PLATTFORM INDUSTRIE 4.0

Plattform Industrie **4.0**

Details of the Asset Administration Shell

from idea to implementation

An Overview

- Industrie 4.0
  Background: What's new, really?
- The key building block
  Industrie 4.0 component with the Asset Administration Shell
- Asset Administration Shell: An overview
  Current work of Plattform Industrie 4.0
- Details of the Asset Administration Shell
  Basis for practical implementations
- Asset Administration Shell in Specialization
  How to develop your own submodels
- Information and support for SMEs
  Where to find assistance for digital transformation

Industrie 4.0

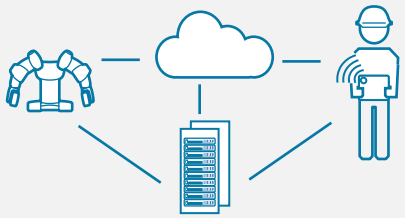
connecting business processes – across company borders

- Internet is available everywhere, simple and cheap.
- Devices are becoming intelligent.
- Using this in a smart way opens up a new world of services and functions.
- Industrie 4.0 connects all parties involved in business processes in the manufacturing and process industry.
- Information from suppliers, customers and within your own company is connected and transparently available.
- Workpieces and machines manage the production autonomously – flexible, efficient, resource-saving.
- There are transitions between companies and sectors.

Industrie 4.0
What‘s new, really?

That’s already possible today

- The cloud
- The network
- Automation devices with Internet access
- Internet-based services



Industrie 4.0: This is new

- **Added value** by exchanging information between value chain partners
- From **Intranet** to **Internet**
- **Neutral and common standards** for communication, services and semantics across companies and sectors

A large number of new **applications** and **business models** will emerge.

Common Standards?!

Requirements for digitised industrial production

- **Common** communication structures: network and protocols
- **Common** rules for cyber security and data protection
- **Common** language including signs, alphabet, vocabulary, syntax, grammar, semantics, pragmatics and culture

Graphic © Anna Salari

An Overview

- Industrie 4.0
  Background: What's new, really?
- The key building block
  Industrie 4.0 component with the Asset Administration Shell
- Asset Administration Shell: An overview
  Current work of Plattform Industrie 4.0
- Details of the Asset Administration Shell
  Basis for practical implementations
- Asset Administration Shell in Specialization
  How to develop your own submodels
- Information and support for SMEs
  Where to find assistance for digital transformation

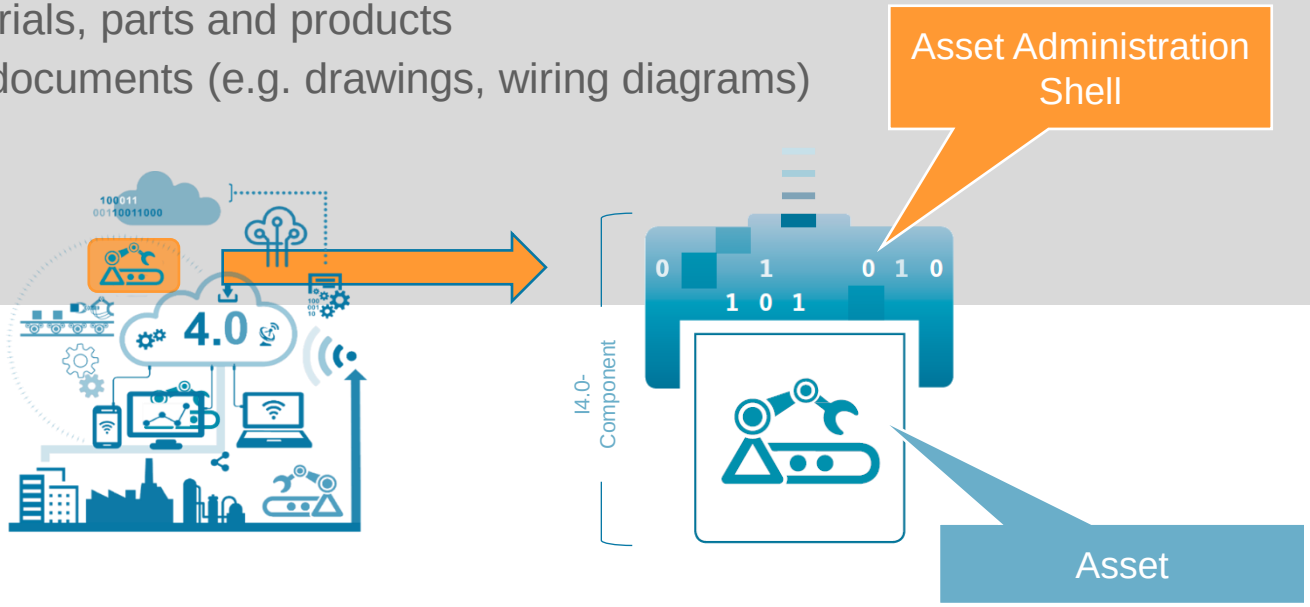
Industrie 4.0 components

Assets integrate into the IT world

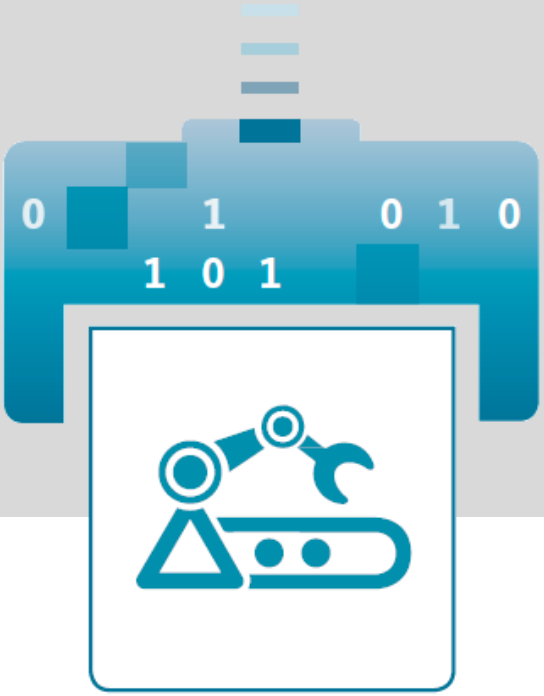
Integration of *assets* into the world of information

Asset = everything that requires a "connection" for an Industrie 4.0 solution

- Machines and their components
- Supply materials, parts and products
- Exchanged documents (e.g. drawings, wiring diagrams)
- Contracts
- Orders
- …



Asset Administration Shell
implements the Digital Twin



Digital Twin

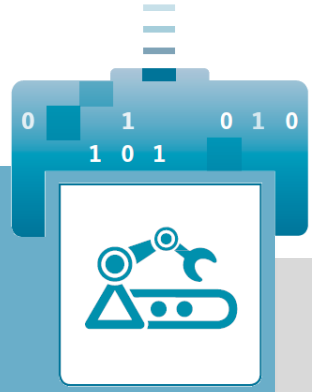
Definition (Industrial Internet Consortium (IIC) & Plattform I4.0): Digital representation, sufficient to meet the requirements of a set of use cases

Digital representation = information that represents characteristics and behaviors of an entity (asset)
i.e. the Asset Administration Shell is the implementation of the Digital Twin for Industrie 4.0

Plattform Industrie 4.0 Glossary http://i40.iosb.fraunhofer.de/

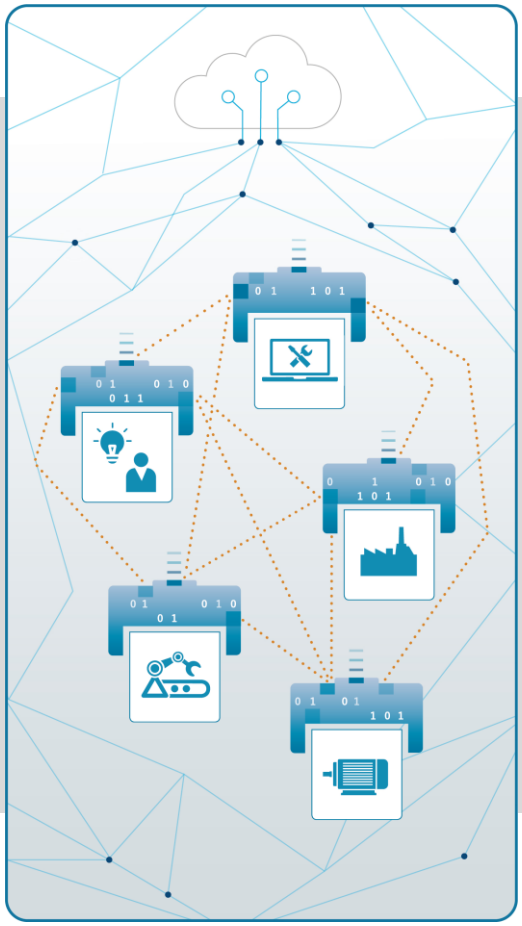
Asset Administration Shell

Why?



- The Asset Administration Shell is the **implementation of the „Digital Twin“** for Industrie 4.0
- The Asset Administration Shell establishes **cross-company interoperability**.
- The Asset Administration Shell is available for **non-intelligent and intelligent products**.
- The Asset Administration Shell covers the **complete life cycle** of products, devices, machines and facilities.
- The Asset Administration Shell enables **integrated value chains**.
- The Asset Administration Shell is the **digital basis for autonomous systems and AI**.

Asset Administration Shell
How?



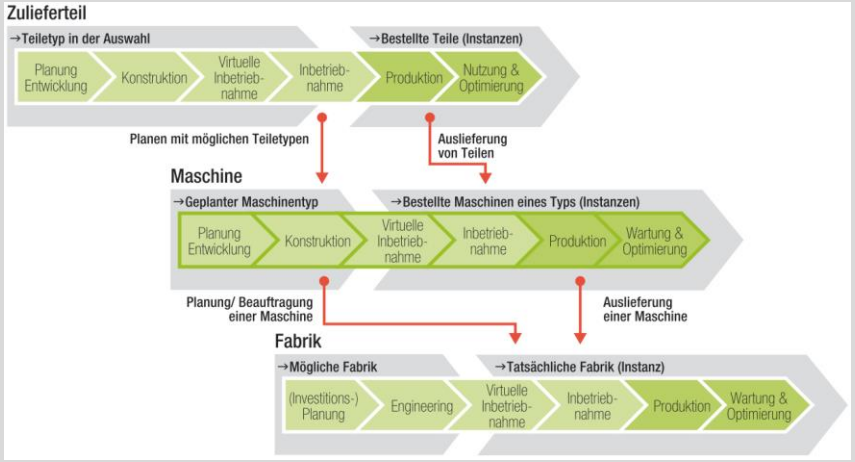
© Plattform Industrie 4.0; Anna Salari, designed by freepik

The Asset Administration Shell…

- integrates the *asset into Industrie 4.0 communication*.
- is *addressable* in the network and *identifies the asset* unambiguously.
- provides a *controlled access to all information* of the asset.
- is the standardised and secure *communication interface*.
- can integrate *intelligent* and also *non-intelligent („passive“) assets* (without a communication interface), e.g. via bar codes or QR codes.
- represents the *entire life cycle* of products, devices, machines and plants.

Industrie 4.0 components

The Asset Administration Shell covers the complete lifecycle



- During engineering, *functionalities* are planned, e.g. a motor with a certain torque and shaft height. A few properties of the motor will be put into the admin shell.
- In a next step, a specific motor *type* from a manufacturer is chosen, more information about that motor type will be added to the admin shell.
- The motor manufacturer delivers a component for calculating and simulating the motor, the choice can be simulated and confirmed.
- Then, during commissioning, the motor will be ordered, the motor *type* becomes a motor *instance* with a serial number, specific data for that individual motor. The admin shell is enriched again.
- Operating parameters (temperature, vibrations, …) are measured during operation of the motor. This can be recorded in the admin shell.
- Maintenance is done on the motor, and it is recorded in the admin shell.
- After end-of-life, the motor is replaced with a new one. This change, and all information about the new motor type & instance is recorded.
- Information in the admin shell can be exchanged between all partners in a value chain: suppliers, engineering partners, system integrators, operators and service partners.

Industrie 4.0 components

Asset Administration Shell

The Asset Administration Shell of an electrical drive...

…*knows properties and capabilities* of the electrical drive and makes it usable.

…*knows where to find the information* from and about the drive and provides it.

…has a specific *standardised syntax and semantic*.

