**.

Constraint AASa-003: A service implementing the SubmodelServiceSpecification/SSP-003 must not accept or provide any Submodel with the attribute “kind=Instance”.

Note 1: due to Constraint AASa-003, SubmodelServiceSpecification/SSP-003 can not be combined with SubmodelServiceSpecification/SSP-001 or SubmodelServiceSpecification/SSP-002 as SubmodelService Specification/SSP-001 or SubmodelServiceSpecification/SSP-002-compliant services may contain Submodel instances but SubmodelServiceSpecification/SSP-003 not.
Note 2: future versions may introduce a Submodel Repository Instance Profile.

Name:	Submodel Repository Template Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/SubmodelServiceSpecification/SSP-003
Feature	Appearance
API and API Operations	*Submodel Repository API:* GetAllSubmodels GetSubmodelById GetAllSubmodelsBySemanticId GetAllSubmodelsByIdShort PostSubmodel PutSubmodelById PatchSubmodelById DeleteSubmodelById *Submodel API by superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath PutFileByPath DeleteFileByPath PutSubmodel PatchSubmodel PostSubmodelElement PostSubmodelElementByPath PutSubmodelElementByPath PatchSubmodelElementByPath DeleteSubmodelElementByPath *AAS Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata Extent: WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRepositoryServiceSpecification/V3.0.1_SSP-003

12.12.9.1 Submodel Repository - Template Read Profile

The Submodel Repository service specification that only provides Submodel Templates is represented through the profile identifier **SubmodelRepositoryServiceSpecification/SSP-004**.

Constraint AASa-004: A service implementing the SubmodelServiceSpecification/SSP-004 must not accept or provide any Submodel with the attribute “kind=Instance”.

Note: due to Constraint AASa-004, SubmodelServiceSpecification/SSP-004 can not be combined with SubmodelServiceSpecification/SSP-001 or SubmodelServiceSpecification/SSP-002 as SubmodelService Specification/SSP-001 or SubmodelServiceSpecification/SSP-002-compliant services may contain Submodel instances but SubmodelServiceSpecification/SSP-004 not.

Name:	Submodel Repository Template Read Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/SubmodelServiceSpecification/SSP-004
Feature	Appearance
API and API Operations	*Submodel Repository API:* GetAllSubmodels GetSubmodelById GetAllSubmodelsBySemanticId GetAllSubmodelsByIdShort *Submodel API by superpath:* GetSubmodel GetAllSubmodelElements GetSubmodelElementByPath GetFileByPath *Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	Level: Core, Deep Content: Normal, Metadata Extent: WithoutBLOBValue
SerializationFormat	JSON
Pagination	supported

See: https://app.swaggerhub.com/apis/Plattform_i40/SubmodelRepositoryServiceSpecification/V3.0.1_SSP-004

12.12.10 Concept Description Repository Service Specification

Service Specification / Profiles	Description
ConceptDescriptionRepositoryServiceSpecification/SSP-001	Full feature set

12.12.10.1 Concept Description Repository Service Specification – Full Profile

Name:	Concept Description Repository Full Profile
Profile Identifier:	https://admin-shell.io /aas/API/3/0/ConceptDescriptionRepositoryServiceSpecification/SSP-001
Feature	Appearance
API and API Operations	*ConceptDescription Repository API* GetAllConceptDescriptions GetConceptDescriptionById GetAllConceptDescriptionsByIdShort GetAllConceptDescriptionsByIsCaseOf' GetAllConceptDescriptionsByDataSpecificationReference PostConceptDescription PutConceptDescriptionById DeleteConceptDescriptionById *Serialization API:* GenerateSerializationByIds *Description API:* GetDescription
SerializationModifier	not applicable
SerializationFormat	JSON
Pagination	Supported

See:
https://app.swaggerhub.com/apis/Plattform_i40/ConceptDescriptionRepositoryServiceSpecification/V3.0.1_SSP-001

12.13 Interactions

Interactions describe the sequence of calls of operations by a client application to achieve a defined goal in a use case. Future versions of the document will describe interactions for further use cases.

Currently, only the key use case “Access a submodel in a distributed system” with focus on a completely decentralized Industry 4.0 system is described.

Since the interaction diagram in the current version only describes a first subset of interactions, some constraints and assumptions are made according to the configuration and qualities of the system.

Constraints and assumptions for calling an AAS and a submodel operation by a client application:

- The calling application hast to be aware that endpoints may change at any time. If the application has cached an endpoint that is no longer vivid, the application needs to start the interaction to resolve the appropriate endpoint again from the beginning.
- Endpoints for infrastructure interfaces like AAS registries are known at design time of the client application or configured manually before start-up.
- The endpoint information of the submodel registry must be known to the client application. The following questions are subject to discussion for future interaction versions:
    a. Will it be accessible via the AAS interface and therefore become a mandatory part of a standard interaction?
    b. How much “control” of submodels is implemented in the AAS and how are distributed submodels handled, which are deployed in network areas not accessible by the AAS server application?
- The AAS server application itself is instantiated and registered by calling an AAS registry interface.
- The AAS-ID is known to the calling application.
- Access to any API is allowed only if authenticated (mechanisms for authentication are to be described separately) and response follows a defined access rights model for all calls.

In Figure 7 below, the interaction starts with a client application resolving the interface endpoint of an Asset Administration Shell registry with a known asset ID. The AAS registry provides the AAS Descriptor object belonging to this asset ID and containing the Submodel Descriptors of the Submodels, which are part of the related AAS. Both descriptor kinds, those of the Asset Administration Shell and those of the Submodels, contain endpoint information for the respective AAS and Submodel Repositories. AAS interface operations – independent of the underlying protocol – are used to retrieve the AAS from the AAS repository answering at one of the supplied endpoints. In the sequence shown in Figure 7, one submodel of this AAS is also provided through the same repository. For the second submodel, however, only the submodel identifier is provided by the AAS registry, while the endpoint information is empty. Therefore, the client application must execute another look-up at a dedicated Submodel Registry, which responds with one Submodel Descriptor object. Equipped with this information, the client application locates the stand-alone Submodel Repository and downloads the second submodel.

