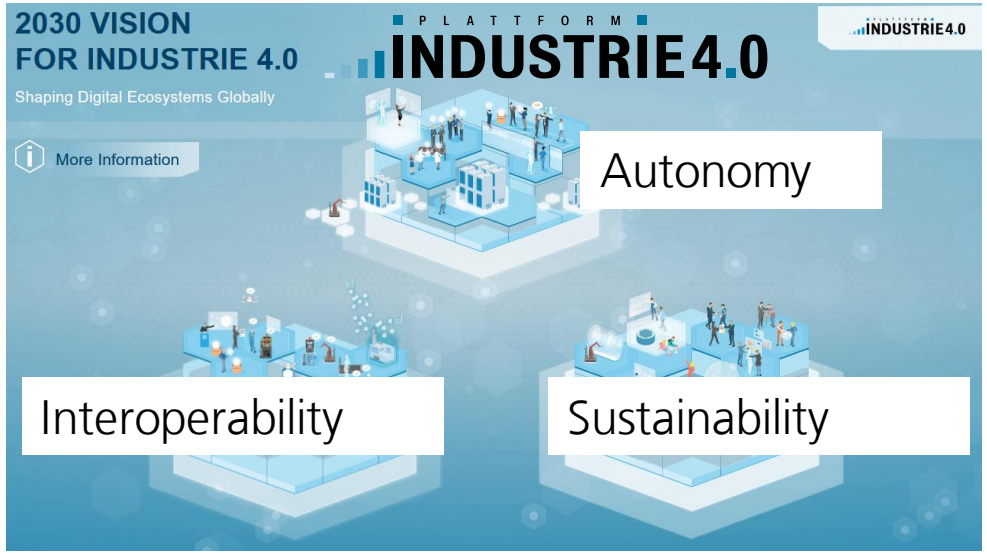
13.06.2023

IDS-I Community: Digital Twin AAS standard enhanced with Data Spaces

DataWeek 2023, Luleå, Sweden

Dr. Ljiljana Stojanovic, Fraunhofer IOSB

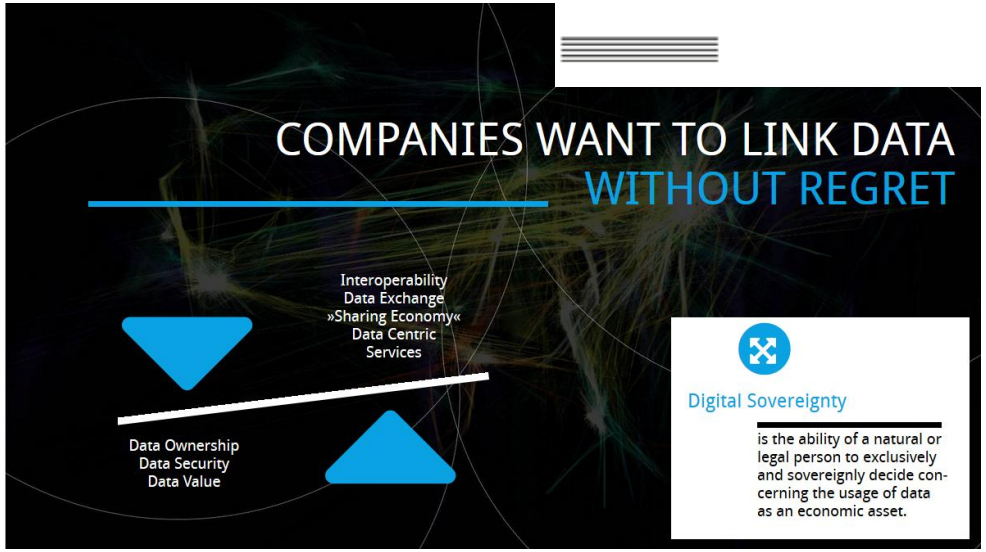
Motivation



Communication and interaction between networked assets in a smart factory and/or supply chain across their whole life cycle