…can be *realised in different ways*:

- as a simple static information source ("HTML file"), e.g. for a screw
- on a field device
- on a gateway that serves multiple devices
- as a connected IT solution with different information sources ("cloud solution")

Overview of the Asset Administration Shell

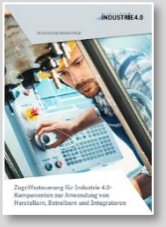
Publications of Plattform Industrie 4.0

Details of the Asset Administration Shell *(includes OPC UA, AutomationML and RDF mappings now)*

The publication states how companies can use the Asset Administration Shell to compile and structure information. In this way all information can be shared as a package (set of files) with partners at several levels of the value chain. It is not necessary to provide online access to this data from the very beginning. ENGLISH

Secure access to CAE data

This document of the working groups with focus on security describes security requirements for accessing CAE data. A proposed solution uses the concepts of the exchange of information between Administration Shells and of access management. GERMAN



Access control for Industrie 4.0 components to be used by manufacturers, operators and integrators

Describes attribute based access control, which is the basis for the Administration Shell and gives examples of how to use it. *GERMAN*

Administration Shell in Practice

In this publication, the Plattform Industrie 4.0 summarizes essential aspects of the Administration Shell and explains to users how they can develop their own generic, asset-specific and free submodels. GERMAN

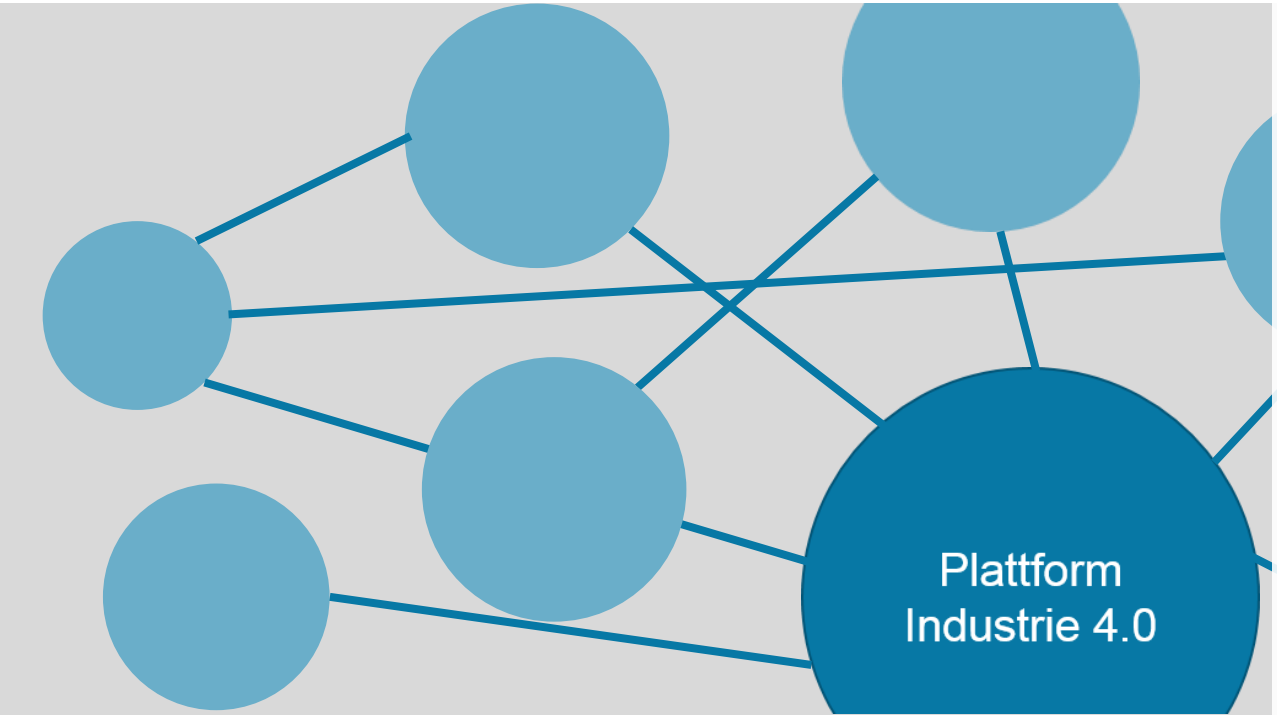
I4.0 language: vocabulary, message structure and semantic interaction protocols

The working group „Semantics and interaction for Industrie 4.0 components" (GMA; sub-working group of WG1 of the Plattform Industrie 4.0), develops a concept for the language between I4.0 components. The paper shows current approaches. GERMAN

Publications of the Plattform Industrie 4.0 are published in the download section

Plattform Industrie 4.0

Digital transformation – a great joint effort



- Industrie 4.0 is an overall-societal project
- A broad range of topics: From technological innovations to social change

Close alliance of:

- Science
- Economy
- Politics
- Associations
- Trade unions

Plattform Industrie 4.0 = collaborative development of a digital ecosystem for „digitalisation of industry“

Plattform Industrie 4.0
brings together know-how

Specialist expertise

+

SME support

+

International activities

Heart of the Platform Industrie 4.0: the working groups

Six working groups
focus on main topics – and give valuable impulses

The working groups…

- see themselves as a *working forum* for representatives from companies, works councils and trade unions.
- are *open* to all interested and qualified companies and works councils

Criteria to participate:

- a proven subject-specific *expertise*
- effective *mandate* of represented organisation
- regional *multiplier effect*



Working groups
Main topics

WG1

Reference Architectures, Standards and Norms

Chair:
Kai Garrels,
ABB STOTZ-KONTAKT GmbH

WG2

Technology and Application Scenarios

Chair:
Johannes Kalhoff,
Phoenix Contact

WG3

Security of Networked Systems

Chair:
Michael Jochem,
Robert Bosch GmbH

Legal Framework

Chair:
Dr. Hans-Jürgen Schlinkert,
ThyssenKrupp

WG4

Work, Education and Training

Chair:
Martin Kamp,
IG Metall

WG5

Digital Business Models for Industrie 4.0

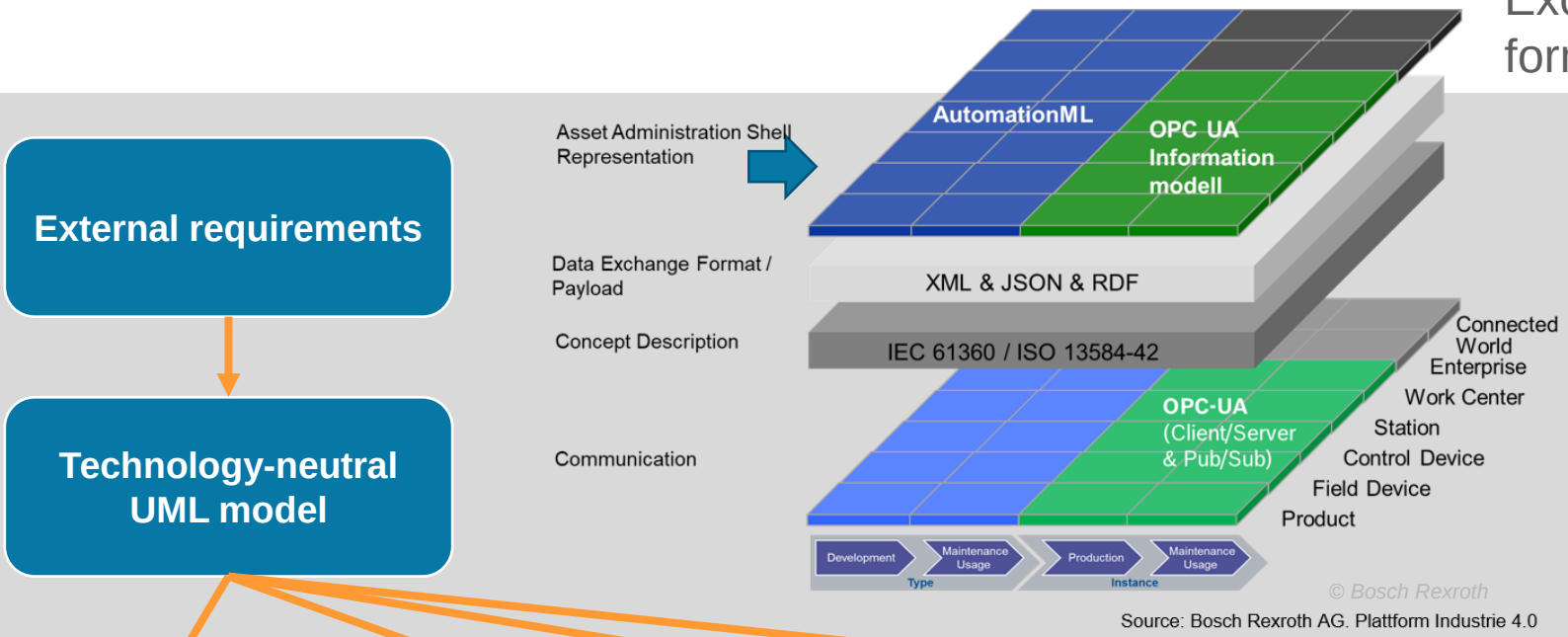
Chair:
Prof. Dr. Svenja Falk,
accenture

WG6

Overview of the Asset Administration Shell

Current approach

RAMI4.0 - Exchange formats



Source: Bosch Rexroth AG. Plattform Industrie 4.0

Security by Design

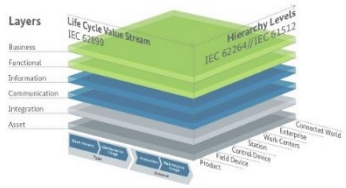
An Overview

- Industrie 4.0
  Background: What's new, really?
- The key building block
  Industrie 4.0 component with the Asset Administration Shell
- Asset Administration Shell: An overview
  Current work of Plattform Industrie 4.0
- Details of the Asset Administration Shell
  Basis for practical implementations
- Asset Administration Shell in Specialization
  How to develop your own submodels
- Information and support for SMEs
  Where to find assistance for digital transformation

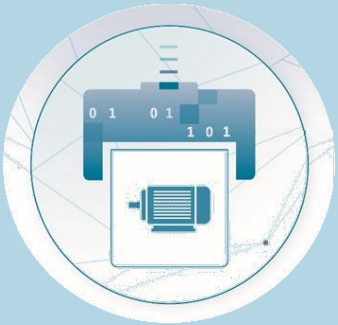
Overview of the Asset Administration Shell

Current work of Plattform Industrie 4.0

Basis: RAMI 4.0



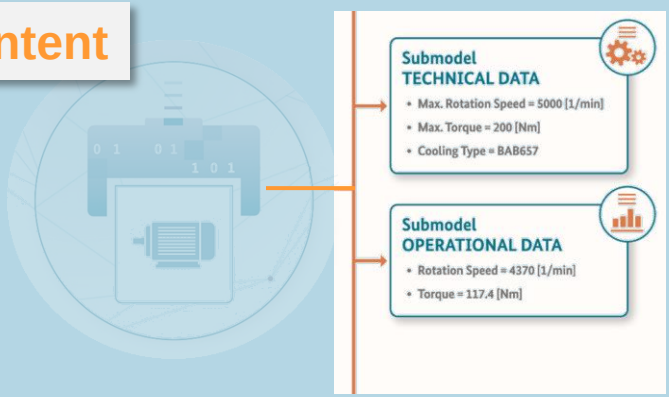
Form



Details **of the Asset Administration Shell**

Create, Find, Access and Modify

Content



Asset Administration Shell *in specialization*

(Former: in Practice)

Understanding and communicating information

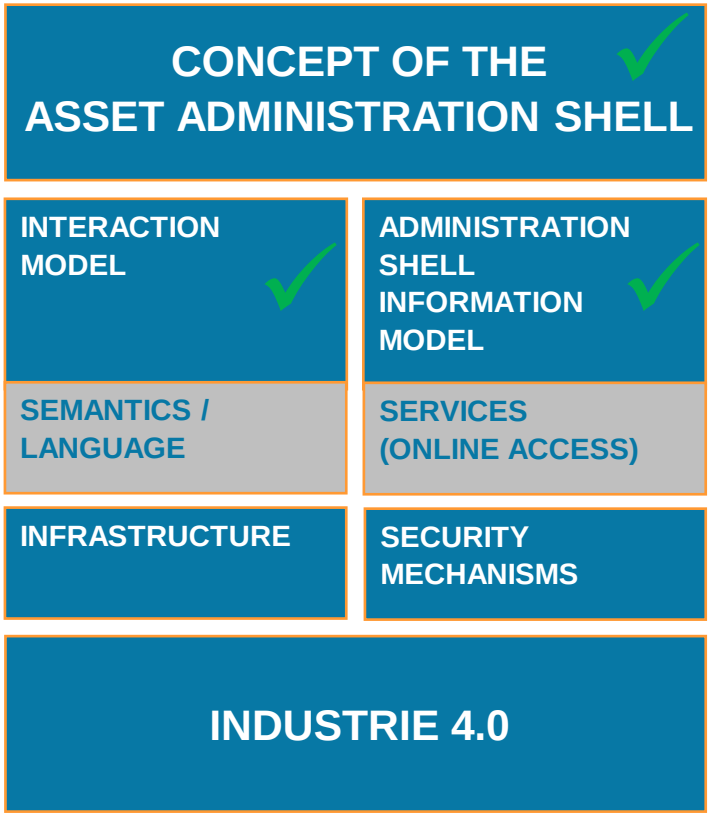
Basis: *Reference Architectural Model Industrie 4.0 (RAMI4.0) and the Industrie 4.0 component*

Overview of the Asset Administration Shell

Latest publication: Details of the Asset Administration Shell

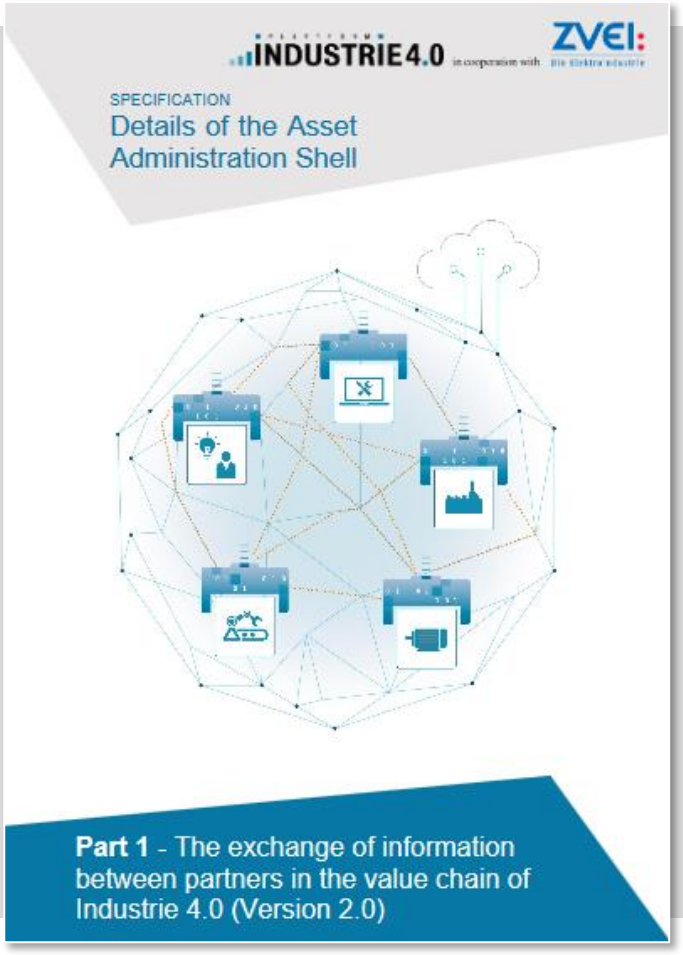
***Details* of the Asset Administration Shell**

„Part 1 - The exchange of information between partners in the value chain“ describes how information needs to be processed and structured in order to pass it as one package from one partner to another.