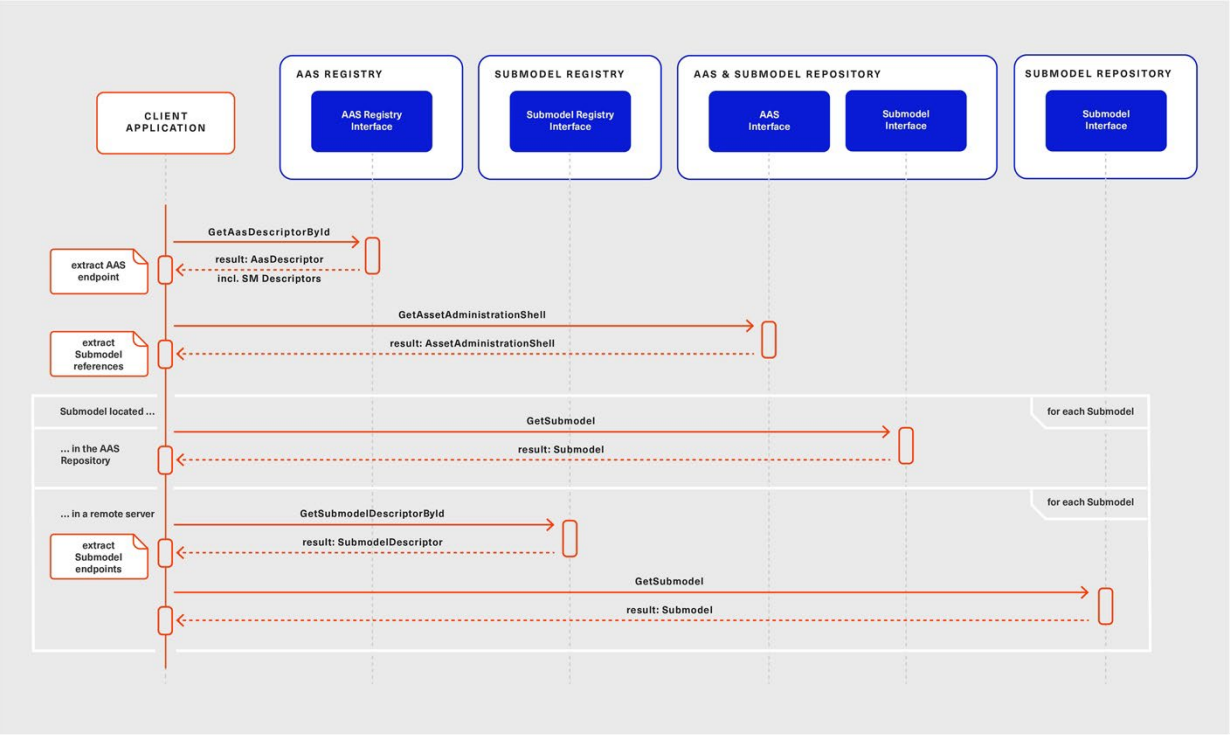


Figure 7 Interactions for Client Applications using AAS and Submodel Interfaces (independent Submodel Registry)

Figure 8 shows a slight variant of the scenario in Figure 7. The AAS Registry only returns the AAS Descriptor without any Submodel Descriptors. The client application retrieves the AAS from the discovered AAS Repository endpoint and learns about its submodel references. Using these references, the client can ask a Submodel Registry, in this case also hosted by the repository server, for the respective Submodel Descriptors. It understands that the Submodels are also available at the same server and downloads them by sending requests to the Submodel Interface.

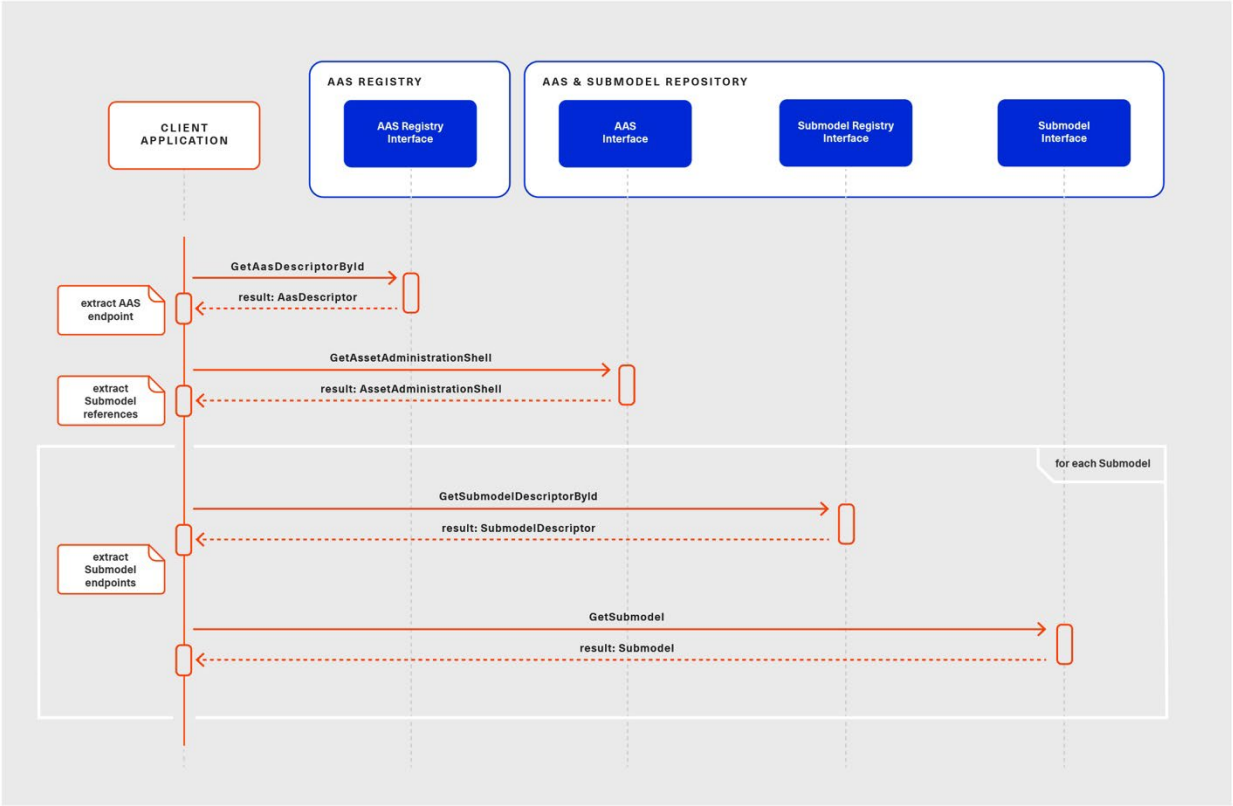


Figure 8 Interaction for Client Application using AAS and Submodel Interfaces (included Submodel Registry)

The difference between Interface and API Operations is outlined in Figure 9. This sequence translates the interaction on the interface level of Figure 7, which is protocol-independent and therefore can be implemented in several different manners, to the specific HTTP API Operations. The generic operations are replaced with HTTP requests, e.g. “GetAasDescriptorById” with “GET /shell-descriptors/<aas-id>”. The returned objects are shortened for better readability. The first request to the Submodel API shows the concatenated path (“/shells/<aas-id>/aas” + “/submodels/<submodel-id>”) and illustrates how contained submodels can be provided natively through an AAS API.