→ Security focus on secure communication
and
access control to assets

INTERNATIONAL DATA SPACES ASSOCIATION



Data sovereignty

→ Security focus on data usage control
and provenance tracking

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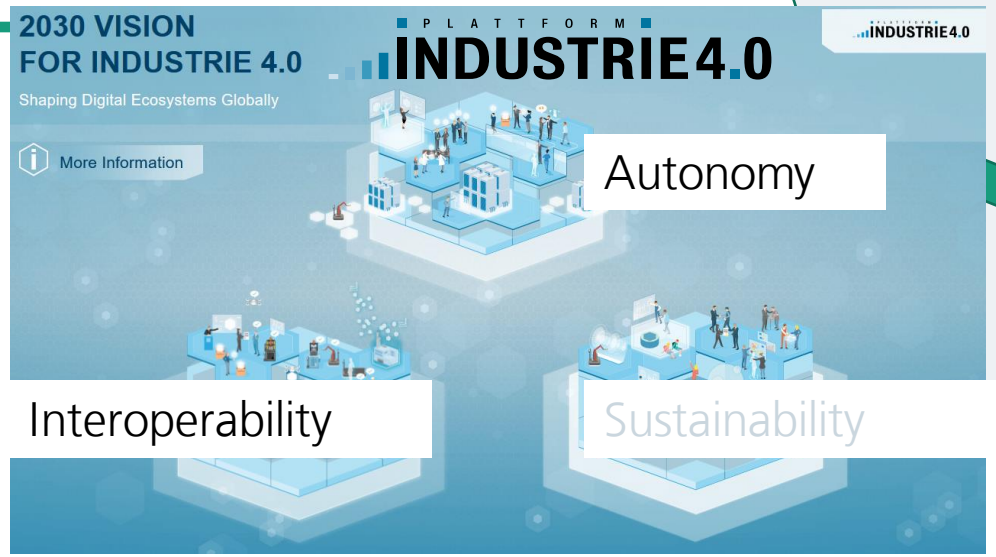
Motivation



gaia-x

INTERNATIONAL DATA SPACES ASSOCIATION

Industrial Production

Application Domains

requirements

validation

I4.0 Solutions	*interoperability*	IDS Solutions
I4.0 Specifications	*compatibility*	IDS Specifications
Reference Architecture Model Industrie 4.0 (RAMI4.0)	*co-existence*	Reference Architecture Model (IDS-RAM)

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The IDS Industrial Community (IDS-I)

- The mission of the IDS-Industrial Community is to enable
  - the **design**,
  - **set-up** and
  - **operation**

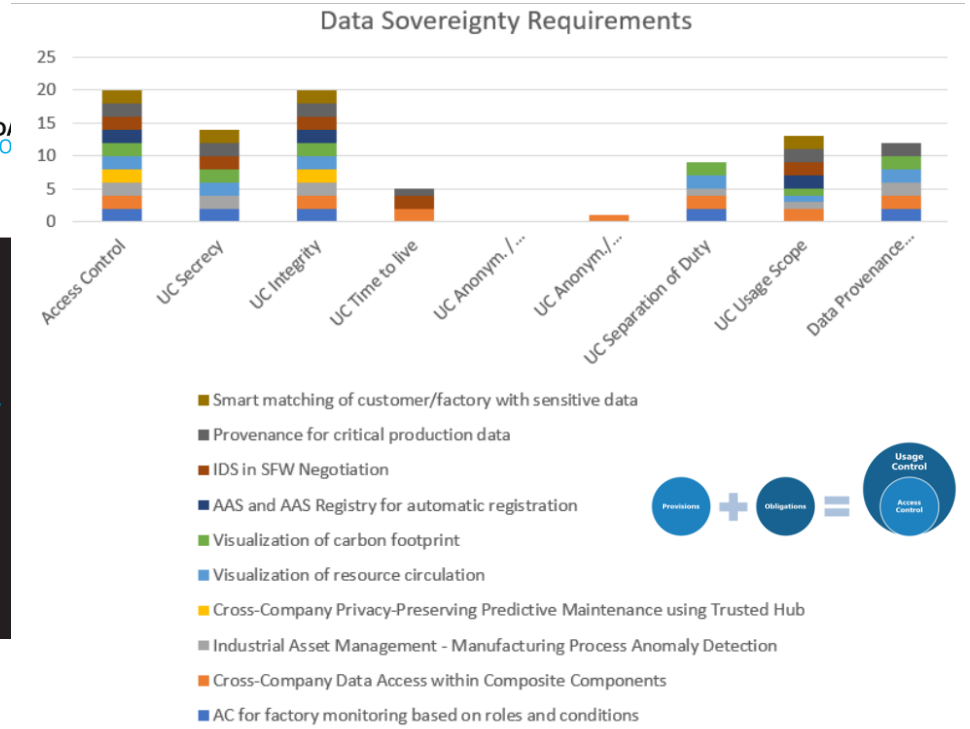
  of International Data Spaces tailored to the needs of the application domain of **industrial production resp. smart manufacturing**
- Bridge the gap between the initiatives IDSA, Plattform Industrie 4.0 and GAIA-X

- Establish in Mai 2020
- Co-Chairs:
  - Dr.-Ing. Thomas Usländer (Fraunhofer IOSB)
  - Andreas Teuscher (SICK AG)
  - Dr. Ljiljana Stojanovic (Fraunhofer IOSB) since 09/22
- Participants:
  - Almost 100 members mainly from Europe
- Meetings:
  - Quarterly or on demand

