



# Smart Factory Web Testbed - overview

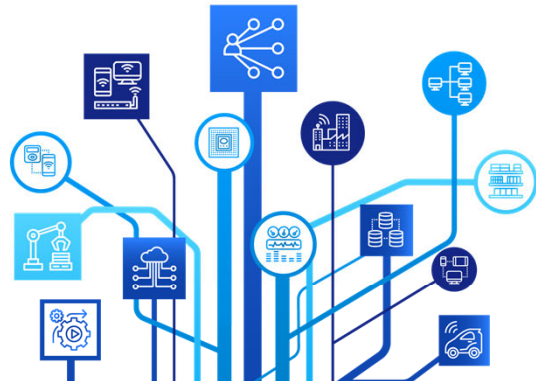
Team:

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Microsoft: Erich Barnstedt, Ron Zahavi

SAP: Erich Clauer, Sven Toothman



September 16, 2021

Presenter: Kym Watson, [kym.watson@iosb.fraunhofer.de](mailto:kym.watson@iosb.fraunhofer.de)

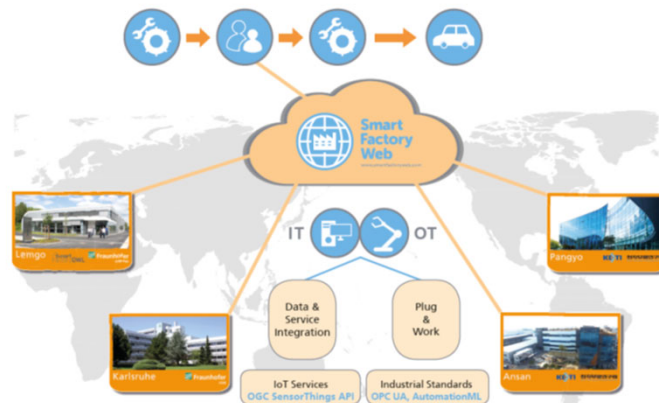
## IIC Testbed Smart Factory Web: Goals



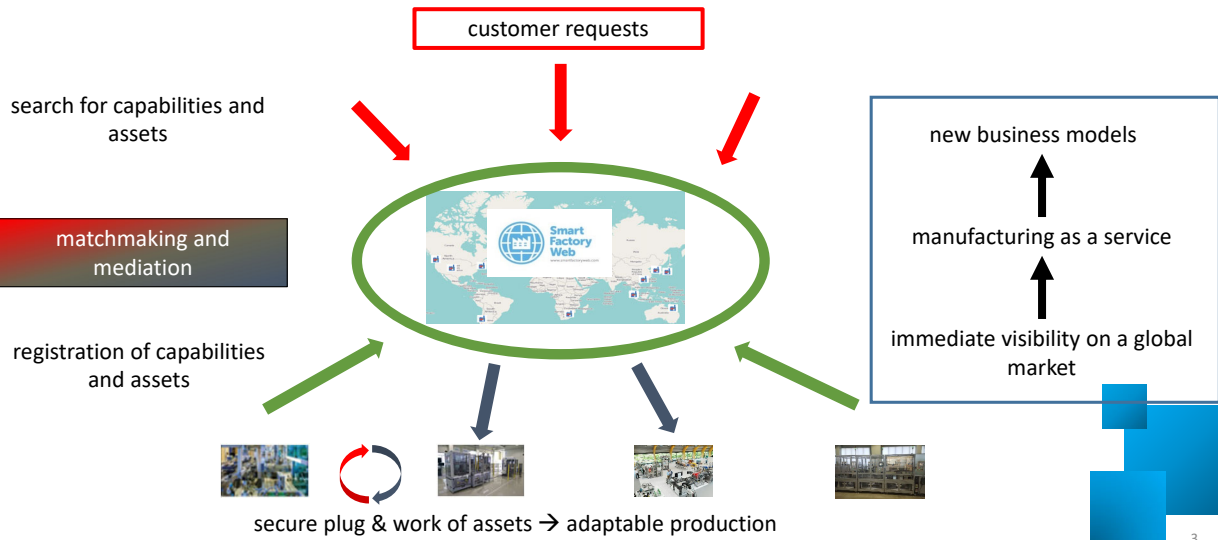
- Flexible adaptation of production capabilities and sharing of resources/assets in a web of Smart Factories to improve order fulfillment
- Provide the technical basis for new business models with flexible assignment and sharing of production resources