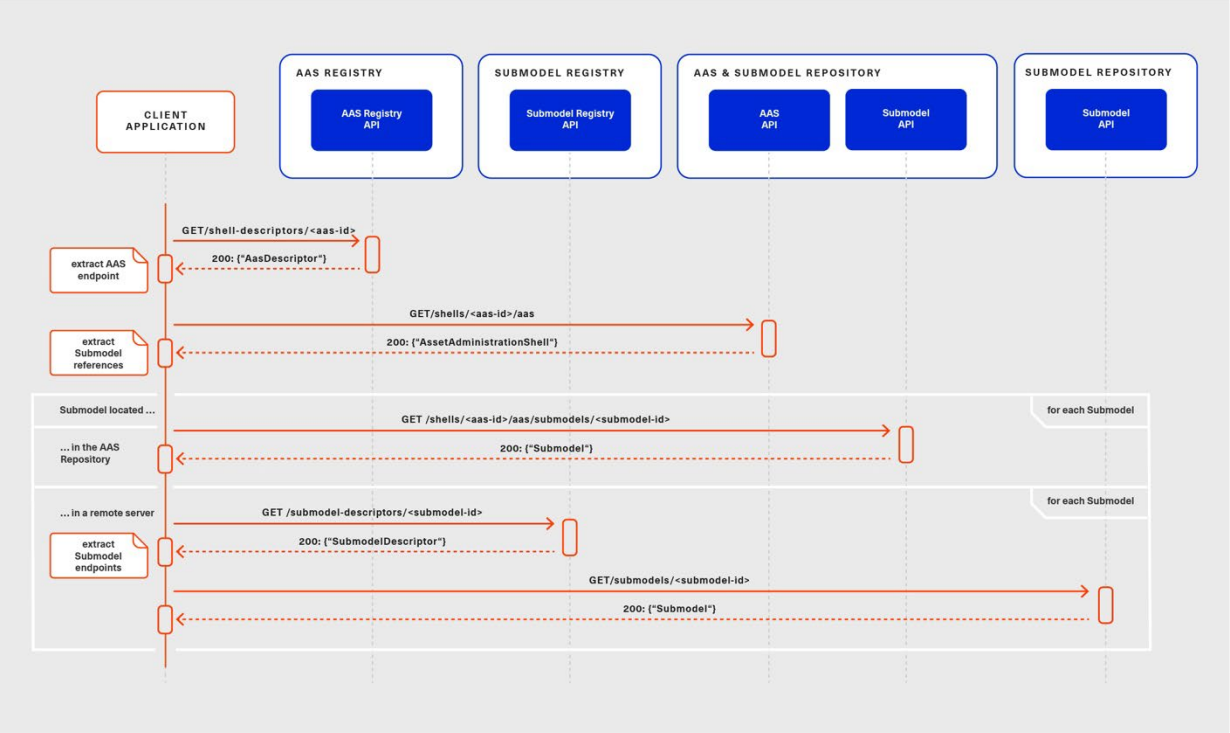


Figure 9 Interaction for Client Application using AAS and Submodels (for HTTP API Operations)

12.14 Security

The AAS metamodel includes a security metamodel, which is defined in the chapter “Overview Metamodel of Administration Shell w.r.t. Security”. This chapter was part of “Details of the Asset Administration Shell Part 1” until version 3.0 RC02. Since Part 1 has been split for the release of version 3.0, this chapter will become the basis of “Specification of the Asset Administration Shell. Part 4: Security”. In addition to the security metamodel, Part 4 will define e.g. authentication, further details about authorization, and signature of data.

Authentication is mandatory. Depending on the ecosystem the AAS uses, different authentication mechanisms might be in place. This clause explains one exemplary authentication mechanisms, which has been developed by the security working group (AG3) of Plattform Industrie 4.0. Other authentication services (e.g. Username/Password, DID=Decentralized Identifiers, Verifiable Credentials, EDC=Eclipse Data Space Connector, or IDS=International Data Spaces) may also be used to receive an access token for authorization.

The following paragraphs describe the most important steps for token-based authentication of the HTTP/REST APIs. For more details, see “Secure Downloadservice” (https://www.plattform-i40.de/PI40/Redaktion/EN/Downloads/Publikation/secure_downloadservice.html). Figure 10 gives an overview.

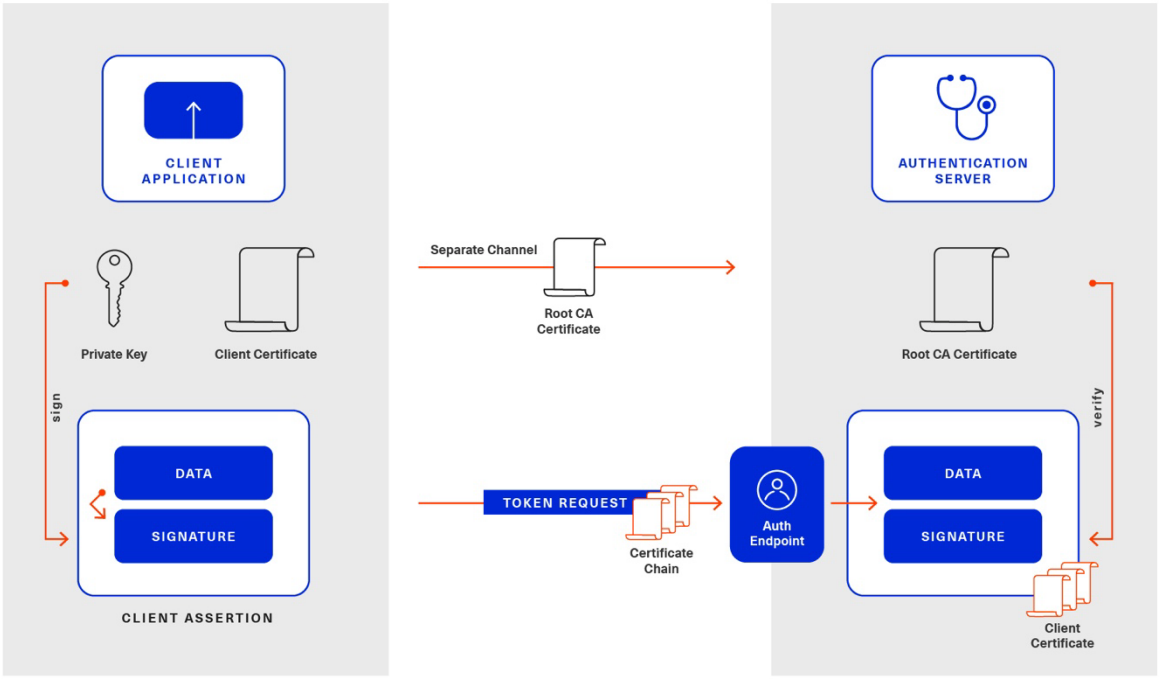


Figure 10 The private_key_certchain_jwt Method [...download service]

A client application uses a client certificate to create a certificate chain. The certificate chain can be checked on the authentication server by the corresponding Root CA certificate, which is signed by a certification authority (CA). The client application sends the certificate chain to the authentication server as token request by a JSON Web Token (JWT). The JWT is signed by the client's private key corresponding to the client certificate (JWT = Data + Signature).

If the authentication is approved, the client application receives an access token from the authentication server (not shown in Figure 10).

Such an access token contains attributes from the client certificate (e.g. username, email address) which will be sent as HTTP header bearer token to the AAS server application. The latter will check, whether the access token has been signed by a trusted authentication server and will make the authorization according to the AAS security metamodel.

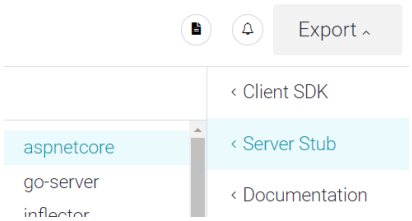
A running demo is explained in "Secure Downloadservice". A corresponding server can be seen on https://admin-shell-io.com/5011/ with a related security AAS at the bottom.