Series of IDS-I Position Papers

Instead of one „Conceptual Paper“ → Series of IDS-I Position Papers

#1, April 2021



Position paper #3, work in progress

Data Sovereignty Architectures for Manufacturing Use Cases
- IDS, Industrie 4.0 and GAIA-X

→ End 2023 – Demonstrator showing synergy between relevant concepts from three different initiatives

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Asset Administration Shell (AAS)

- Implementation of the Digital Twin for Industry 4.0
- An AAS is a logical representation of an asset
  - It integrates the asset into Industrie 4.0 communication
  - It is addressable in the network and identifies the asset unambiguously
  - It provides a controlled access to all information of the asset
  - It provides the standardized interfaces
- It covers the complete life cycle of products, devices, machines and facilities

https://www.iosb.fraunhofer.de/servlet/is/81724/

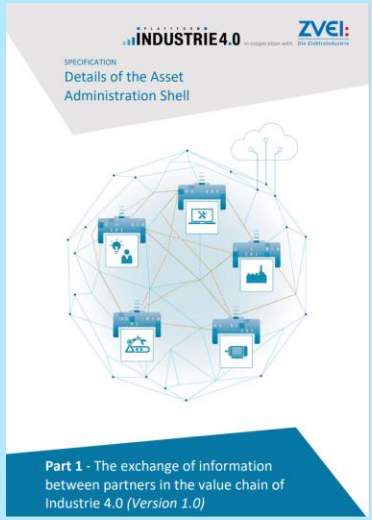
Current state of the specifications

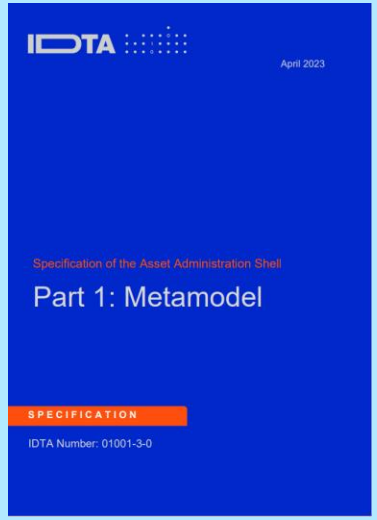
Main drivers

- Plattform Industrie 4.0 (https://www.plattform-i40.de)
- Since 2021 also the IDTA (Industrial Digital Twin Association) (https://industrialdigitaltwin.org/content-hub/downloads)

Key document

Details of the Asset Administration Shell – Part 1 - Metamodel



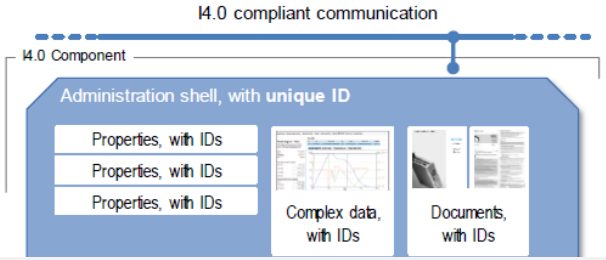


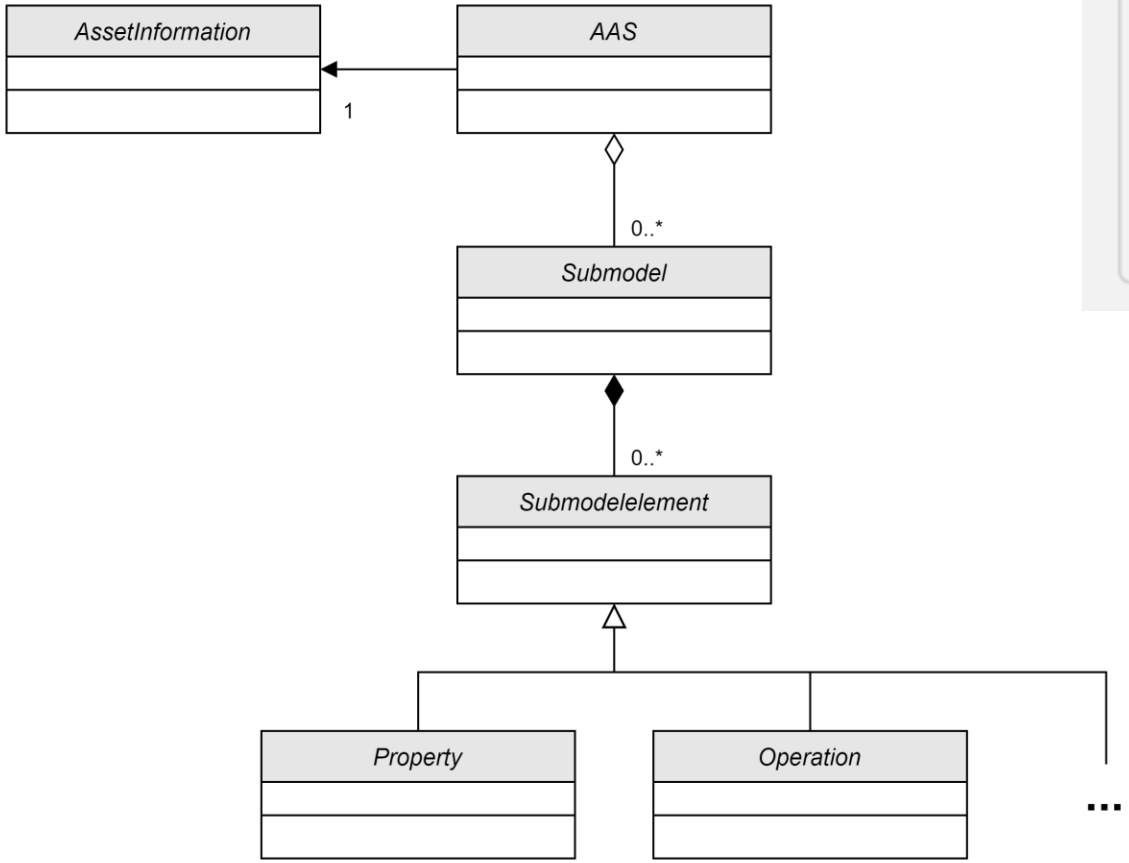
Version 1 Nov 2018 | Version 2 Nov 2019 | Version 3 Apr 2023