Details of the Asset Administration Shell

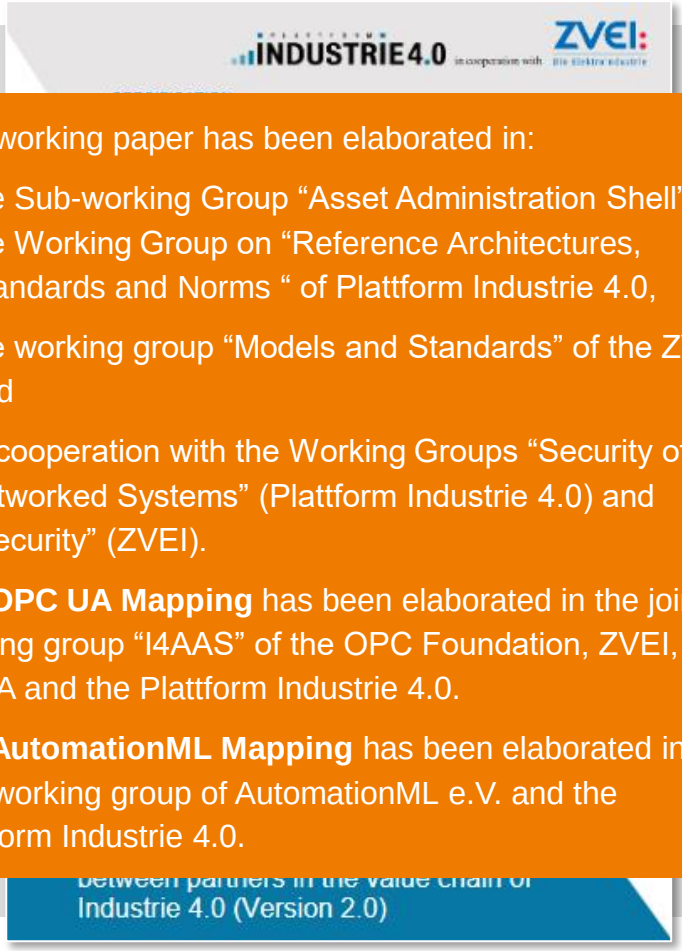
Publication at SPS 2019



Scope and content:

- adresses developers mainly
- describes a technology-neutral information model for Administration Shell (UML)
- mappings for OPC UA, AutomationML and RDF
- Security by Design
- provides specific exchange formats for information (XML, JSON)
- defines a package format for exchanging content („.aasx“)

Details of the Asset Administration Shell
Publication at SPS 2019



This working paper has been elaborated in:

- the Sub-working Group “Asset Administration Shell” of the Working Group on “Reference Architectures, Standards and Norms “ of Plattform Industrie 4.0,
- the working group “Models and Standards” of the ZVEI and
- in cooperation with the Working Groups “Security of networked Systems” (Plattform Industrie 4.0) and “Security” (ZVEI).

The **OPC UA Mapping** has been elaborated in the joint working group “I4AAS” of the OPC Foundation, ZVEI, VDMA and the Plattform Industrie 4.0.

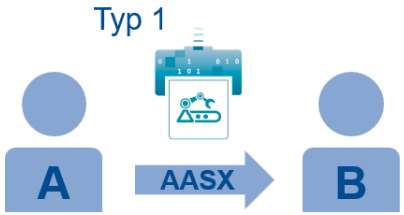
The **AutomationML Mapping** has been elaborated in the joint working group of AutomationML e.V. and the Plattform Industrie 4.0.

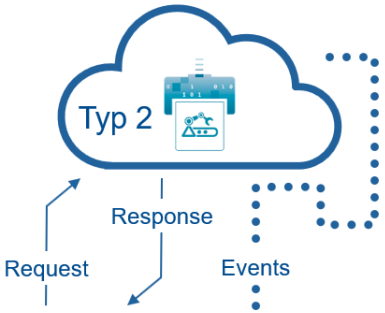
Organisation:

- is part 1 of a document series
- is versioned
- is discussed with international partners
- Asset Administration Shell is on its way to becoming an international standard: IEC accepted request for standardization in November 2019

Details of the Asset Administration Shell

Where do we stand with usable specifications?





Specification series: Details of the Asset Administration Shell

Part 1 - Information model for the AAS for the exchange of information between partners in the value chain

- AutomationML
- XML / JSON
- OPC UA
- RDF
- Paketformat
- Security

V2.0 available

Part 2 - Interfaces and API for single AAS

- HTTP(S) REST
- OPC UA
- Message Broker, u.a. wie OPC UA, AMQP, MQTT, DDS

Planned for HM 2020

Part 3 - Infrastructure, which hosts and interconnects multiple AAS

- Edge
- On-premise
- Public cloud

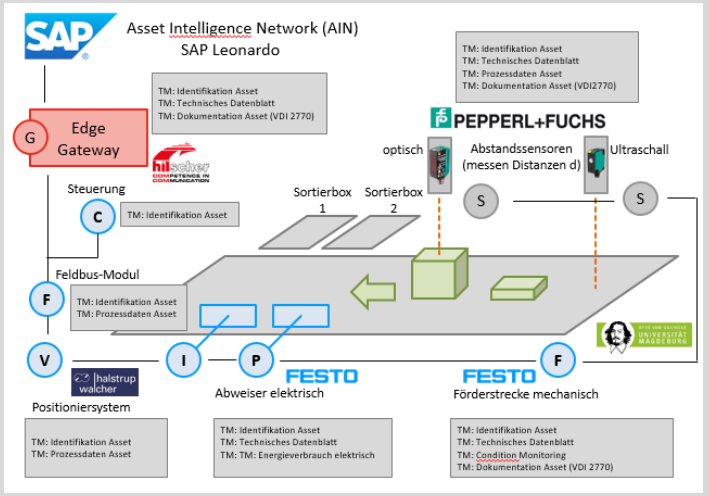
in progress

Overview of the Asset Administration Shell

Latest publication: The Asset Administration Shell in Specialization

The Asset Administration Shell *in Specialization*…

- explains how users can **develop their own submodels**.
- defines **standardised basic submodels**, which apply to a broad variety of assets in the Industrie 4.0 world (e. g. catalogue data).
- provides **templates for submodels**. These include identification and documentation.
- describes a **Industrie 4.0 scenario** which implements and uses the Administration Shell.



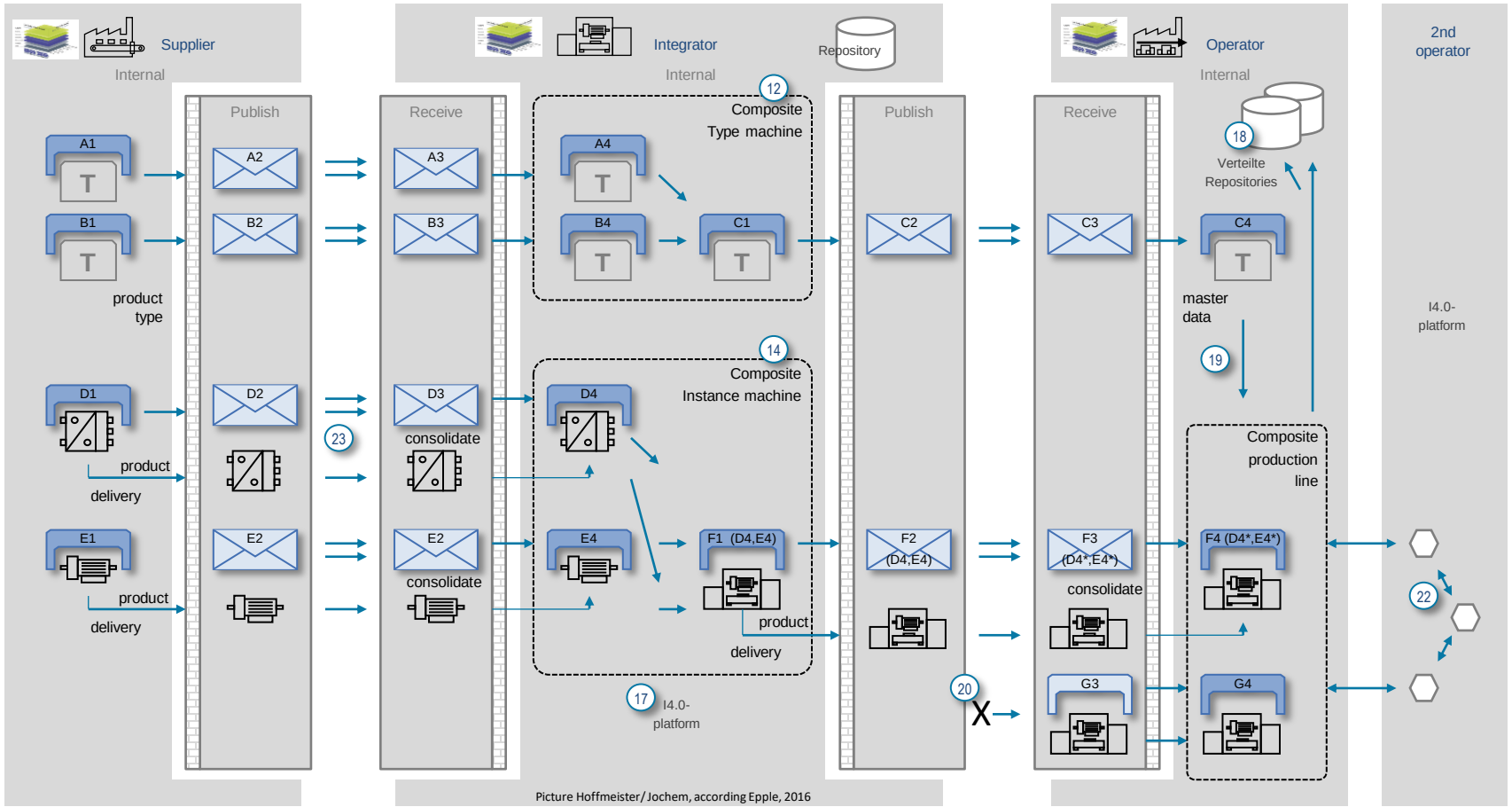
Available in the online library of the Platform Industrie 4.0 (GERMAN)

An Overview

- Industrie 4.0
  Background: What's new, really?
- The key building block
  Industrie 4.0 component with the Asset Administration Shell
- Asset Administration Shell: An overview
  Current work of Plattform Industrie 4.0
- Details of the Asset Administration Shell
  Basis for practical implementations
- Asset Administration Shell in Specialization
  How to develop your own submodels
- Information and support for SMEs
  Where to find assistance for digital transformation

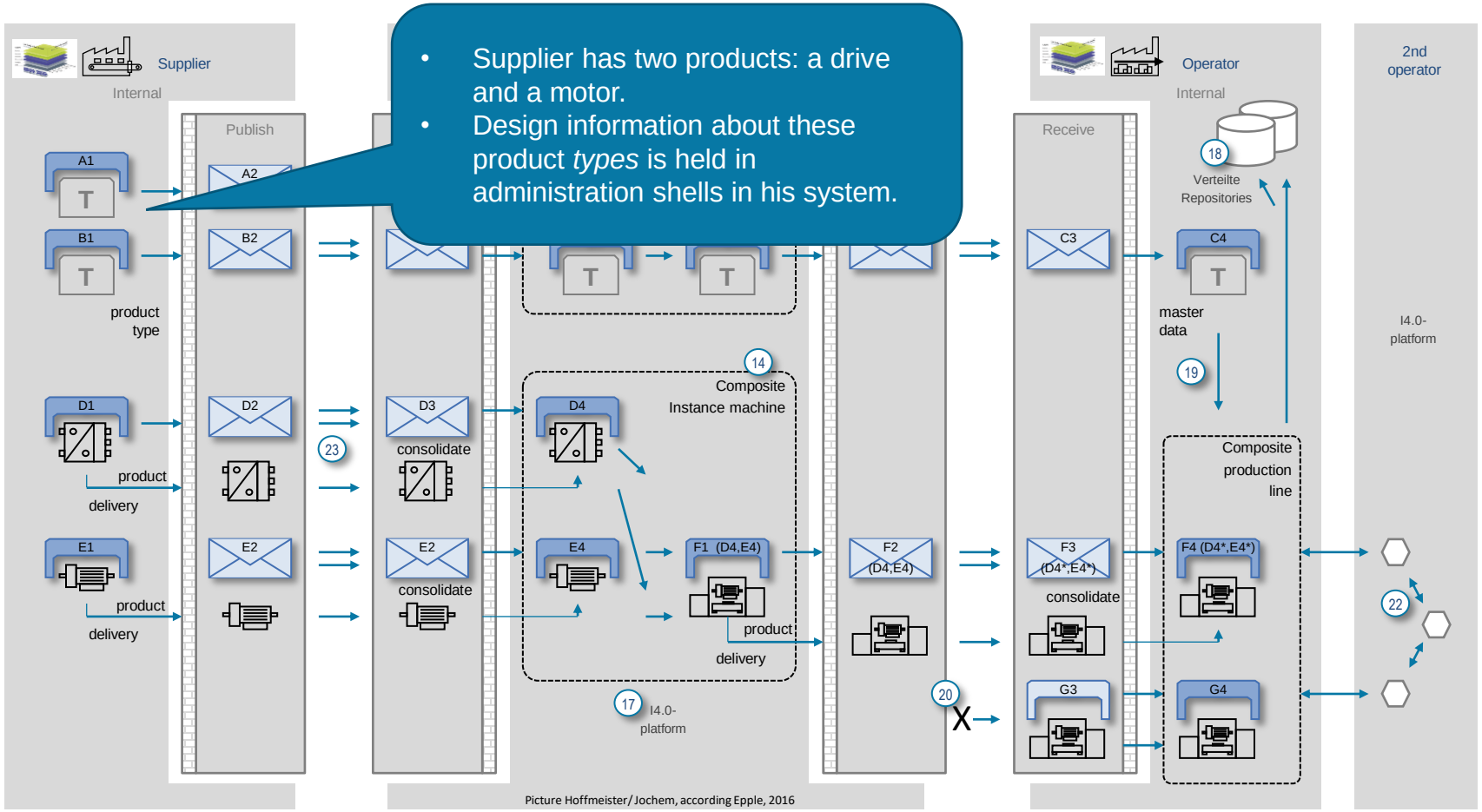
Details of the Asset Administration Shell