The AAS security metamodel does not deal with authentication; it assumes that the user is already authenticated. The example security AAS is only created for demonstration purposes and is not standardized. Since the version of the AASX Package Explorer used does not yet support the AAS security metamodel, the required information in subsequent steps like the access permission rules for AAS are modelled as a submodel.

The different security and authentication steps are explained in the video https://admin-shell-io.com/screencasts/security/Industrie_40_Security_with_AASX_Server.mp4.

12.15 API Code Generation

SwaggerHub includes the possibility to generate code from an API, e.g. for C# .NET:



API code can be created for both servers and clients in various programming languages.

Known issues include the following:

- When generating the aspnetcore server stub for the AssetAdministrationShellEnvironmentApi, the operation PutFileByPath is not generated automatically and must be added manually.
- When generating the aspnetcore server stub for the AasxFileServerInterfaceApi, the operations PostAASXPackage and PutAASXPackageById are not generated automatically and must be added manually.

The SwaggerHub code generator development team is not part of the AAS activities and has been informed about these issues.

13 Summary and Outlook

This document specifies the interfaces for a single Asset Administration Shell and its Submodels, as well as for a repository of Asset Administration Shells. Additionally, infrastructural interfaces like Registry and Discovery of a set of Asset Administration Shells are specified.

All interfaces are specified in a technology-neutral way before defining technology-specific APIs.

In this version of the specification, HTTP/REST APIs are defined and mapped to the technology-neutral specification as a frontrunner.

In subsequent versions of this specification, APIs using other technologies are planned to be supported, e.g. gRPC or MQTT.

Additionally, further interfaces, service specifications, and profiles may be defined. Querying will also be a topic.

Another very important topic that will be looked at in upcoming versions of the specification in more detail is the definition of access control based on the information provided by an Asset Administration Shell to ensure the trustworthiness of the contained information across different system boundaries.

Annex A. Templates used for Specification

This Annex explains the table templates used for documentation of interfaces, operations, data types, etc.

Card. is the cardinality (or multiplicity) defining the lower and upper bound of the number of instances of the member element. "*" denotes an arbitrary infinite number of elements of the corresponding Type. "0..1" means optional. "0..*" or "0..3" etc. means that the list may be either not available (null object) or empty or has infinitely many / exactly three elements.

Note: attributes having a default value are always considered to be optional; there is always a value for the attribute because the default value is used for initialization in this case.

Table 18 Interface Description

Interface: <Interface Name>	
Operation Name	**Description**
Oper1	Human-understandable description of the operation of the interface. Only major input and output information shall be described, no individual request and result parameters. Note: all words in the service operation name are written together in italics without a blank in between. The first letter of the first word is lower case, all other words are upper case.
…	
operN (optional)	Human-understandable description of the operation n of the interface. Optional operations are to be marked by suffix (optional) after the operation name.

Table 19 Operation Description

Operation Name:	Name of the operation: all individual words in the operation name are capitalized
Explanation:	Human-understandable description of the functionality The operation provides its functionality through the following input and output parameters: • Input parameter 1: human-understandable description of the purpose of the input parameter 1 • … • Input parameter N: human-understandable description of the purpose of input parameter N • Output parameter 1: human-understandable description of the purpose of output parameter 1: human-understandable description of the purpose of the input parameter 1 • …

Operation Name:	Name of the operation: all individual words in the operation name are capitalized			
	• Output Parameter N: human-understandable description of the purpose of output parameter N: If ***payload*** is mentioned as output parameter, only the returned payload in case of a successful operation (status code: Success, SuccessCreated) is denoted in column *Type*. In case of failure see Clause 10.2.9.1. If no ***payload*** is mentioned as output parameter, the status code shall be SuccessNoContent in case of success, otherwise see 12.10. Convention: all words in the interface name are written together in italics without a blank in between. The first letter of the first word and all other words are written in upper case letters.			
semanticId	The unique identifier of this operation			
Name	**Description**	**Mand.**	**Type**	**Card.**
Input Parameter				
inputParameter1	Human-understandable description of the input parameter 1 of the operation.	States whether the inputParameter1 is mandatory (“yes”) or optional (“no”)	Type of the input parameter 1	The cardinality of type of the inputParameter1, e.g. zero-to-one (“0..1”) or at-least-one (“1..*).
…				
inputParameterN	Human-understandable description of the input parameter N of the operation.	States whether the inputParameterN is mandatory (“yes”) or optional (“no”)	Type of the input parameter N	The cardinality of type of the inputParameterN, e.g. zero-to-one (“0..1”) or at-least-one (“1..*).
Output Parameter				
outputParameter1	Human-understandable description of the output parameter 1 of the operation.	States whether the outputParameter1 is mandatory (“yes”) or optional (“no”)	Type of the output parameter 1	The cardinality of type of the outputParameter1, e.g. zero-to-one (“0..1”) or at-least-one (“1..*).
…				
outputParameterN	Human-understandable description of the output parameter N of the operation.	States whether the outputParameterN is mandatory (“yes”) or optional (“no”)	Type of the output parameter N	The cardinality of type of the outputParameterN, e.g. zero-to-one (“0..1”) or at-least-one (“1..*).

Table 20 Data Types for Payload Description

Class Name	Name of the class: all individual words in the class name are capitalized
Explanation	Human-understandable description of the class The Class has following attributes: • Attribute 1: human-understandable description of the purpose of the attribute 1 • … • Attribute N: human-understandable description of the purpose of the attribute N Convention: all words in the class name are written together in italics without a blank in between. The first letter of the first word and all other words are written in upper case letters.
Inherits from	Name of the class this class inherits from
semanticId	The unique identifier of this class

Attribute (* = mandatory)	**Explanation**	**Type**	**Card.**
attribute1	Human-understandable description of the attribute 1 of the class.	Type of the attribute 1	Cardinality of the attribute 1
…			
attributeN	Human-understandable description of the attribute N of the class.	Type of the attribute N	Cardinality of the attribute N

Table 21 Enumeration Description

Enumeration Name:	Name of the enumeration: all individual words in the enumeration name are capitalized
Explanation:	Human-understandable description of the enumeration The enumeration has following literals: • Literal 1: human-understandable description of the purpose of the literal 1 • … • Literal N: human-understandable description of the purpose of the literal N Convention: all words in the enumeration name are written together in italics without a blank in between. The first letter of the first word and all other words are written in upper case letters.
semanticId	The unique identifier of this enumeration
Literal	**Description**
Literal1	Human-understandable description of the literal 1 of the enumeration.
…	
LiteralN	Human understandable description of the literal N of the enumeration.