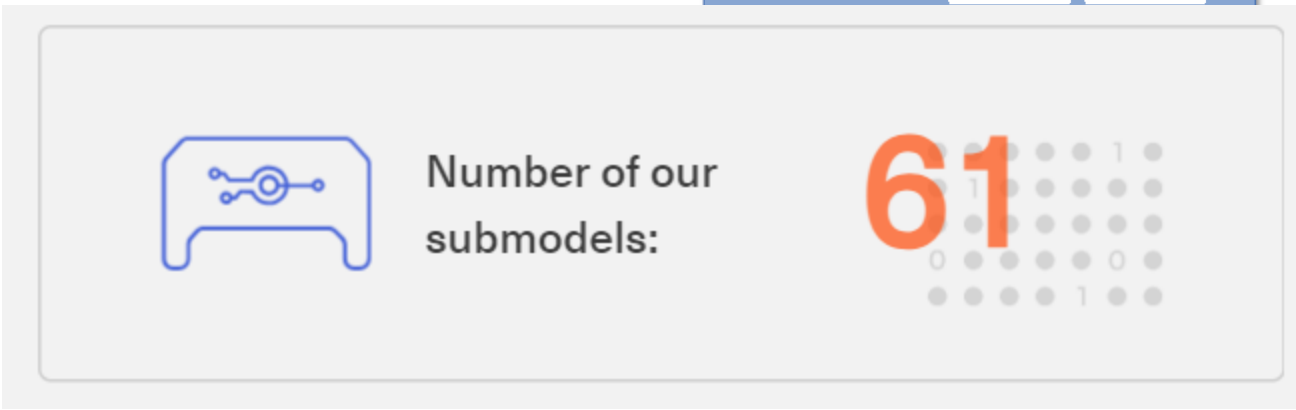
Additional documents

- Part 2: Application Programming Interfaces (Version 3 Apr 2023)
- Part 3a – Data Specification (Version 3 Apr 2023)
- Part 5 – Package File Format AASX (Version 3 Apr 2023)