Leading picture for Use Cases: a three-step value chain



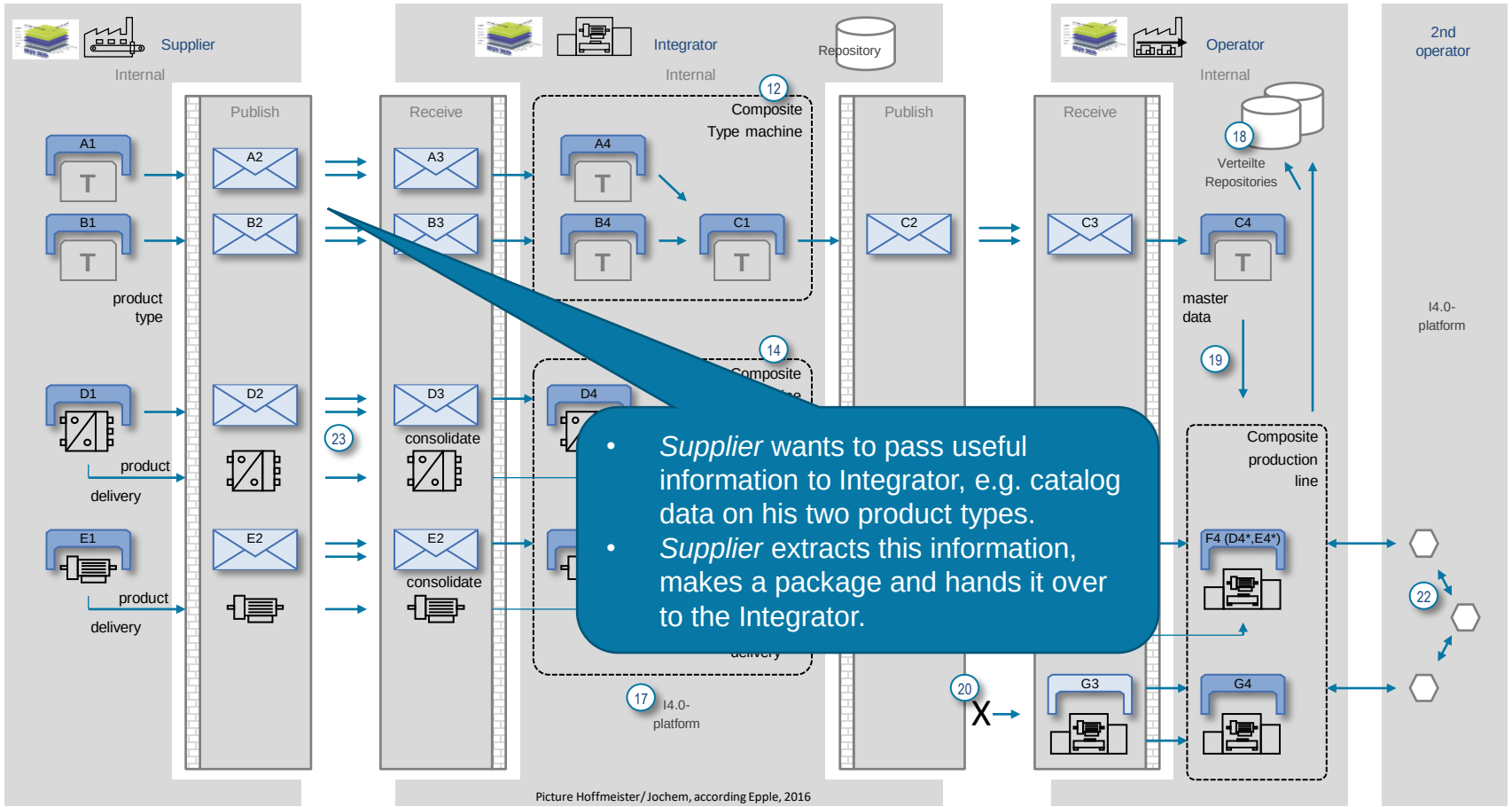
Details of the Asset Administration Shell

Use Case: Information about Products (“Types”)



Details of the Asset Administration Shell

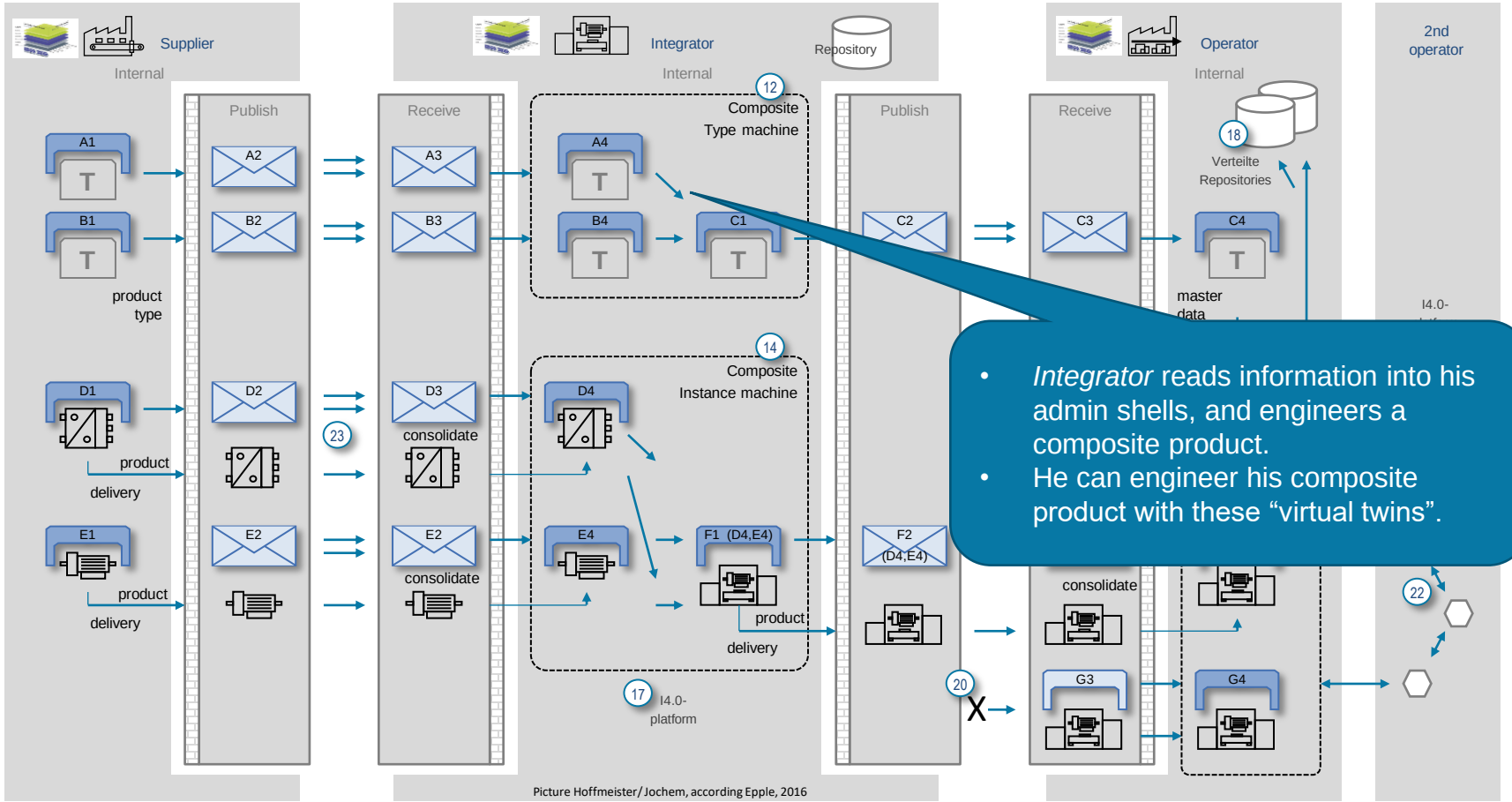
Use Case: Information about Products (“Types”)



Picture Hoffmeister/Jochem, according Epple, 2016

Details of the Asset Administration Shell

Use Case: Engineering with Product Types

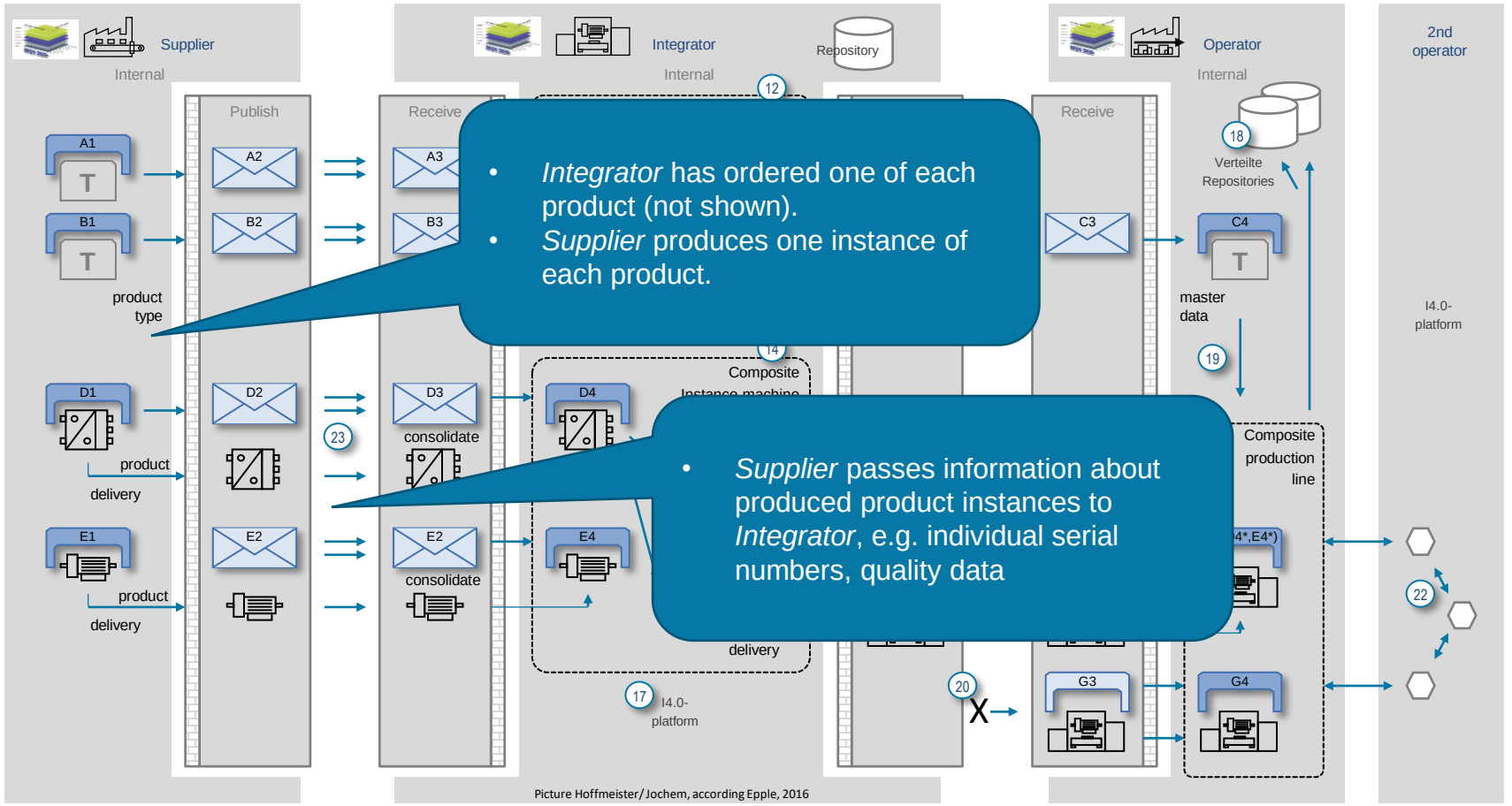


- *Integrator* reads information into his admin shells, and engineers a composite product.
- He can engineer his composite product with these “virtual twins”.

Picture Hoffmeister/Jochem, according Epple, 2016

Details of the Asset Administration Shell

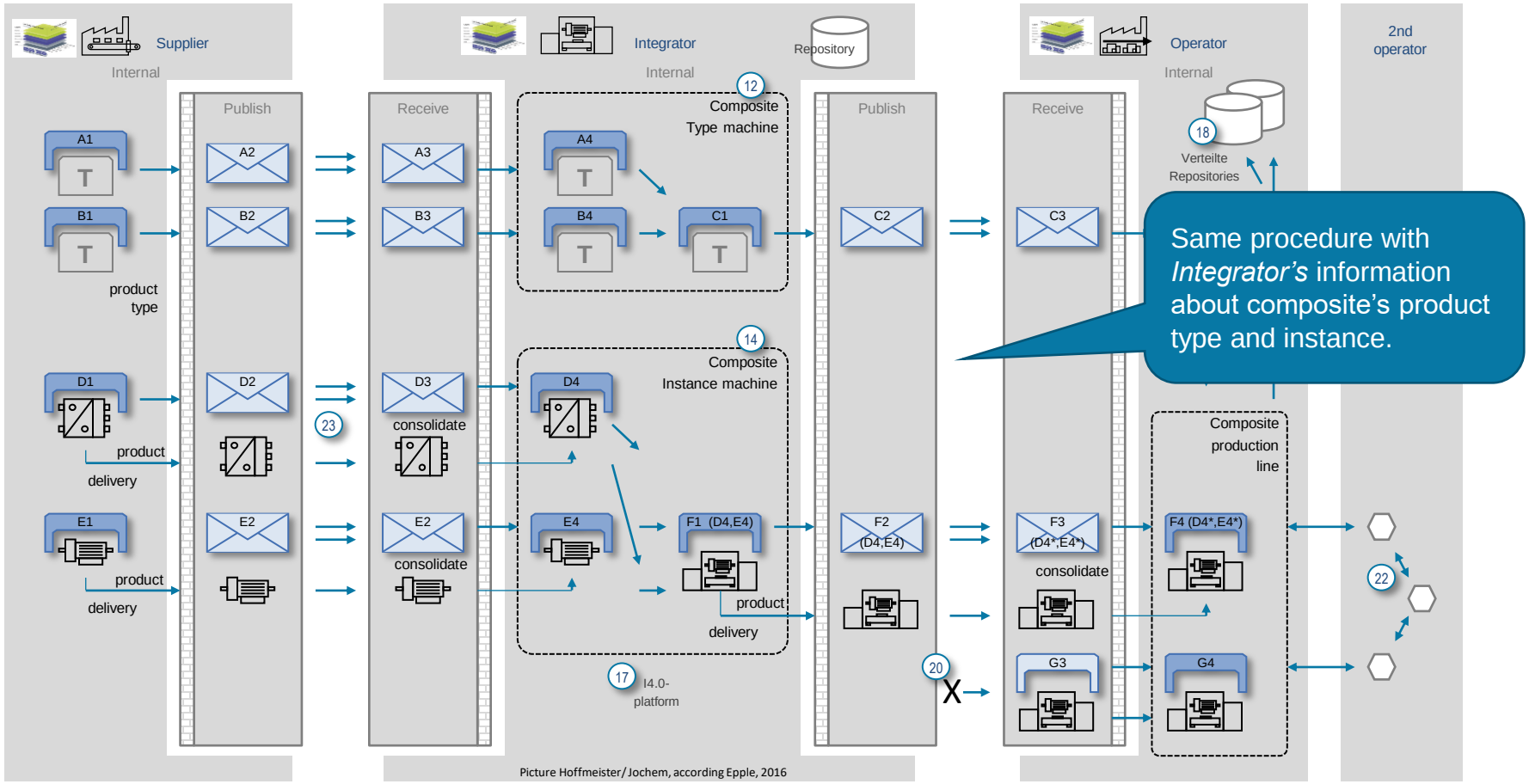
From Design to Reality: “Types” become “Instances”