Annex B. ValueOnly-Serialization Example

The following example shows the ValueOnly-Serialization for an entire Submodel that validates against the JSON-schema specified in Clause 11.4.3.
As mentioned in Clause 11.4.3, *SubmodelElementCollection*s cannot be validated within the same schema due to circularity reasons; instead they have their own specific validation schema. An exemplary *SubmodelElementCollection* is added to the following JSON for completeness. It is, however, not validatable against the schema in Clause 11.4.3 due to the reasons mentioned above.


```
{
  "MyPropertyIdShortNumber": 5000,
  "MyPropertyIdShortString": "MyTestStringValue",
  "MyPropertyIdShortBoolean": true,
  "MyMultiLanguageProperty": [
    {
      "de": "Das ist ein deutscher Bezeichner"
    },
    {
      "en": "That's an English label"
    }
  ],
  "MyRange": {
    "min": 3,
    "max": 15
  },
  "MyFile": {
    "contentType": "application/pdf",
    "value": "SafetyInstructions.pdf"
  },
  "MyBlob": {
    "contentType": "application/octet-stream",
    "value": "VGhpcyBpcyBteSBibG9i"
  },
  "MyEntity": {
    "statements": {
      "MaxRotationSpeed": 5000
    },
    "entityType": "SelfManagedEntity",
    "globalAssetId": "http://customer.com/demo/asset/1/1/MySubAsset"
  },
  "MyReference": {
    "type": "ModelReference",
    "keys": [
      {
        "type": "Submodel",
        "value": "http://customer.com/demo/aas/1/1/1234859590"
      },
      {
        "type": "Property",
        "value": "MaxRotationSpeed"
      }
    ]
  },
  "MyBasicEvent": {
    "observed": {
      "type": "ModelReference",
      "keys": [
        {
          "type": "Submodel",
          "value": "http://customer.com/demo/aas/1/1/1234859590"
        },
        {
```

```
          "type": "Property",
          "value": "CurrentValue"
        }
      ]
    }
  },
  "MyRelationship": {
    "first": {
      "type": "ModelReference",
      "keys": [
        {
          "type": "Submodel",
          "value": "http://customer.com/demo/aas/1/1/1234859590"
        },
        {
          "type": "Property",
          "value": "PlusPole"
        }
      ]
    },
    "second": {
      "type": "ModelReference",
      "keys": [
        {
          "type": "Submodel",
          "value": "http://customer.com/demo/aas/1/0/1234859123490"
        },
        {
          "type": "Property",
          "value": "MinusPole"
        }
      ]
    }
  },
  "MyAnnotatedRelationship": {
    "first": {
      "type": "ModelReference",
      "keys": [
        {
          "type": "Submodel",
          "value": "http://customer.com/demo/aas/1/1/1234859590"
        },
        {
          "type": "Property",
          "value": "PlusPole"
        }
      ]
    },
    "second": {
      "type": "ModelReference",
      "keys": [
        {
          "type": "Submodel",
          "value": "http://customer.com/demo/aas/1/0/1234859123490"
        },
        {
          "type": "Property",
          "value": "MinusPole"
        }
      ]
    },
    "annotation": [
      {
        "AppliedRule": "TechnicalCurrentFlowDirection"
```

```
        }
      ]
    },
    "MySubmodelElementIntegerPropertyList": [
      1,
      2,
      30,
      50
    ],
    "MySubmodelElementFileList": [
      {
        "contentType": "application/pdf",
        "value": "MyFirstFile.pdf"
      },
      {
        "contentType": "application/pdf",
        "value": "MySecondFile.pdf"
      }
    ],
    "MySubmodelElementCollection":
    {
      "myStringElement": "That's a string",
      "myIntegerElement": 5,
      "myBooleanElement": true
    }
}
```

Annex C. SerializationModifier Examples

1. Description

SerializationModifiers are only allowed for GET and PATCH operations.

GET operations can use any combination of SerializationModifiers.

POST operations create new resources using the input content.

PUT operations replace existing resources using the input content.

POST and PUT use the regular serialization. The client creates the input content as needed, so that no further SerializationModifiers need to be used.

PATCH operations may use the regular serialization, the metadata serialization, or the ValueOnly-serialization. The SerializationModifier Core is not used. The resources in the input content must already exist on the server and are replaced one by one accordingly. If one of the resources in the input content does not exist, no changes will be made on the server. “Resource exists” means, that the type of a SubmodelElement is the same in the input content and on the server. For example, a property may only be replaced by a property; elements of a SubmodelElementCollection or SubmodelElementList can only be replaced if they already exist on the server. A SubmodelElementList with five elements cannot be patched with a SubmodelElementList with more than five elements. A SubmodelElementList with five elements can be patched with a SubmodelElementList with less than five elements since all required elements starting from index 0 already exist.

Note: values remain unchanged with content=metadata.

2. Examples for GET Operations

	Deep (default)	Core

Normal (default)

If applied to the Submodel:


```
{
  "modelType": "Submodel",
  "id":
"http://i40.customer.com/type/1/1
/7A7104BDAB57E184",
  "idShort": "TechnicalData",
  "semanticId": {
    "keys": [ {
        "type":
"GlobalReference",
        "value": "0173-1#01-
AFZ615#016"
    } ],
    "type": "ExternalReference"
  },
  "submodelElements": [ {
    "modelType":
"SubmodelElementCollection",
    "idShort": "RotationSpeed",
    "semanticId": {
      "keys": [ {
          "type":
"GlobalReference",
          "value":
"http://purl.org/iot/vocab/iot-
taxonomy-lite#RotationalSpeed"
      } ],
      "type": "ExternalReference"
    },
    "value": [ {
        "modelType": "Property",
        "idShort":
"MaxRotationSpeed",
        "category": "PARAMETER",
        "semanticId": {
          "keys": [ {
              "type":
"ConceptDescription",
              "value": "0173-
1#02-BAA120#008"
          } ],
```


If applied to the Submodel:


```
{
  "modelType": "Submodel",
  "id":
"http://i40.customer.com/type/1/1/7A71
04BDAB57E184",
  "idShort": "TechnicalData",
  "semanticId": {
    "keys": [ {
        "type": "GlobalReference",
        "value": "0173-1#01-
AFZ615#016"
    } ],
    "type": "ExternalReference"
  },
  "submodelElements": [ {
    "modelType":
"SubmodelElementCollection",
    "idShort": "RotationSpeed",
    "semanticId": {
      "keys": [ {
          "type": "GlobalReference",
          "value":
"http://purl.org/iot/vocab/iot-
taxonomy-lite#RotationalSpeed"
      } ],
      "type": "ExternalReference"
    }
  } ]
}
```

<table>
<tr><td></td><td>

<pre>
          "type":
"ExternalReference"
        },
        "valueType": "xs:int",
        "value": "5000"
      }]
  }]
}
</pre>

</td><td></td></tr>
<tr><td>Metadata</td><td>

If applied to the Submodel:

<pre>
{
  "modelType": "Submodel",
  "id":
"http://i40.customer.com/type/1/1
/7A7104BDAB57E184",
  "idShort": "TechnicalData",
  "semanticId": {
    "keys": [{
        "type":
"GlobalReference",
        "value": "0173-1#01-
AFZ615#016"
    }],
    "type": "ExternalReference"
  },
  "submodelElements": [{
    "modelType":
"SubmodelElementCollection",
    "idShort": "RotationSpeed",
    "semanticId": {
      "keys": [{
          "type":
"GlobalReference",
          "value":
"http://purl.org/iot/vocab/iot-
taxonomy-lite#RotationalSpeed"
      }],
      "type": "ExternalReference"
    },
</pre>