AAS meta-model and submodels



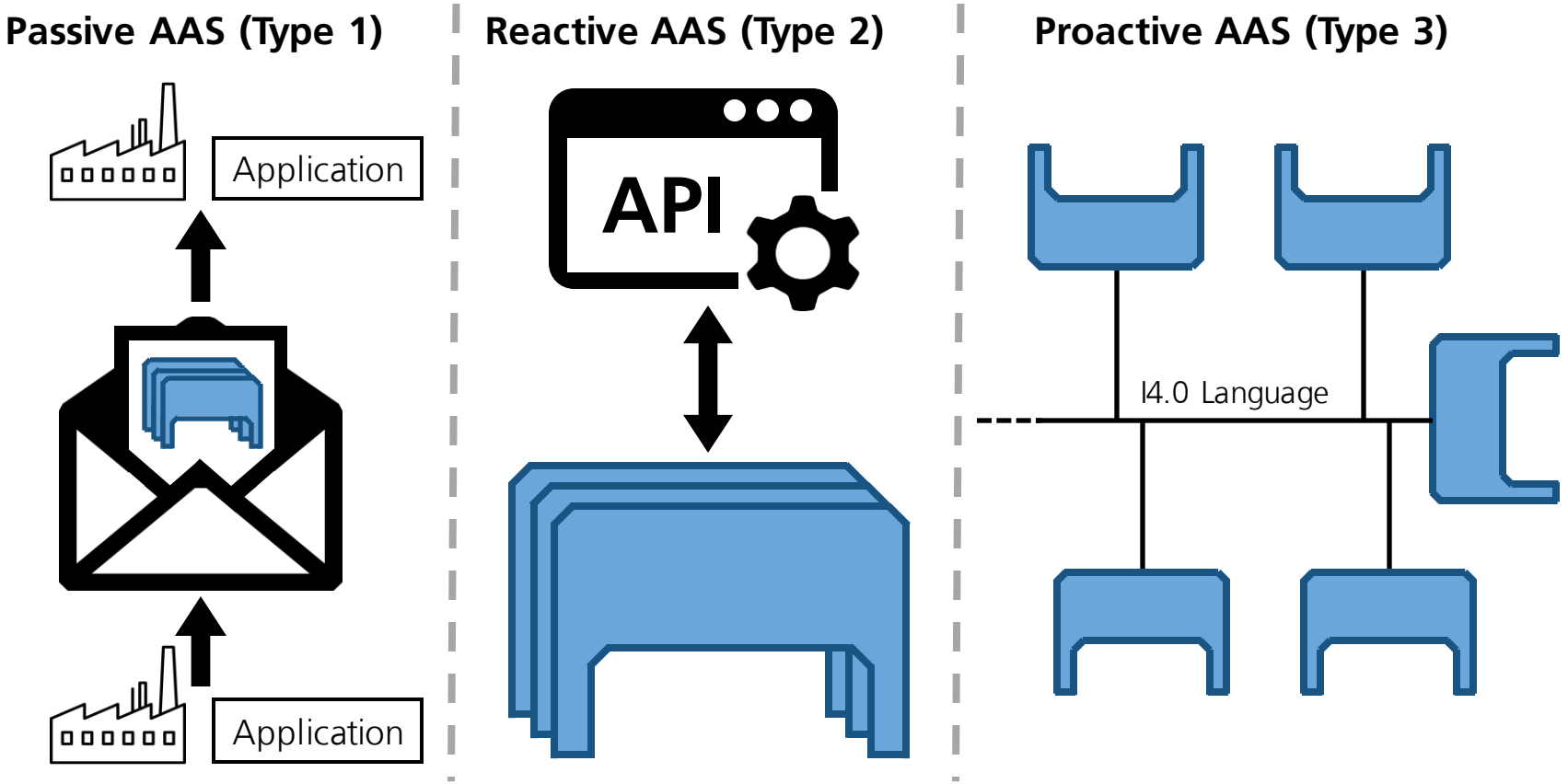




- An AAS consists of **various submodels**, each of which represents a specific aspect or feature of the asset
- **An AAS submodel template** is a predefined structure or schema that defines the format and content of an AAS submodel
- It is designed to provide **a standardized way** of representing a specific aspect of an asset or system

Different AAS Types

- **Type 1: Passive**
  Exchange standardized files
- **Type 2: Reactive**
  Read/Write via standardized API
- **Type 3: Proactive**
  Autonomous communication via standardized I4.0 languages



Open-Source AAS Implementations

Jacoby, M.; Baumann, M.; Bischoff, T.; Mees, H.; Müller, J.; Stojanovic, L.; Volz, F. Open-Source Implementations of the Reactive Asset Administration Shell: A Survey. *Sensors* **2023**, *23*, 5229. https://doi.org/10.3390/s23115229

	AASX Server	Eclipse BaSyx	FA³ST Service	NOVAAS
General Criteria				
Main Contributors	Phoenix Contact Zurich University of Applied Sciences Fraunhofer IOSB-INA Festo SE & Co. KG	Fraunhofer IESE objective partner AG	Fraunhofer IOSB	NOVA School of Science and Technology
License	Apache v2.0	MIT	Apache v2.0	EUPL v1.2
Programming Language	C#	Java		
Usage				
CLI	✓	✓		
Docker	✓	✓		
Embedded	-	✓		
AAS-Specific Criteria				
Metamodel Version	v2 / v3*	v2		
Model Format				
AASX	✓	✓		
JSON	(✓)	✓		
XML	(✓)	✓		
RDF	-	-		
API Interfaces				
AAS Repository	- / ✓*	✓		
AAS	(✓) / ✓*	✓		
SM Repository	- / ✓*	-		
SM	(✓) / ✓*	(✓)		
CD Repository	-	-		
AAS Serialization	- / ✓*	-		
AAS Basic Discovery	- / ✓*	-		
AASX File Server	(✓) / ✓*	-		
Descriptor	-	-		
API Protocols				
HTTP	✓	✓		
OPC UA	✓	-		