Picture Hoffmeister/Jochem, according Epple, 2016

Details of the Asset Administration Shell

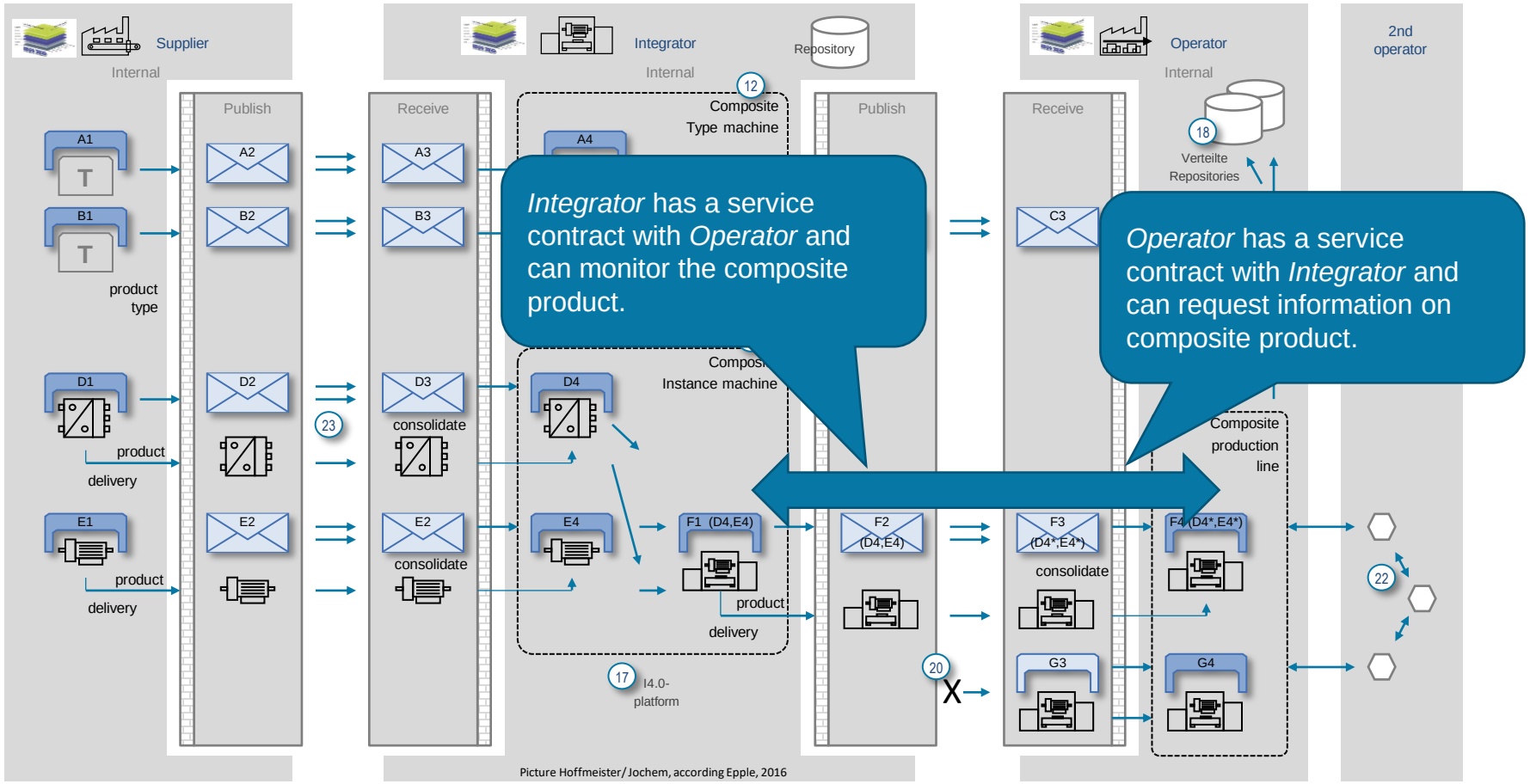
Leading picture for Use Cases: a three-step value chain



Picture Hoffmeister/Jochem, according Epple, 2016

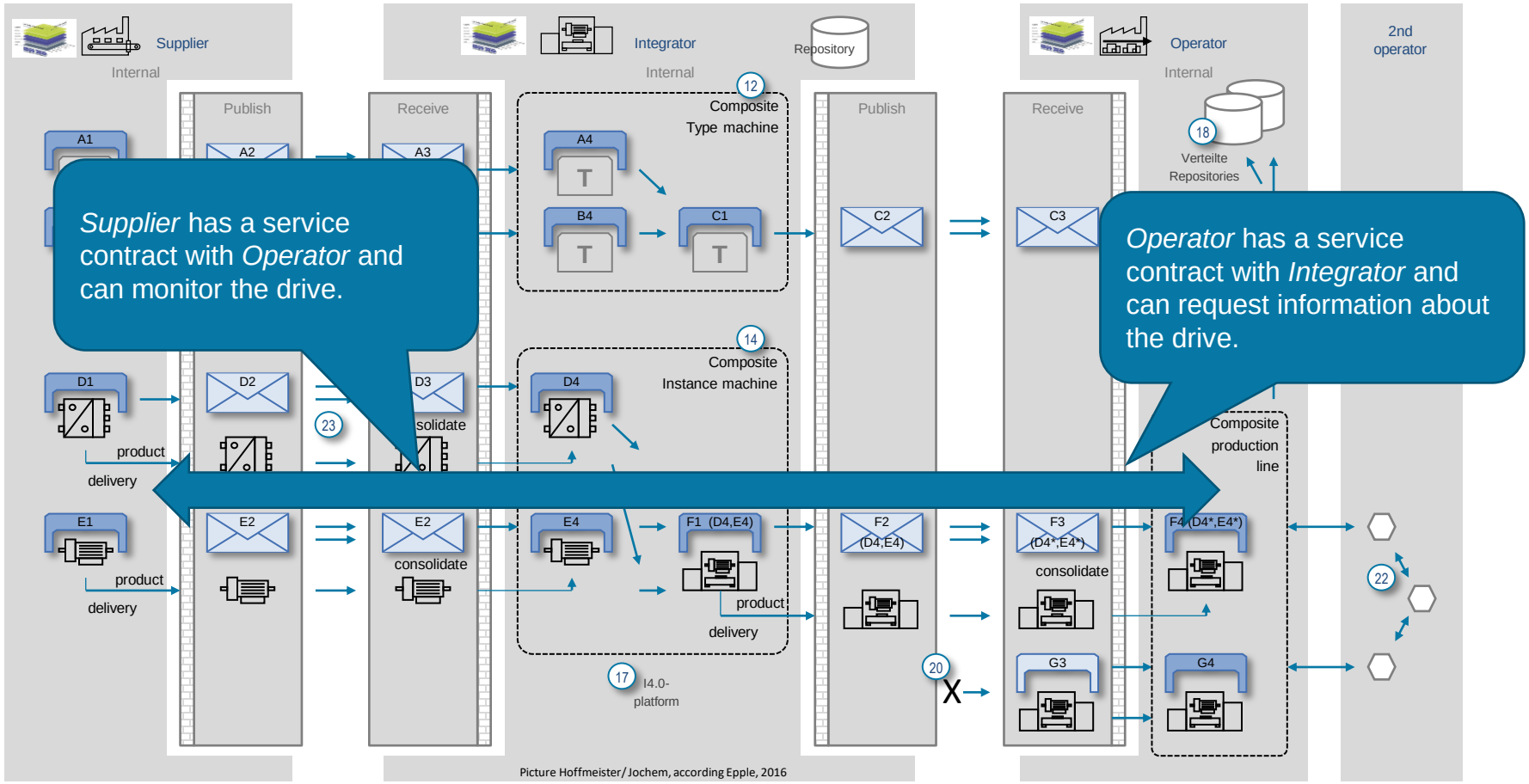
Details of the Asset Administration Shell

Use Case: Remote Monitoring & Asset Health



Details of the Asset Administration Shell

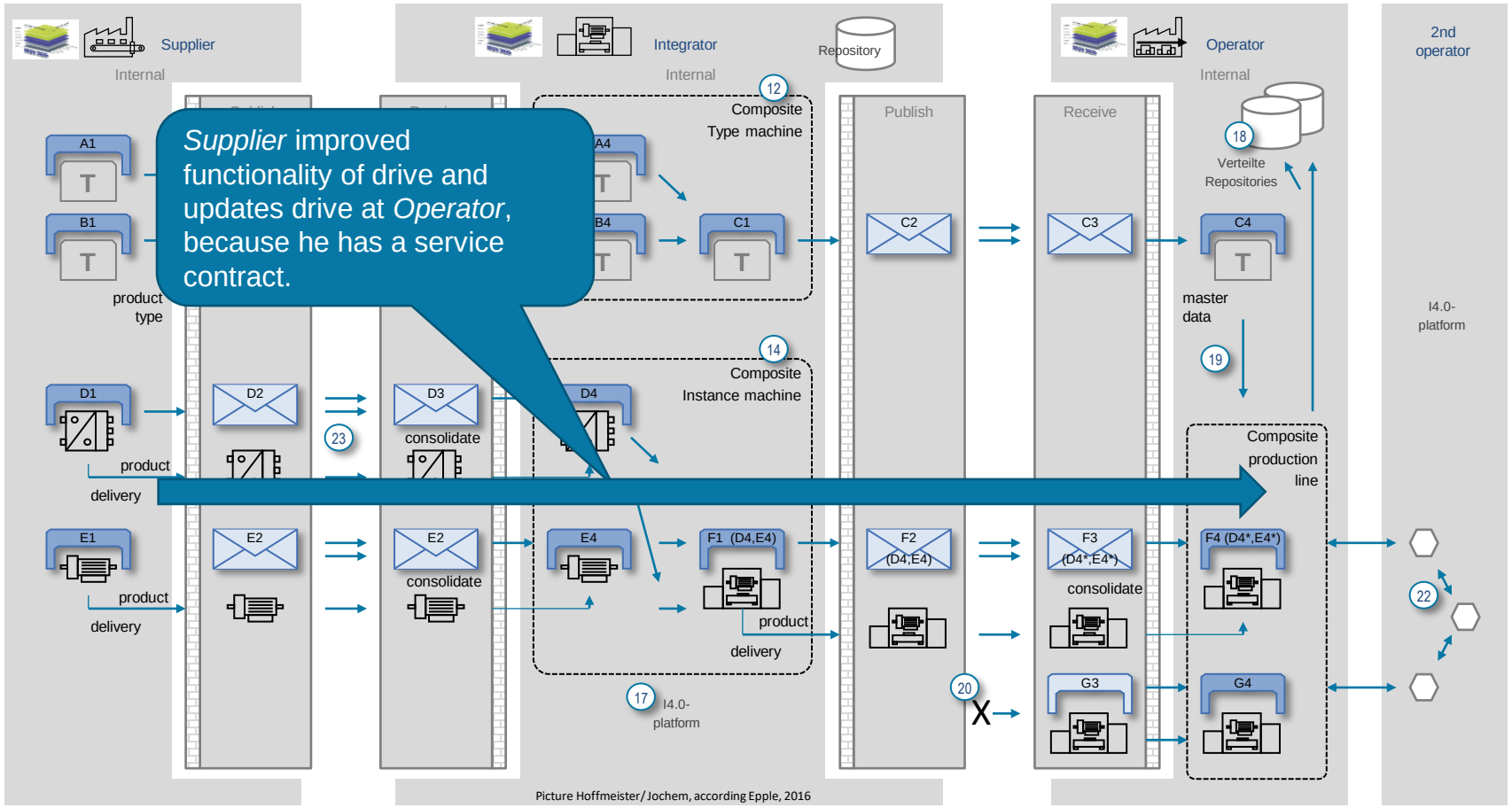
Use Case: Remote Monitoring & Asset Health