**Sponsors**

**Testbed participants:**



# Towards a Marketplace for Manufacturing

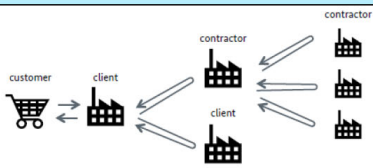


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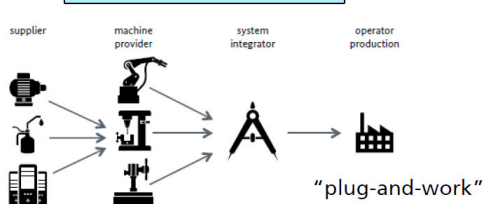
# Combination of Industrie 4.0 Application Scenarios



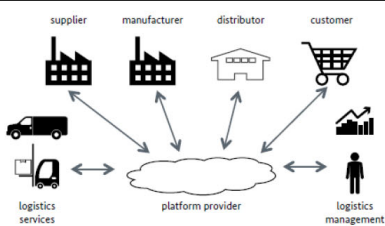
## OCP – Order-Controlled Production



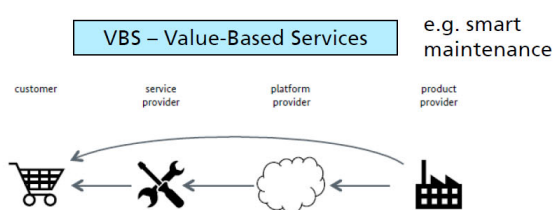
## AF – Adaptable Factory



## SAL – Self-organising Adaptive Logistics

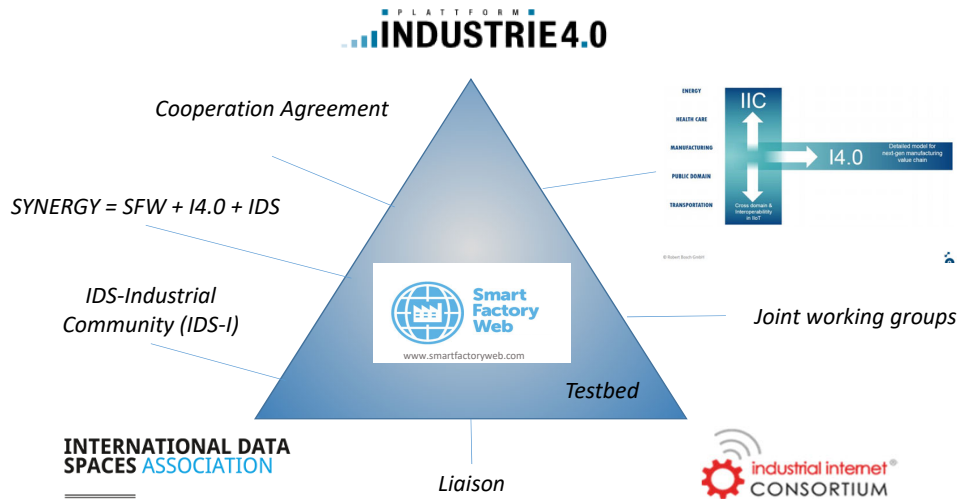


## VBS – Value-Based Services



Source: Plattform Industrie 4.0

# Smart Factory Web (SFW) as joint testbed across initiatives



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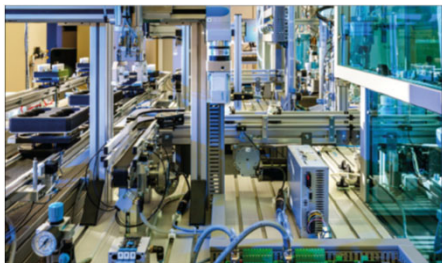
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# Model factories of Fraunhofer IOSB



Members of LNI4.0 LABS NETWORK INDUSTRIE 4.0

R&D projects and training for industry



IOSB, Karlsruhe

Source: Fraunhofer IOSB

© Fraunhofer IOSB, 2017



Source: Fraunhofer IOSB

SmartFactoryOWL, Lemgo

An initiative of Fraunhofer IOSB-INA and Hochschule OWL

Customer specific and versatile production facilities for filling, assembly, packaging

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# Model factories of KETI in Korea



Manufacturing Industry  
Innovation 3.0



**Pangyo Model Factory**

© KETI 2018; Source: KETI



**ANSAN Model Factory**  
Smart Manufacturing Innovation Center (SMIC)

Process of testing, evaluating, and integrating key technologies required for manufacturing innovation