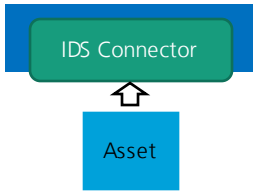
* only in undocumented API † via custom coding

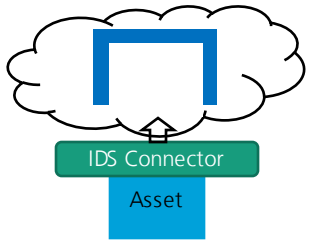
	AASX Server	Eclipse BaSyx	FA³ST Service	NOVAAS
Implementation-specific Criteria				
Asset Synchronization				
HTTP				
Read	-	✓◇	✓	(✓)†
Write	-	(✓)†	✓	-
Execute	-	✓†,◇	✓	-
OPC UA				
Read	✓	(✓)†,△	✓	(✓)†
Write	-	(✓)†	✓	-
Execute	-	(✓)†	✓	-
Subscribe	(✓)	(✓)†,△	✓	-
MQTT				
Write	-	(✓)†	✓	-
Subscribe	-	(✓)†,△	✓	-
Data Persistence				
In-Memory	✓	✓	✓	✓
File	-	(✓)†	✓	-
Database	-	✓	-	-
Security	(✓)	✓	-	(✓)
Other Features	Publish value changes via MQTT	Publish any changes via MQTT Custom extensions via feature-decorators	Parallel synchronized end-points Open Architecture	No/Low-code approach Publish value changes via MQTT
Ecosystem Criteria				
Client Library	(✓)	✓	-	-
Model Editor	✓	-	-	-
Model Validation	-	(✓)	✓	-
Registry	(✓)	✓	-	-
Visualization	✓	✓	-	✓
Other	Integrated with AASX Package Explorer XLS Parser	DataBridge UI Plugin Mechanism KeyCloack Integration†	Eclipse Dataspace Connector v2 Model Converter	Dashboard KeyCloak Integration

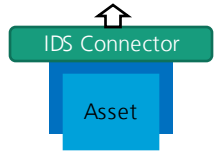
* only in undocumented API † via custom coding ◇ via delegation △ via DataBridge

How to integrated an AAS with an IDS connector?

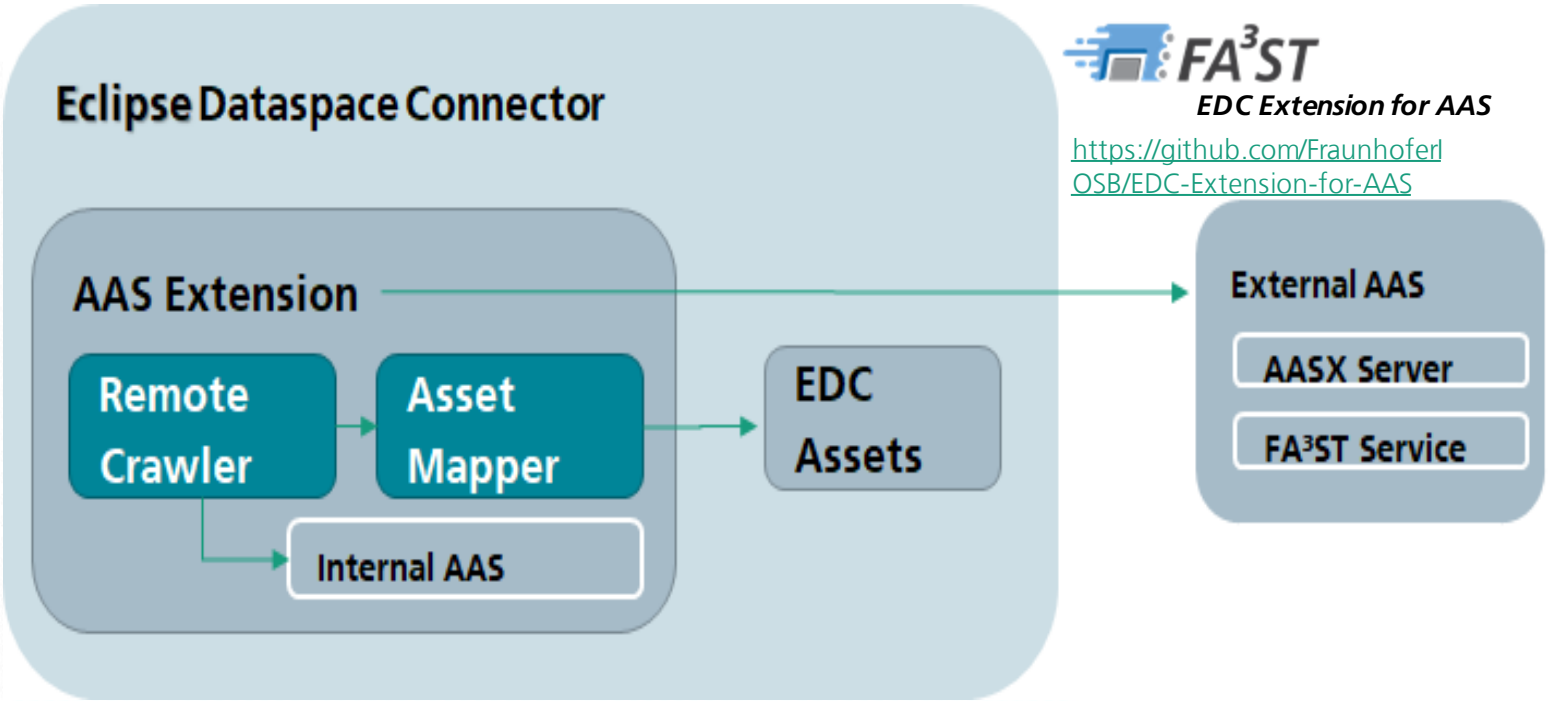
- **Different possibilities for integration**