Picture Hoffmeister/Jochem, according Epple, 2016

Details of the Asset Administration Shell

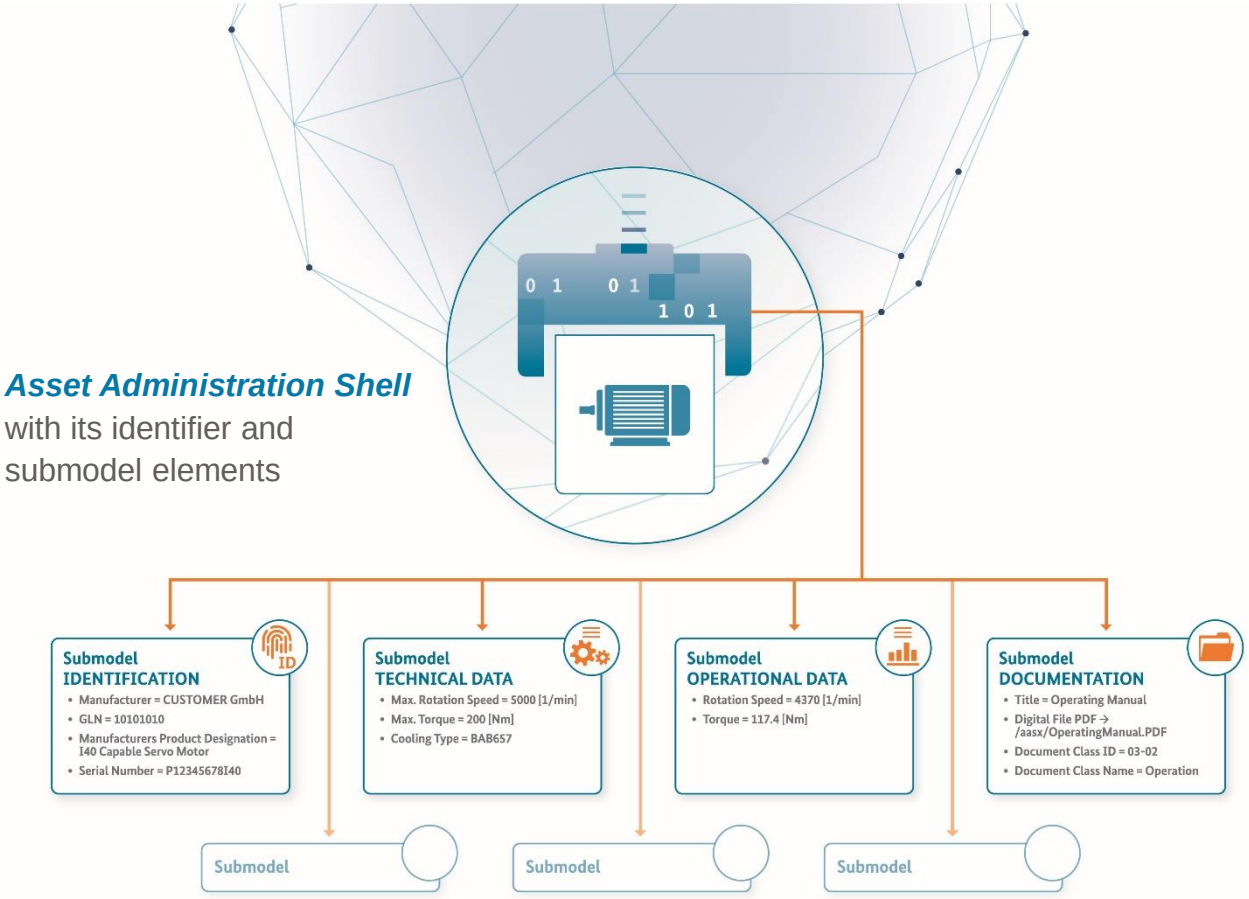
Use Case: Service Contracts



Picture Hoffmeister/Jochem, according Epple, 2016

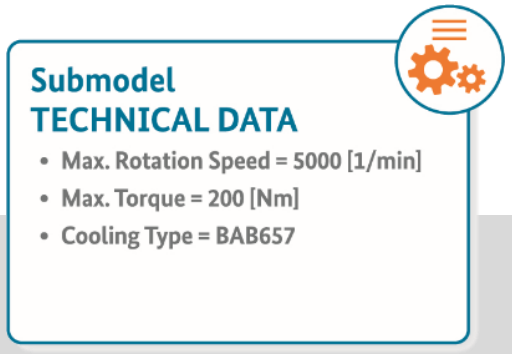
Details of the Asset Administration Shell

The generic structure of the meta-information model



The Asset Administration Shell including submodels on technical data, operational data and documentation for a sample servomotor. © Plattform Industrie 4.0/Anna Salari, designed by freepik

Details of the Asset Administration Shell
Submodels



Submodel **= aggregates information that belongs together**

- *Submodels* combine different functional aspects of an Industrie 4.0 component
- *Basic submodels* (standardised): apply to many assets in the Industrie 4.0 world (e.g. catalogue data of products)
- *Free submodels*: agreed between partners in the value chain for a specific use case

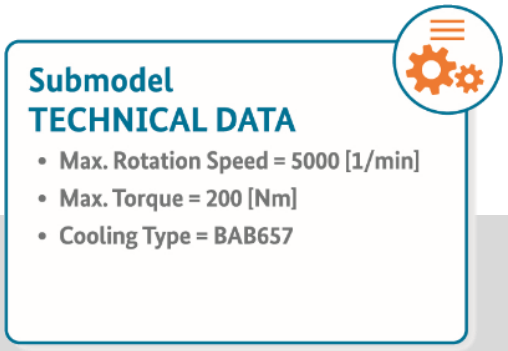
Submodels should always be linked to a use case that creates value.

An Administration Shell may contain many submodels.

Aim: To develop one sub-model for each functional aspect.

Details of the Asset Administration Shell

Submodel elements / Properties



Submodels **contain submodel elements**

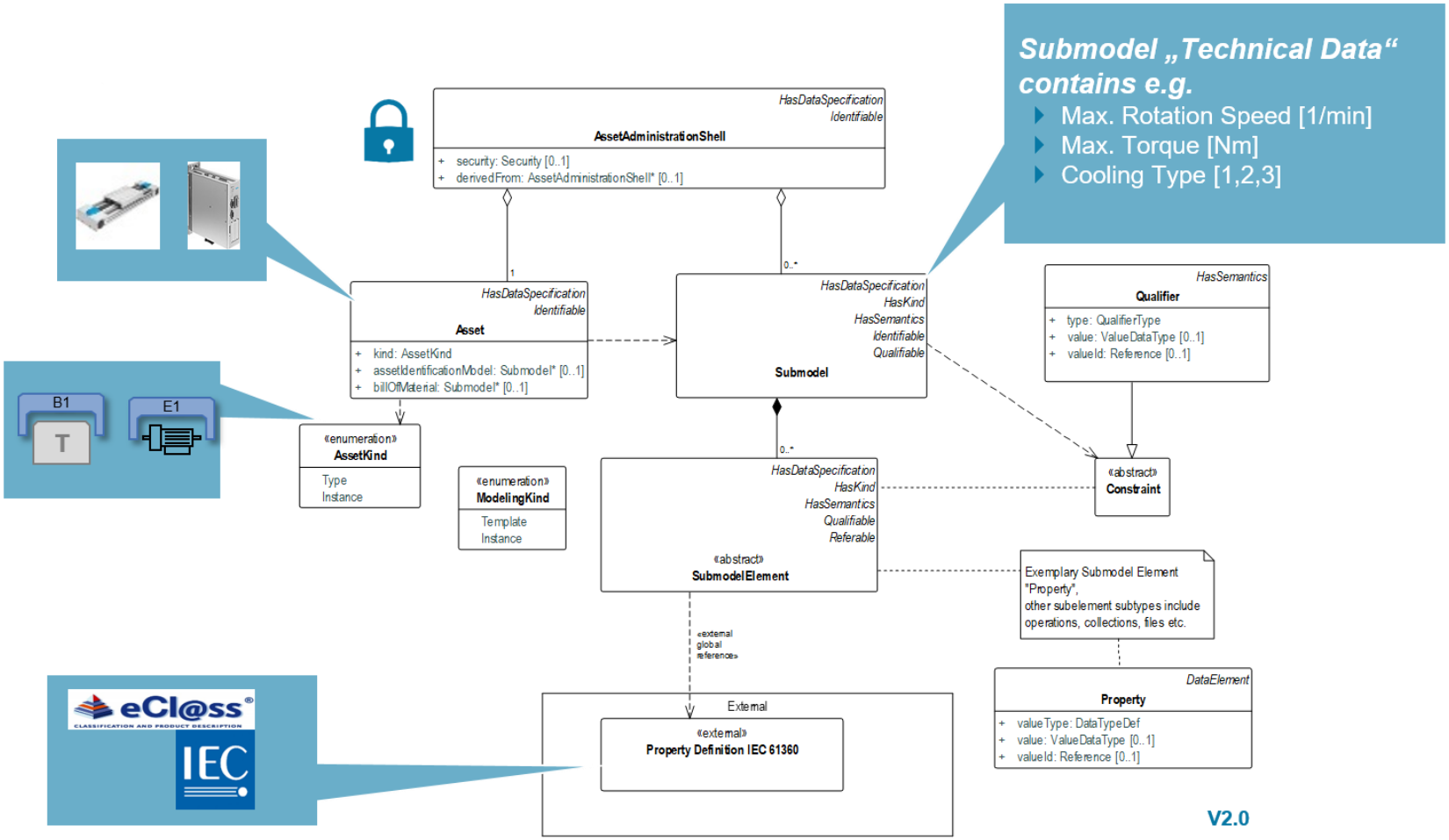
(Submodel elements include e.g. properties.)

- *Product properties* in terms of IEC61360-1 or ecl@ss
- *Process variables* and parameters, telemetry data
- *Operations* that do actions
- *Events* to observe properties etc.
- *References* to external data sources or files
- *References* to other Administration Shells and their parts

  (submodels, properties), also from external partners in the value chain
- *Capabilities* of the asset, description of method calls
- *Sets* of properties, e.g. lists or arrays

Details of the Asset Administration Shell

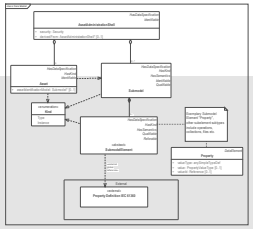
Meta information model - Basic



Details of the Asset Administration Shell

XML Schema: Example

Meta-information model



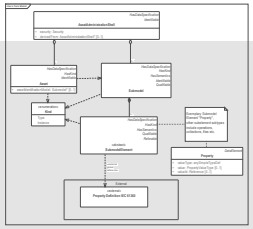
```
[…]
<property>
  <idShort>>NMax</idShort>
  <category>PARAMETER</category>
  <description lang="EN">maximum rotation speed</description>
  <description lang="DE">maximale Drehzahl</description>
  <semanticId>
    <keys>
      <key local="false" type="GlobalReference"
           idType="IRDI">0173-1#02-baa120#007</key>
    </keys>
  </semanticId>
  <valueType>double<valueType>
  <value>2000</value>
</property>
[…]
```

(Simplified) example of a property “maximum rotation speed" (idShort=NMax) with semantic reference

Details of the Asset Administration Shell

JSON scheme: Example

Meta-information model



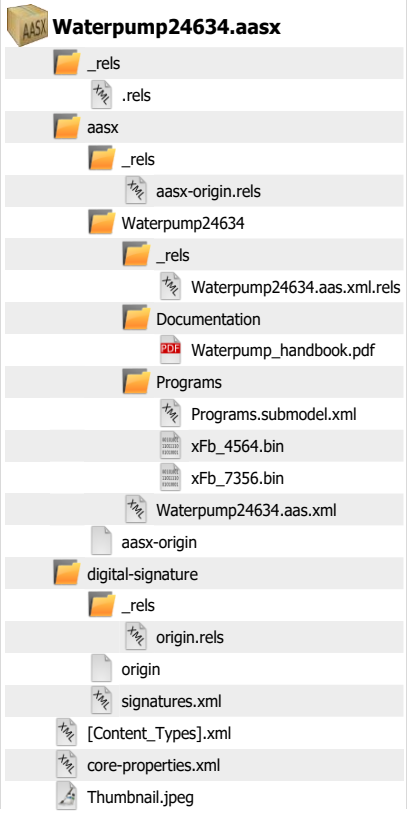
```
"submodelElements": [
    {
      "idShort": "NMax",
      "modelType": {
         "name": "Property“ },
      "semanticId": {
       "keys": [
        {
           "type": "ConceptDescription",
           “idType": "IRDI",
           "value": "0173-1#02-BAA120#007",
           "local": true,
           "index": 0
        } ]
      },
      "category": "PARAMETER"
    }
  ],
```

Simplified example for a property “maximum rotation speed" (idShort=NMax) with reference to local dictionary

Details of the Asset Administration Shell
Package format for exchanging content

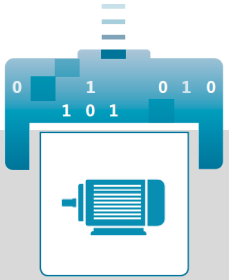
Content package as file collection **(similar to a ZIP file, Open Office XML File Formats/Open Packaging Conventions ISO/IEC 29500-2)**

- Asset information, submodels, properties and the values of their attributes are packed together.
- Several Administration Shells can be put in one package.
- Submodels and properties can be shown as separate files.
- Each file can be signed and encrypted.



Details of the Asset Administration Shell

Use of semantic IDs



Property
MaxRotationSpeed

- semanticId = 0173-1#02-BAA120#008
- value = 2000

2000 = year?
2000 = Euro?
2000 = steps?
2000 = …?

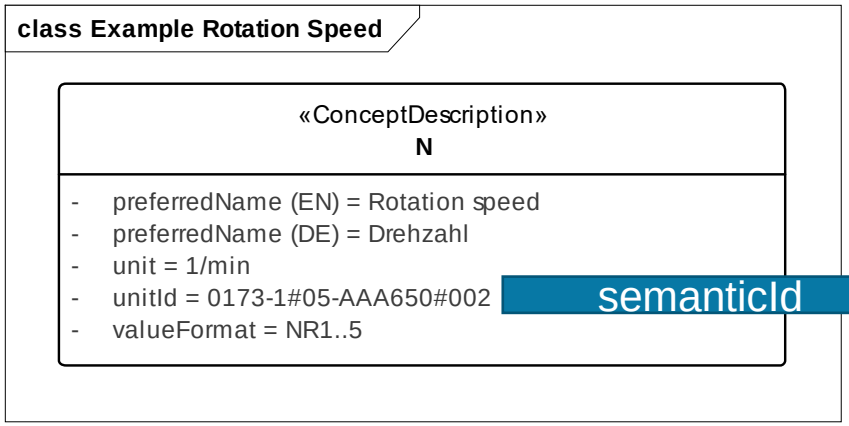
semanticId

Property	0173-1#02-BAA120#008 Max. rotation speed
Data type	INTEGER_MEASURE
Unit of measure	1/min
Definition	Greatest possible rotation speed with wich the motor or feeding unit may be operated

2000 = Max. rotation speed (1/min)