</td><td>

If applied to the Submodel:

<pre>
{
  "modelType": "Submodel",
  "id":
"http://i40.customer.com/type/1/1/7A71
04BDAB57E184",
  "idShort": "TechnicalData",
  "semanticId": {
    "keys": [{
        "type": "GlobalReference",
        "value": "0173-1#01-
AFZ615#016"
    }],
    "type": "ExternalReference"
  },
  "submodelElements": [{
    "modelType":
"SubmodelElementCollection",
    "idShort": "RotationSpeed",
    "semanticId": {
      "keys": [{
          "type": "GlobalReference",
          "value":
"http://purl.org/iot/vocab/iot-
taxonomy-lite#RotationalSpeed"
      }],
      "type": "ExternalReference"
    }
  }]
}
</pre>

</td></tr>
</table>

<table>
<tr><td></td><td>

<pre>
    "value": [{
        "modelType": "Property",
        "idShort":
"MaxRotationSpeed",
        "category": "PARAMETER",
        "semanticId": {
          "keys": [{
              "type":
"ConceptDescription",
              "value": "0173-
1#02-BAA120#008"
          }],
          "type":
"ExternalReference"
        },
        "valueType": "xs:int"
      }]
  }]
}
</pre>

</td><td>

If applied to the Property, i.e. idShortPath “RotationSpeed.MaxRotationSpeed”:

<pre>
{
   "modelType": "Property",
   "idShort": "DocumentId",
   "category": "PARAMETER",
   "semanticId": {
       "keys": [{
           "type": "GlobalReference",
           "value": "0173-1#02-
BAA120#008"
       }] ,
       "type": "ExternalReference"
   },
   "valueType": "xs:int"
}
</pre>

</td></tr>
<tr><td>Value</td><td>

If applied to the Submodel:

<pre>
{
  "TechnicalData": {
    "RotationSpeed": {
      "MaxRotationSpeed": "5000"
    }
  }
}
</pre>

</td><td>

If applied to the Submodel:

<pre>
{
  "TechnicalData": {
    "RotationSpeed": {}
  }
}
</pre>

</td></tr>
<tr><td>Reference</td><td>

Not allowed, see Clause 12.8:

“The combination of Level=Deep and Content=Reference is not allowed.”

</td><td>

If applied to the Submodel:

<pre>
{
  "keys": [{
     "type": "Submodel",
     "value":
"http://i40.customer.com/type/1/1/7A71
04BDAB57E184"
  }],
  "type": "ModelReference"
}
</pre>

</td></tr>
</table>

		If applied to the Property inside the SubmodelElementCollection, i.e. idShortPath “RotationSpeed.MaxRotationSpeed”:
		`{`
		`"keys": [ {`
		`"type": "Submodel",`
		`"value": "http://i40.customer.com/type/1/1/7A7104BDAB57E184"`
		`}, {`
		`"type": "SubmodelElementCollection",`
		`"value": "RotationSpeed"`
		`}, {`
		`"type": "Property",`
		`"value": "MaxRotationSpeed"`
		`}],`
		`"type": "ModelReference"`
		`}`

Path	If applied to the Submodel:
	`[`
	`"RotationSpeed",`
	`"RotationSpeed.MaxRotationSpeed"`
	`]`
		If applied to the Submodel:
		`[`
		`"RotationSpeed"`
		`]`

		If applied to the Property inside the SubmodelElementCollection: `[ ]`

3. Examples for PATCH Operations

	Deep (default)

Normal (default)

If applied to the Submodel:


```
{
  "modelType": "Submodel",
  "id": "http://i40.customer.com/type/1/1/7A7104BDAB57E184",
  "idShort": "TechnicalData",
  "semanticId": {
    "keys": [ {
        "type": "GlobalReference",
        "value": "0173-1#01-AFZ615#016"
    } ],
    "type": "ExternalReference"
  },
  "submodelElements": [ {
    "modelType":  "SubmodelElementCollection",
    "idShort": "RotationSpeed",
    "semanticId": {
      "keys": [ {
          "type": "GlobalReference",
          "value": "http://purl.org/iot/vocab/iot-taxonomy-lite#RotationalSpeed"
      } ],
      "type": "ExternalReference"
  },
    "value": [ {
        "modelType": "Property",
        "idShort": "MaxRotationSpeed",
        "category": "PARAMETER",
        "semanticId": {
          "keys": [ {
              "type": "ConceptDescription",
              "value": "0173-1#02-BAA120#008"
          } ],
          "type": "ExternalReference"
        },
        "valueType": "xs:int",
        "value": "5000"
      } ]
  } ]
}
```

If applied to the SubmodelElementCollection, i.e. idShortPath “OperatingManual”:


```
{
    "modelType":  "SubmodelElementCollection",
    "idShort": "RotationSpeed",
    "semanticId": {
      "keys": [ {
          "type": "GlobalReference",
          "value": "http://purl.org/iot/vocab/iot-taxonomy-lite#RotationalSpeed"
      } ],
      "type": "ExternalReference"
    },
    "value": [ {
        "modelType": "Property",
        "idShort": "MaxRotationSpeed",
        "category": "PARAMETER",
        "semanticId": {
          "keys": [ {
              "type": "ConceptDescription",
              "value": "0173-1#02-BAA120#008"
          } ],
          "type": "ExternalReference"
        },
        "valueType": "xs:int",
        "value": "5000"
   } ]
}
```


If applied to the Property, i.e. idShortPath “OperatingManual.DocumentId”:


```
{
  "modelType": "Property",
  "idShort": "MaxRotationSpeed",
  "category": "PARAMETER",
  "semanticId": {
    "keys": [ {
      "type": "ConceptDescription",
      "value": "0173-1#02-BAA120#008"
    } ],
    "type": "ExternalReference"
  },
```

<table>
<tr><td></td><td>

<pre>
  "valueType": "xs:int",
  "value": "5000"
}
</pre>

</td></tr>
<tr><td>Metadata</td><td>

If applied to the Submodel:

<pre>
{
  "modelType": "Submodel",
  "id": "http://i40.customer.com/type/1/1/7A7104BDAB57E184",
  "idShort": "TechnicalData"
}
</pre>

If applied to the SubmodelElementCollection, i.e. idShortPath “RotationSpeed”:

<pre>
{
    "modelType": "SubmodelElementCollection",
    "idShort": "RotationSpeed",
    "semanticId": {
      "keys": [{
          "type": "GlobalReference",
          "value": "http://purl.org/iot/vocab/iot-taxonomy-lite#RotationalSpeed"
      }],
      "type": "ExternalReference"
    }
}
</pre>

If applied to the Property, i.e. idShortPath “RotationSpeed.MaxRotationSpeed”:

<pre>
{
  "modelType": "Property",
  "idShort": "MaxRotationSpeed",
  "category": "PARAMETER",
  "semanticId": {
    "keys": [{
        "type": "ConceptDescription",
        "value": "0173-1#02-BAA120#008"
    }],
    "type": "ExternalReference"
  }
}
</pre>

</td></tr>
</table>

Value	If applied to the Submodel:
	`{`
	`"TechnicalData": {`
	`"RotationSpeed": {`
	`"MaxRotationSpeed": "5000"`
	`}`
	`}`
	`}`
	If applied to the SubmodelElementCollection, i.e. idShortPath “RotationSpeed”:
	`{`
	`"RotationSpeed": {`
	`"MaxRotationSpeed": "5000"`
	`}`
	`}`
	If applied to the Property, i.e. idShortPath “RotationSpeed.MaxRotationSpeed”:
	`{`
	`"MaxRotationSpeed": "5000"`
	`}`

Annex D. Backus-Naur-Form

The Backus-Naur form (BNF) – a meta-syntax notation for context-free grammars – is used to define grammars. For more information see Wikipedia[9].