- **Several solutions already available**
  - Basyx
  - Mondragon
  - FA³ST: EDC AAS Extension
  - Etc.



FA³ST
EDC Extension for AAS
https://github.com/FraunhoferIOSB/EDC-Extension-for-AAS

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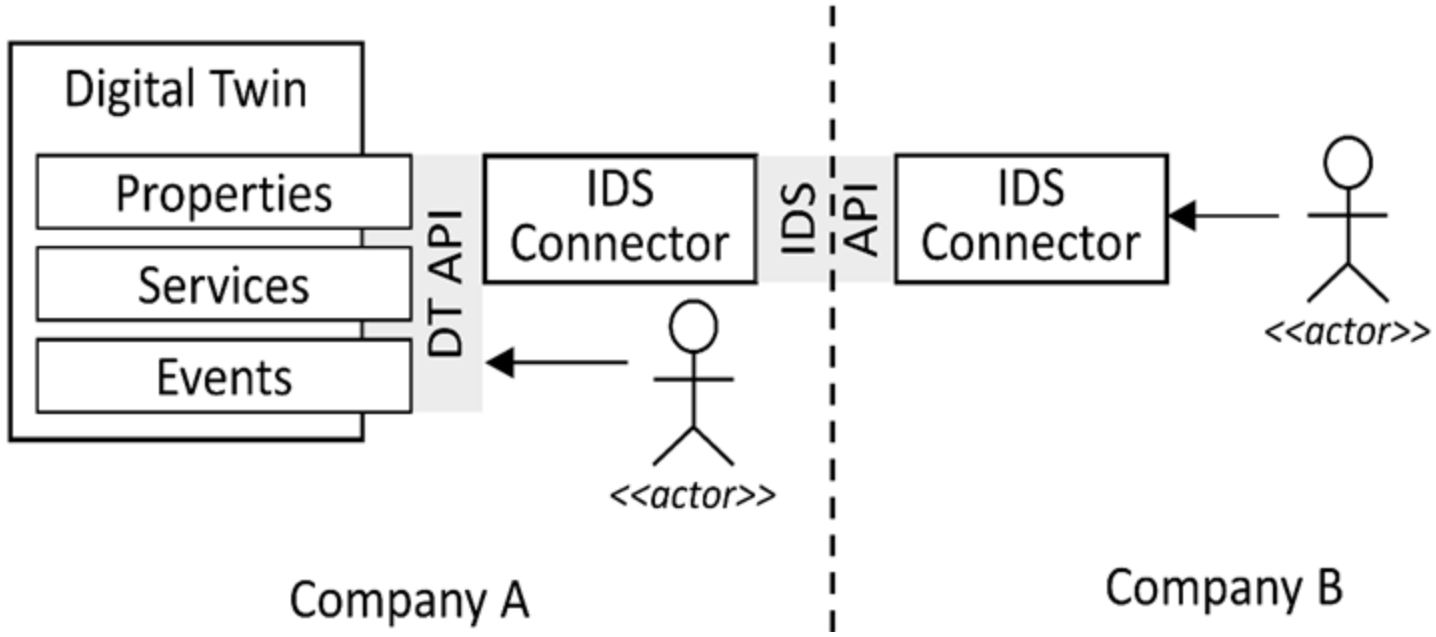
How can the existing solutions be generalized and made interoperable?