Details of the Asset Administration Shell

Use of semantic IDs for physical units



eCl@ss

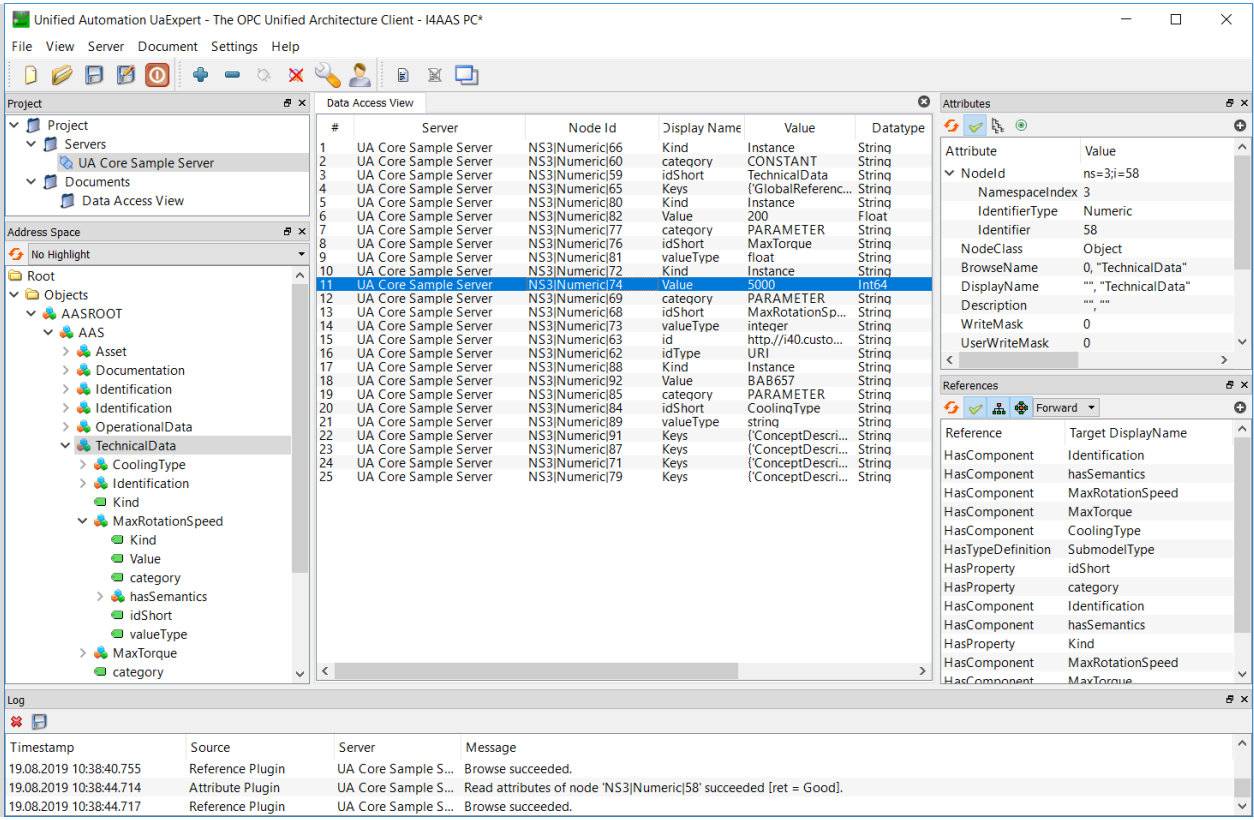
Allgemein	Admin	Relationen	Attribut	CR	Verlauf	Release	Ver

ID	0173-1#05-AAA650#002
Name	1/min
Primäre Sprache	Deutsch
Strukturierte Bezeichnung	min^{-1}
Kurzbezeichnung	1/min
Erklärung	Kehrwert der Einheit Minute
Ursprung der Definition	NIST Special Publication 811:1995
Kommentar	
SI-Symbol	1/min
SI-Name	reciprocal minute
DIN-Symbol	min^{-1}
ECE-Name	reciprocal minute
ECE-Kode	C94
NIST-Name	revolutions per minute
Umrechnungsfaktor	1.0/60
ID für Herausgeber	0173-1
Herausgeber	ECL

Simplified example

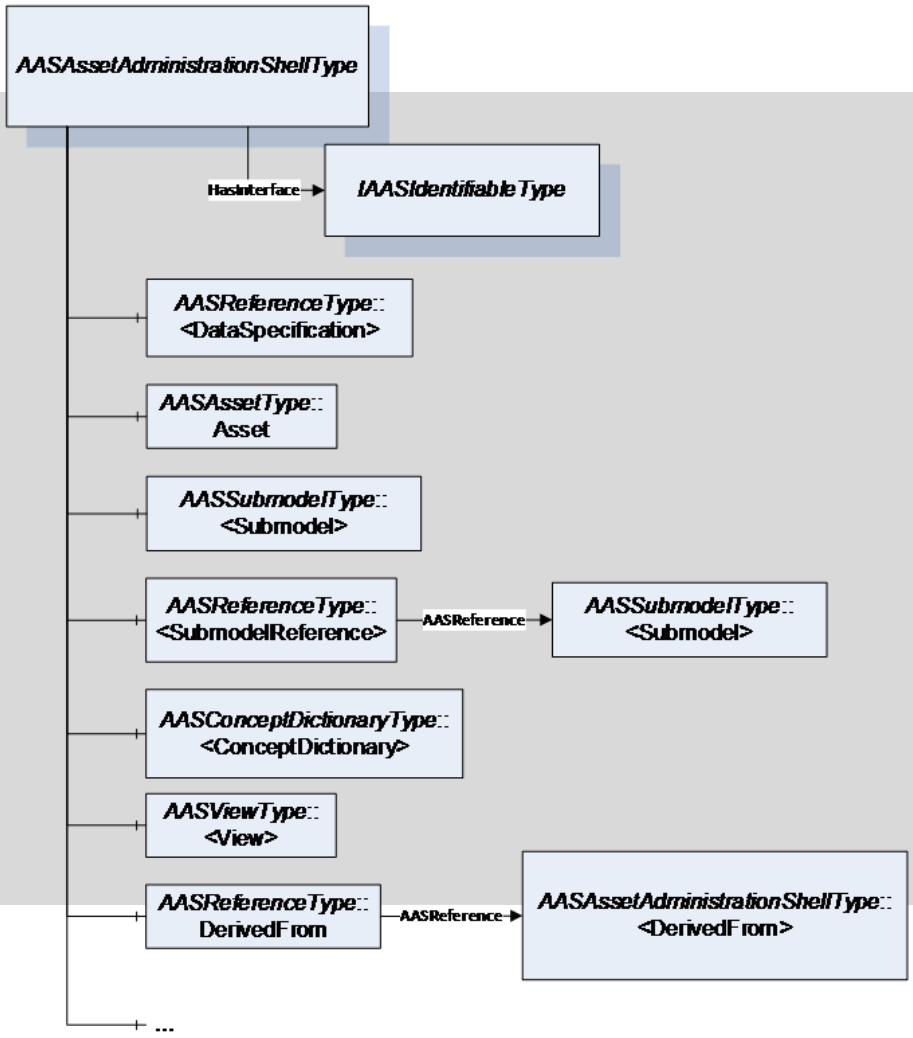
Details of the Asset Administration Shell

OPC UA Companion Specification

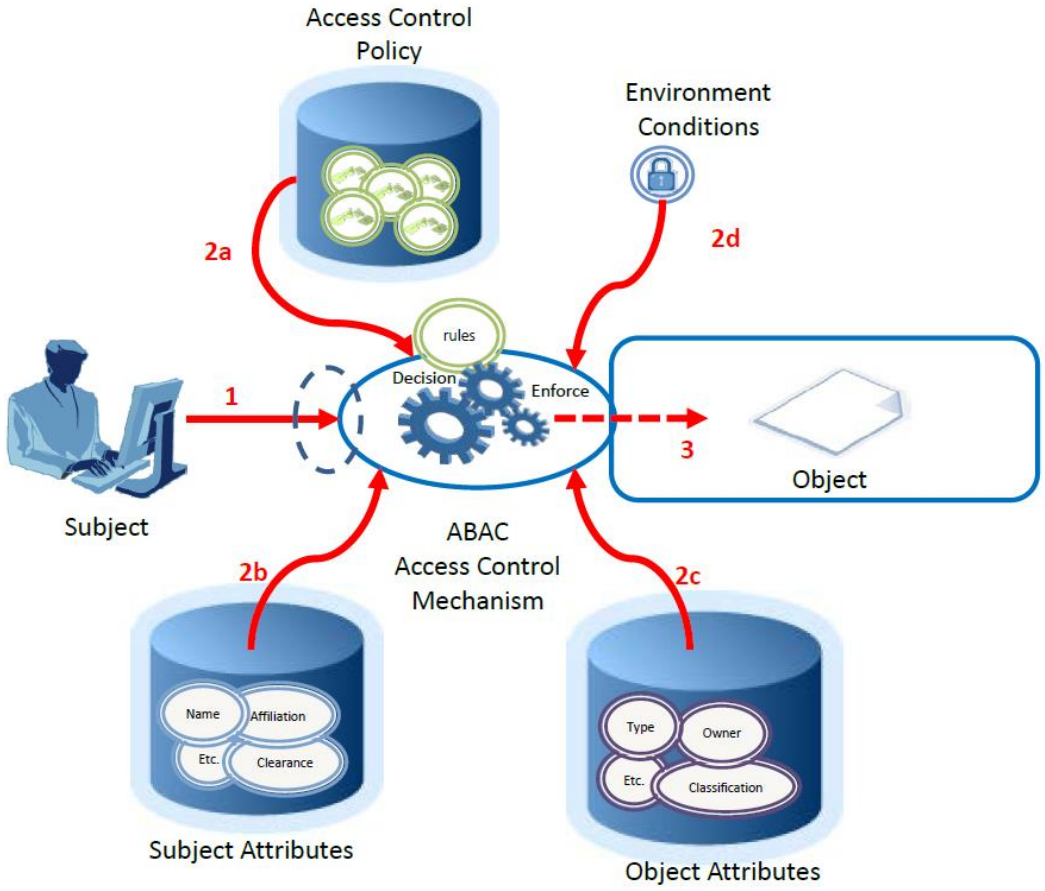


Details of the Asset Administration Shell

OPC UA Companion Specification



Security
Attribute Based Access Control (ABAC)

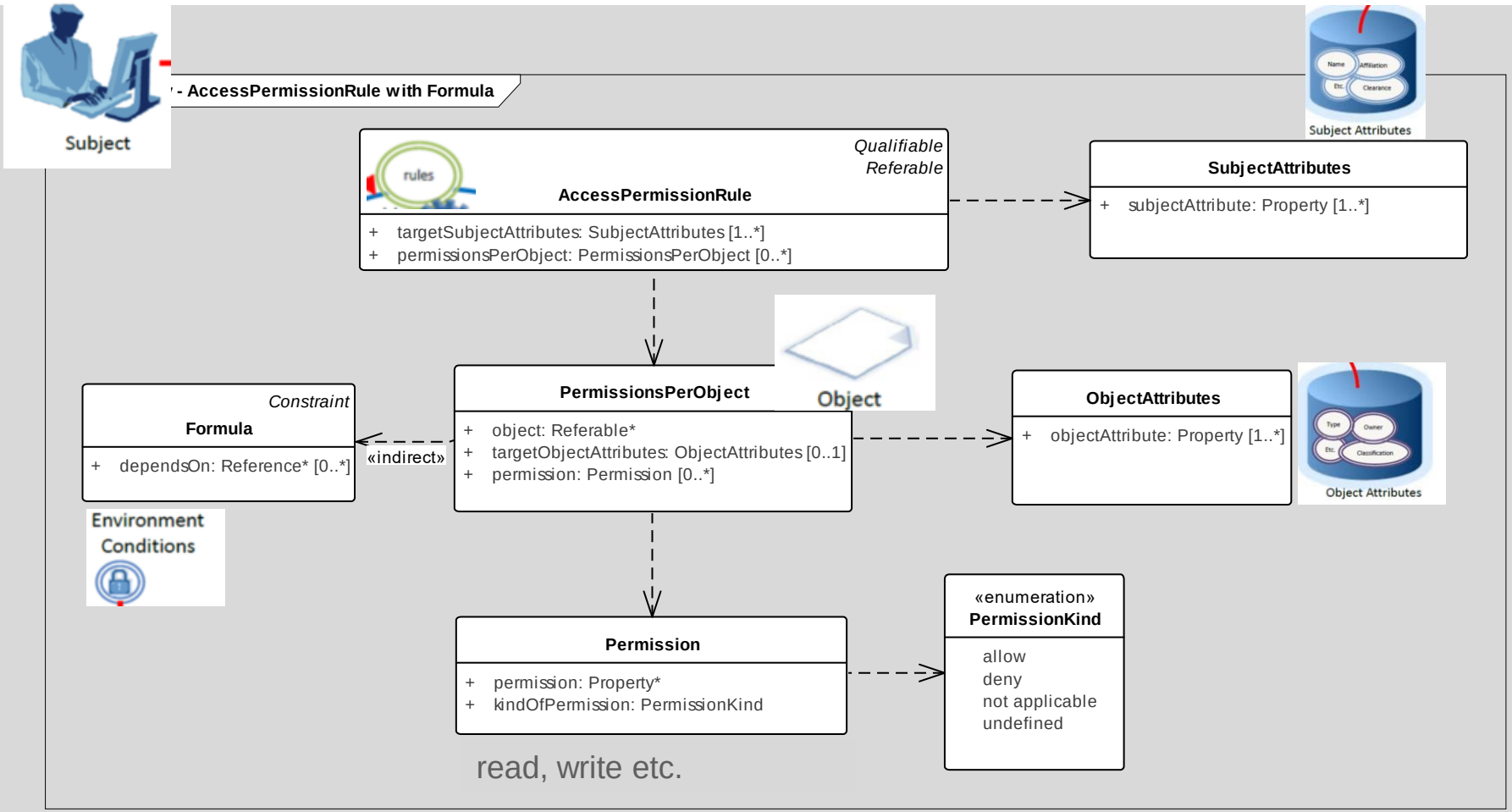


Rule e.g.:

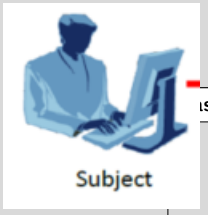
Maintenance engineers may read and change the data that is relevant to them between 3 pm and 5 pm. The prerequisite is that the machine is not active and that the accessing maintenance engineer has successfully performed the defined security check.