A BNF specification is a set of derivation rules, written as

<symbol> ::= __expression__

where:

- <symbol> is a nonterminal (variable) and the __expression__ consists of one or more sequences of either terminal or nonterminal symbols,
- ::= means that the symbol on the left must be replaced with the expression on the right,
- more sequences of symbols are separated by the vertical bar "|", indicating a choice, the whole being a possible substitution for the symbol on the left,
- symbols that never appear on a left side are terminals, while symbols that appear on a left side are non-terminals and are always enclosed between the pair of angle brackets <>,
- terminals are enclosed with quotation marks: "text". "" is an empty string,
- optional items are enclosed in square brackets: [<item-x>],
- items existing 0 or more times are enclosed in curly brackets are suffixed with an asterisk (*) such as <word> ::= <letter> {<letter>}*,
- Items existing 1 or more times are suffixed with an addition (plus) symbol, +, such as <word> ::= {<letter>}+,
- round brackets are used to explicitly to define the order of expansion to indicate precedence, example: (<symbol1> | <symbol2>) <symbol3>,
- text without quotation marks is an informal explanation of what is expected; this text is cursive if grammar is non-recursive and vice versa.

Example:

```
<contact-address> ::= <name> "e-mail addresses:" <e-mail-Addresses>
<e-mail-Addresses> ::= {<e-mail-Address>}*
<e-mail-Addresse> ::= <local-part> "@" <domain>
<name> ::= characters
<local-part> ::= characters conformant to local-part in RFC 5322
<domain> ::= characters conformant to domain in RFC 5322
```

Valid contact addresses:

Hugo Me e-mail addresses: Hugo@example.com

Hugo e-mail addresses: Hugo.Me@text.de

Invalid contact addresses:

Hugo

Hugo Hugo@ example.com

Hugo@example.com

[9] https://en.wikipedia.org/wiki/Backus%E2%80%93Naur_form

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Change Notes

1. General

- BWC = * Means not backward compatible
- BWC = (*) means not backward compatible but just renaming

2. Interface Changes w.r.t. V3.0 to V3.0.1

BWC	Interface Change	Kind of Change	Comment
	Endpoint	Changed	Added an entry for the “Description Interface” in the table of available values for Endpoint/interface
(*)	Endpoint	Changed	Attributes of type “IdShortType” corrected to “ShortIdType”
	Endpoint	Changed	Removed example
	GetAllAssetAdministrationShellDescriptors	Changed	Added names for the parameters.
	GetAllSubmodelsBySupplementalSemanticId	Removed	Reference to this Interface Operation has been deleted from the overview table in Clause 7.3.1.
(*)	ProtocolInformation	Changed	Attributes of type “IdShortType” corrected to “ShortIdType”
*	ServiceSpecificationProfileEnum	Changed	Correct profile identifiers from Clause 12 are used.
*	ValueOnly-Serialization	Changed	Corrected the serialization rule for *SpecificAssetIdValue*

3. Operation Changes w.r.t. V3.0 to V3.0.1

Bugfixes:

- Part1-MetaModel-Schemas domain in SwaggerHub had the class Reference without the "type: object" declaration.
- AASX File Server Service Specification was missing the pagination metadata object in the OpenAPI file.
- Part2-API-Schemas domain in SwaggerHub had the AssetId query parameter without base64-url-encoding, also appeared in the DiscoveryServiceSpecification and the Entire-API-Collection

Operation Change Old	Operation Change New	Kind of Change	Comment
all	Change references in SwaggerHub links from https://api.swaggerhub.com/domains/.../V3.0#/... to https://api.swaggerhub.com/domains/.../V3.0.1#/...	Changed	Required to make changes in the domain files accessible to the API definitions.

all	Change SwaggerHub links from https://app.swaggerhub.com/.../V3.0_... to https://app.swaggerhub.com/.../V3.0.1_...	Changed	Creating new SwaggerHub version for the bugfixes.
All Post* API Operations except PostAllAssetLinksById	Added Location response header as demanded by RFC 9110	Changed	Added respective statements also to Table 15.
DeleteAssetAdministrationShell	Removed this API Operation from the AssetAdministrationShellService Specification and Entire-API-Collection OpenAPI files.	Removed	Affects only OpenAPI files published at SwaggerHub. Profile definitions stay the same.
DeleteSubmodelById	Corrected endpoint from "/shells/{aasIdentifier}/submodels/{submodelIdentifier}/$metadata" to "/shells/{aasIdentifier}/submodels/{submodelIdentifier}" in SwaggerHub definitions	Changed	
GetAllAssetAdministrationShellIdsByAssetLink	Pagination data added to the response object in the OpenAPI files.	Changed	
GetAllSubmodelElements-ValueOnly GetAllSubmodelElements-Metadata GetAllSubmodelElements-Reference GetAllSubmodelElements-Path	Removed the array around the PagedResult object in the response in the OpenAPI files.	Changed	
GetSubmodelById	Removed the SerializationModefifier "Level" where Content=Reference from SwaggerHub definitions	Changed	
GetSubmodelElementByPath	Removed pagination from SwaggerHub definitions	Changed	
PostSubmodelElement	Removed Serialization Modifiers	Changed	
PutSubmodelById	Removed the SerializationModefifier "Level" from SwaggerHub definitions	Changed	

4. Interface Changes w.r.t. V1.0RC03 to V3.0

Major Changes:

- Introduction of service specifications and profiles

- Introduction of pagination for "GetAll*" API operations in http/REST
- Distinction between replace and update for operations
- SerializationModifier Content as path: $metadata, $value, $reference, $path
- Introduction of length constraints for string attributes

BWC	Interface Change	Kind of Change	Comment
	Submodel	New	PatchSubmodel and PatchSubmodelElementByPath (PUT to completely replace and PATCH to update content)
	Asset Administration Shell, Submodel, AASX File Server, AAS Repository, Submodel Repository, CD Repository, AAS Registry, Submodel Registry, AAS Basic Discovery	Changed	Add Pagination: GetAllAssetAdministrationShells GetAllAssetAdministrationShellsByAssetId GetAllAssetAdministrationShellsByIdShort GetAllSubmodelReferences GetAllSubmodels GetAllSubmodelsBySemanticId GetAllSubmodelsByIdShort GetAllSubmodelElements GetSubmodelElementByPath GetAllConceptDescriptions GetAllConceptDescriptionsByIdShort GetAllConceptDescriptionsByIsCaseOf GetAllConceptDescriptionsByDataSpecificationReference GetAllAssetAdministrationShellDescriptors GetAllSubmodelDescriptors GetAllAssetAdministrationShellIdsByAssetLink GetAllAASXPackageIds
	Submodel	Changed	SerializationModifier Content as path: $metadata, $value, $reference, $path
	Asset Administration Shell	New	GetThumbnail, PutThumbnail
	Submodel Repository	New	PatchSubmodelForId was missing
	Registry	New	Add extensions to descriptor
	AssetAdministrationShellDescriptor	New	Add the attributes assetKind and assetType
	SubmodelDescriptor	New	Add supplementalSemanticId
	*	Changed	Rename GetDescriptor to GetDescription
	*	Changed	API versioning with major + minor

	*	New	Profiles
	*	Changed	Clarify service specifications and APIs
	CD Registry	Changed	Renaming parameter ‘cdIdentifier’ in GetConceptDescriptionById to ‘id’. Parameter has not been changed in the HTTP API.