- Support SMEs so they can use AAS and an IDS connector without effort
- Support integration of the existing AAS implementations like Basyx, AASX Server, FA³ST Service with different connectors (EDC, TRUE, etc.)
- Apply the same approach to other components, e.g. IDS broker, AAS register, GAIA-X federated catalog



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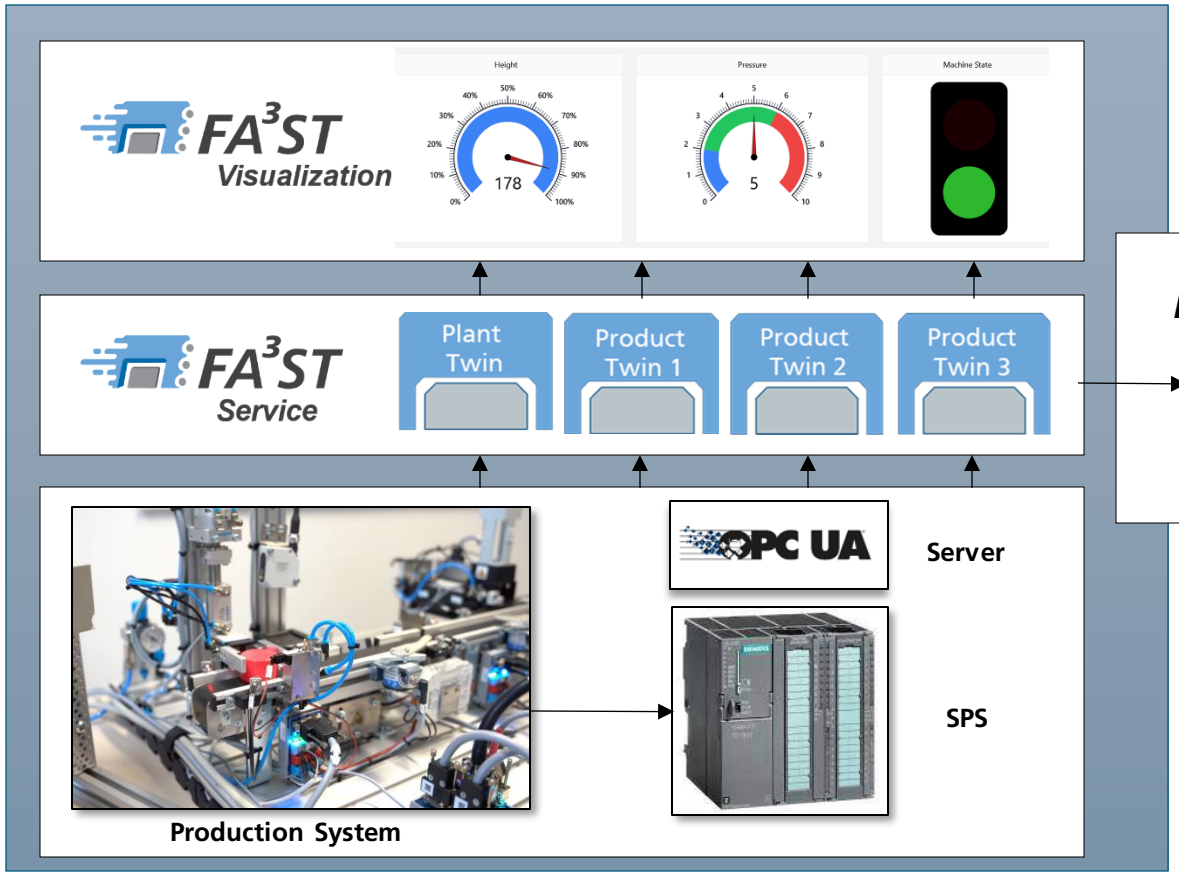
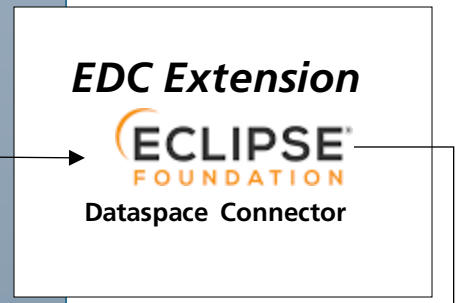
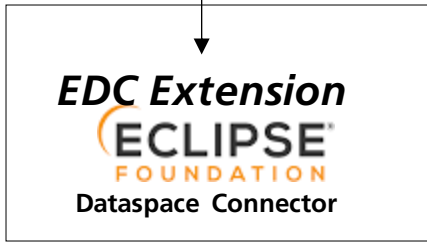
Demonstrator: Minimal-viable Dataspace

- Connect demo in Karlsruhe with a demo in Dortmund to test EDC Extension for AAS across different locations
- Collaborative condition monitoring & product-carbon footprint (DPP)
- Toolbox to help SMEs experiment with DT-aware, circular dataspaces







Machine Manufacturer

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