Source: NIST Special Publication 800-162

Security
Access rules



Security
Access rules



Maintenance Engineer

Role=Maintenance Engineer
&& SecurityCheck = true

ss Security - AccessPermissionRule with Formula

Qualifiable
Referable
AccessPermissionRule
+ targetSubjectAttributes: SubjectAttributes [1..*]
+ permissionsPerObject: PermissionsPerObject [0..*]

SubjectAttributes
+ subjectAttribute: Property [1..*]

Object: Submodel
“Maintenance”

Constraint
Formula
+ dependsOn: Reference* [0..*]

«indirect»

PermissionsPerObject
+ object: Referable*
+ targetObjectAttributes: ObjectAttributes [0..1]
+ permission: Permission [0..*]

ObjectAttributes
+ objectAttribute: Property [1..*]

Mode = idle

(Time > 15 && Time < 17)

Time is an environmental variable

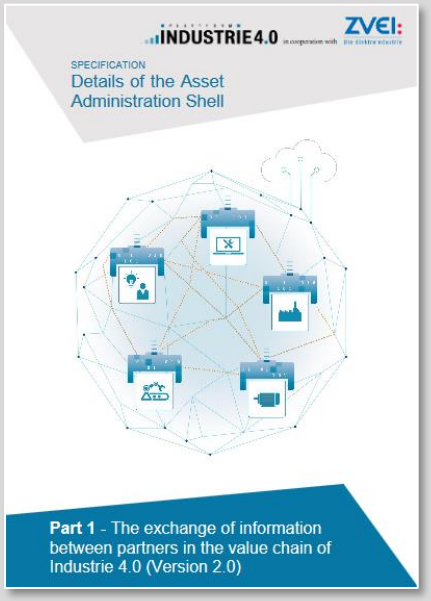
Permission
+ permission: Property*
+ kindOfPermission: PermissionKind

«enumeration»
PermissionKind
allow
deny
not applicable
undefined

allow
Read & Write

Details of the Asset Administration Shell

Summary and outlook

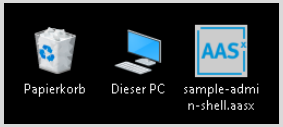


- Developers can *implement* information models directly.
- Information and data can be *exchanged in a package* (file group) from one partner to the next *in a standardized way* (XML, JSON, .aasx).
- Including *OPC UA, AutomationML und RDF mappings*
- *Security aspects* have been considered from the very beginning.
- Upcoming parts of the document series for developers:
  - Interface of the Administration Shell (API)
  - Infrastructure elements like Registry

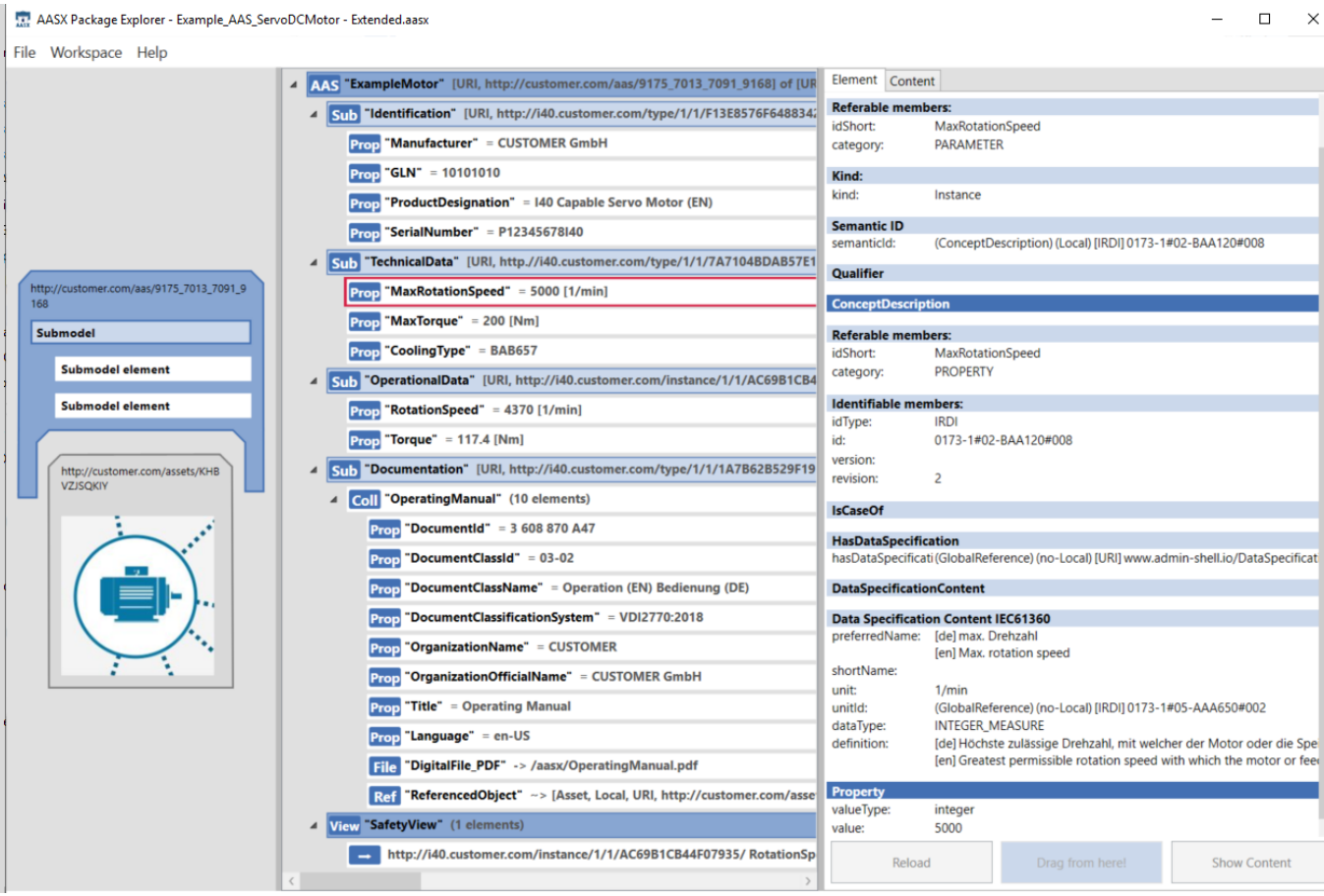
The AASX Package Explorer

A tool that helps software developers to work with the Asset Administration Shell right away

- Exemplary implementation of an Administration Shell that has to be exchanged



- Exemplary Browser and Editor
- Companies can develop their own solutions based on their own business use case.



Download the tool for free: https://github.com/admin-shell/aasx-package-explorer

The Asset Administration Shell
Advantages - Summary

The Asset Administration Shell

- is a generic possibility to compose information for I4.0 use cases.
- can be used for non-intelligent and intelligent products.
- is bridging company and sector borders.
- is scalable and extendable.
- spans all phases of asset lifecylces, from design to operations to maintenance.
- allows for integrated value chains.
- serves as the digital basis for the development of autonomous systems and AI.

An Overview

- Industrie 4.0
  Background: What's new, really?
- The key building block
  Industrie 4.0 component with the Asset Administration Shell
- Asset Administration Shell: An overview
  Current work of Plattform Industrie 4.0
- Details of the Asset Administration Shell
  Basis for practical implementations
- Asset Administration Shell in Specialization
  How to develop your own submodels
- Information and support for SMEs
  Where to find assistance for digital transformation

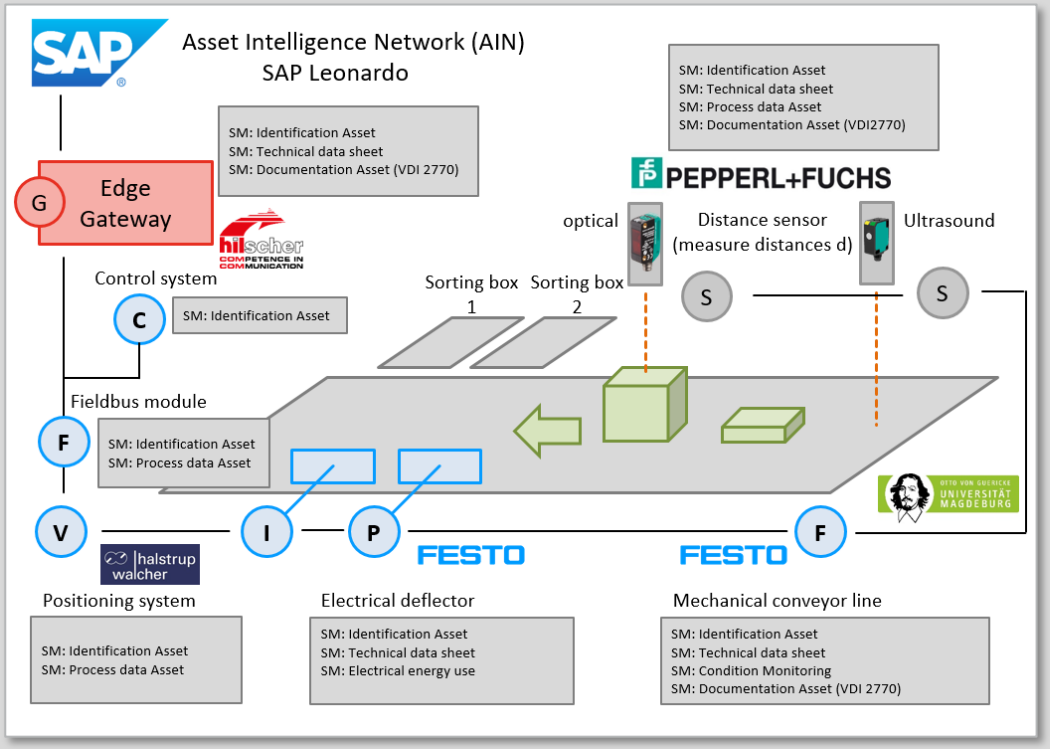
Asset Administration Shell in Specialization
Aim and topics

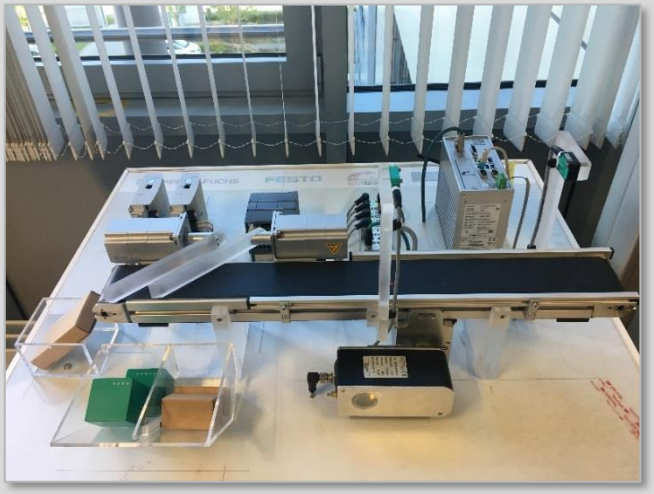
- *Practical implementation* of Asset Administration Shells and submodels
  Starting point: a use case and sample scenario with a clear customer value
- *Specification* of ID, metadata of the Administration Shell and its submodels using submodel elements (e.g. properties)
- *Guideline* for the definition of submodels
- *Definition of basic submodels,* standardised
- *Specification of free submodels,* agreed between two partners
- *Implementation* in a demonstrator

The publication "Verwaltungsschale in der Praxis" (Version 1.0) can be found in the download area at www.plattform-i40.de.

Asset Administration Shell in Specialization

A demonstration





Asset Administration Shell in Specialization

Overview submodels of the example scenario

Component	Specific submodel	Submodel classification
Mechanical conveyor line (Festo)	SM: Identification Asset	Basic submodel optional
	SM: Technical data sheet	Basic submodel optional
	SM: Condition Monitoring (based on motor data and sensor data)	Free submodel
	SM: Documentation in line with VDI 2770	Basic submodel optional
Positioning system (Halstrup & Walcher)	SM: Identification Asset	Basic submodel optional
	SM: Process data	Free submodel
Distance sensor ultrasound (Pepperl & Fuchs)	SM: Identification Asset	Basic submodel optional
	SM: Process data	Free submodel
	SM: Technical data sheet	Basic submodel optional
	SM: Documentation in line with VDI 2770	Basic submodel optional
Distance sensor optical (Pepperl & Fuchs)	SM: Identification Asset	Basic submodel optional
	SM: Process data	Free submodel
	SM: Technical data sheet	Basic submodel optional
	SM: Documentation in line with VDI 2770	Basic submodel optional
Electrical deflector 1 (Festo)	SM: Identification Asset	Basic submodel optional
	SM: Technical data sheet	Basic submodel optional
	SM: Point-to-point movement, rotative	Free submodel
	SM: Electrical energy use	Free submodel
Electrical deflector 2 (Festo)	SM: Identification Asset	Basic submodel optional
	SM: Technical data sheet	Basic submodel optional
	SM: Point-to-point movement, rotative	Free submodel
	SM: Electrical energy use	Free submodel
Net Iot Edge Gateway (Hilscher)	SM: Identification Asset	Basic submodel optional
	SM: Technical data sheet	Basic submodel optional
	SM: Topology detection	Free submodel
	SM: Documentation in line with VDI 2770	Basic submodel optional

Asset Administration Shell in Specialization
Outlook

PHASE 1

Implementation of the **structure of the Administration Shell**; the possibilities of the Administration Shell are also shown for passive components (process data).

PHASE 2

Interaction of Administration Shells: The Administration Shell of the sorting machine communicates with its customers via an I4.0 language and thus independently optimises the processing of orders – without a leading system. The failure rate is minimized. The demonstrator shows Industrie 4.0 communication where the **components act independently**.

Implementation of described Administration Shells and submodels → Communication between Administration Shells → Independently operating Industrie 4.0 components without central control

An Overview

- Industrie 4.0
  Background: What's new, really?
- The key building block
  Industrie 4.0 component with the Asset Administration Shell
- Asset Administration Shell: An overview
  Current work of Plattform Industrie 4.0
- Details of the Asset Administration Shell
  Basis for practical implementations
- Asset Administration Shell in Specialization
  How to develop your own submodels
- Information and support for SMEs
  Where to find assistance for digital transformation

Information and support ONLINE

Digital transformation: Where to find assistance

INSPIRATION

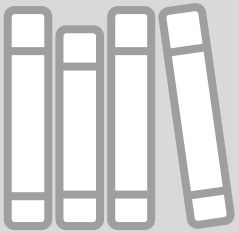
Map

More than **350 use cases** of **large and small companies** in a broad range of industrial sectors.

https://www.plattform-i40.de/PI40/Navigation/EN/Services-Results/Industrie-4-0-Map/industrie-4-0-map.html

FIRST STEPS

Library



More than **140 publications of Plattform Industrie 4.0 & partners:**

- Working papers
- Roadmaps
- Guidelines
- Discussion papers
- etc.

https://www.plattform-i40.de/SiteGlobals/PI40/Forms/Listen/Downloads/EN/Downloads_Formular.html?cl2Categories_Typ_name=veroeffentlichung

SUPPORT

Compass

Overview of more than 120 support services:

- Workshops
- Events
- Contact details of testbeds in Germany
- Competence centres
- etc.

https://www.plattform-i40.de/PI40/Navigation/DE/Angebote-Ergebnisse/Kompass/kompass.html

Plattform Industrie 4.0
Platform's Project Office

Plattform Industrie 4.0
Geschäftsstelle
Bülowstraße 78
D-10783 Berlin
Tel.: +49 30 2759 5066-50
geschaeftsstelle@plattform-i40.de

www.plattform-i40.de/en