5. Operation Changes w.r.t. V1.0RC03 to V3.0

Operation Change Old	Operation Change New	Kind of Change	Comment
GetDescriptor	GetDescription	Changed	Rename, get profiles

6. Interface Changes w.r.t. V1.0RC02 to V1.0RC03

BWC	Interface Change	Kind of Change	Comment
*	Discovery	Changed	IndentifierKeyValuePair to SpecificAssetId
*	Submodel	Changed	SubmodelElementStruct remains as SubmodelElementCollection
*	Submodel	Changed	ModelReference and GlobalReference are combined back to Reference
*	Submodel	Changed	Rename trimmed to metadata
	Submodel	New	Add GetFileByPath
	Submodel	New	Add PutFileByPath
*	Submodel	Changed	InvokeOperationAsync
	Registry	Changed	Endpoint
*	Registry	Changed	Remove /registry from REST path
*	All	New	API Versioning adds a prefix to all interfaces

7. Operation Changes w.r.t. V1.0RC02 to V1.0RC03

Operation Change Old	Operation Change New	Kind of Change	Comment
		Changed	inputArgument and inoutputArgument are OperationVariable
GetAllAssetAdminstrationShellsByAssetLink		Changed	IdentifierKeyValuePair to SpeicifcAssetId

GetAllAssetLinksById		Changed	IdentifierKeyValuePair to SpeicifcAssetId
PostAllAssetLinksById		Changed	IdentifierKeyValuePair to SpeicifcAssetId

8. Interface Changes w.r.t. V1.0RC01 to V1.0RC02

BWC	Interface Change	Kind of Change	Comment
*	Asset Administration Shell	Changed	Renamed: RemoveSubmodelReference to DeleteSubmodelReference Removed: PutSubmodelReference, PatchAssetAdministrationShell New: GetAssetInformation PutAssetInformation GetAllSubmodelReferences PostSubmodelReference
*	Submodel	Changed	Removed: GetAllSubmodelElementsByParentPathAndSemanticId, GetAllSubmodelElementsBySemanticId New: PutSubmodel, PostSubmodelElement, PostSubmodelElementByPath
*	Asset Administration Shell Serialization	Changed	Renamed: GetSerializationByIds to GenerateSerializationByIds Removed: GetAASX
	AASX File Server	New	New interface
(*)	Asset Administration Shell Registry	Changed	Renamed: PutAssetAdministrationShellDescriptor to PutAssetAdministrationShellDescriptorById New: PostAssetAdministrationShellDescriptor
(*)	Submodel Registry	Changed	Renamed: PutSubmodelDescriptor to PutSubmodelDescriptorById New: PostSubmodelDescriptor
(*)	Asset Administration Shell Repository	Changed	Renamed:

			GetAllAssetAdministrationShellsById to GetAssetAdministrationShellById, PutAssetAdministrationShell to PutAssetAdministratioShellById New: PostAssetAdministrationShell
(*)	Submodel Repository	Changed	Renamed: PutSubmodel to PutSubmodelById New: PostSubmodel
(*)	Asset Administration Shell Basic Discovery	Changed	Removed: GetAllAssetAdministrationShellIdsByAssetId, PutAssetId New: GetAllAssetAdministrationShellIdsByAssetLink, GetAllAssetLinksById, PutAllAssetLinksById, DeleteAllAssetLinksById
(*)	Submodel Discovery Basic	Removed	
(*)	Concept Description Repository	Changed	Renamed: GetAllConceptDescriptionsWtihDataSpecificationReference to GetAllConceptDescriptionsByDataSpecificationReference, PutConceptDescription to PutConceptDescriptionById New: PostConceptDescription

9. Operation Changes w.r.t. V1.0RC01 to V1.0RC02

Operation Change Old	Operation Change New	Kind of Change	Comment
PatchAssetAdministrationShell		Removed	
PutSubmodelReference		Removed	Substituted by PostSubmodelReference
	PostSubmodelReference	New	For PutSubmodelReference
RemoveSubmodelReference	DeleteSubmodelReference	Changed	
	GetAllSubmodelReferences	New	
	PostSubmodelReference	New	
	GetAssetInformation	New	
	PutAssetInformation	New	
	PutSubmodel	New	
	PostSubmodelElement	New	
	PostSubmodelElementByPath	New	
GetAllSubmodelElementsByParentPathAndSemanticId		Removed	
GetAllSubmodelElementsBySemanticId		Removed	
GetAASX		Removed	
GetSerializationByIds	GenerateSerializationByIds	Renamed	
	GetAllAASXPackageIds	New	
	GetAASXByPackageId	New	
	PostAASXPackage	New	
	PutAASXByPackageId	New	
	DeleteAASXByPackageId	New	
PutAssetAdministrationShellDescriptor	PutAssetAdministrationShellDescriptorById	Changed	Naming pattern byId
	PostAssetAdministrationDescriptor	New	
PutSubmodelDescriptor	PutSubmodelDescriptorById	Changed	Naming pattern byId
	PostSubmdeoDescriptor	New	
GetAllAssetAdministrationShellsById	GetAssetAdministrationShellById	Changed	Naming pattern resource singular

	PostAssetAdministrationShell	New	
PutAssetAdministrationShell	PutAssetAdministrationShellById	Changed	Naming pattern byId
PutSubmodel	PutSubmodelById	Changed	Naming pattern byId
	PostSubmodel	New	
GetAllAssetAdministrationShellIdsByAssetId		Removed	substituted by GetAllAssetAdministrationShellIdsByAssetLink and GetAllAssetLinksById
PutAssetId		Removed	Substituted by PutAllAssetLinksById and DeleteAllAssetLinksById
	GetAllAssetAdministrationShellIdsByAssetLink	New	Before: GetAllAssetAdministrationShellIdsByAssetId
	GetAllAssetLinksById	New	
	PutAllAssetLinksById	New	
	DeleteAllAssetLinksById	New	
GetAllSubmodelIdsBySemanticId		Removed	
GetAllConceptDescriptionsWithDataSpecificationReference	GetAllConceptDescriptionsByDataSpecificationReference	Renamed	Renaming With ➔ By
PutConceptDescription	PutConceptDescriptionById	Changed	Naming pattern byId
	PostConceptDescription	New	

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