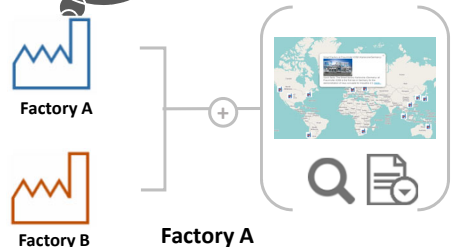


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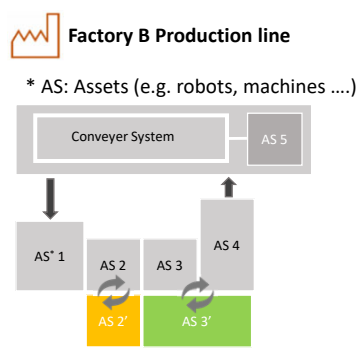
# Usage Scenario and View: Order driven, flexible adaption of production value chains



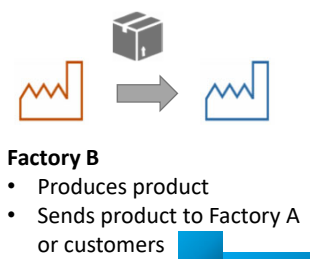
I need more production lines since my factory is running at full capacity with customer orders



- Factory A**
- Check the status of other factories
  - Find an available Factory B
  - Place an order with specific requirements via the SFW portal

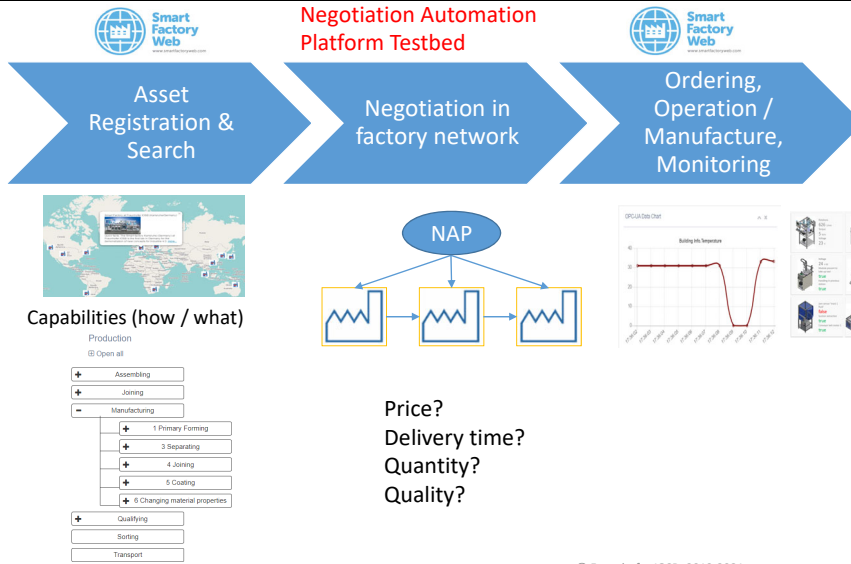


- Factory B**
- Check its production status
  - If OK, adapt production assets of Factory B by secure Plug & Work techniques
- replace AS 2 and 3&4 with AS 2' and AS 3'**



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# Smart Factory Web Workflow in 3 Steps



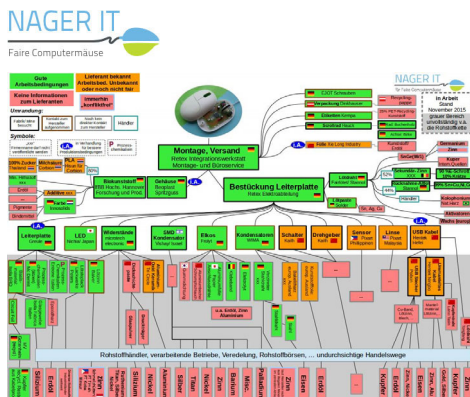
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# Inclusion of supply chains



(1) Make supply chains transparent e.g. following fair trade principles

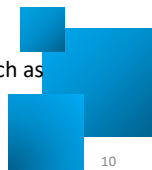


Source: <https://www.nager-it.de/en/maus/lieferkette>

A collection of cards providing information about fair trade, including questions like 'Was ist Fairer Handel?', 'Wer produziert fair?', 'Wer handelt fair?', 'Und ich?', and 'GEPA®'. It also features images of people and products like coffee and chocolate.

Source: <https://www.fairtrade.de/index.php/mID/1.2/lan/de>

(2) Risk management to quickly adapt to events such as natural disasters, diseases, political unrest or trade uncertainties



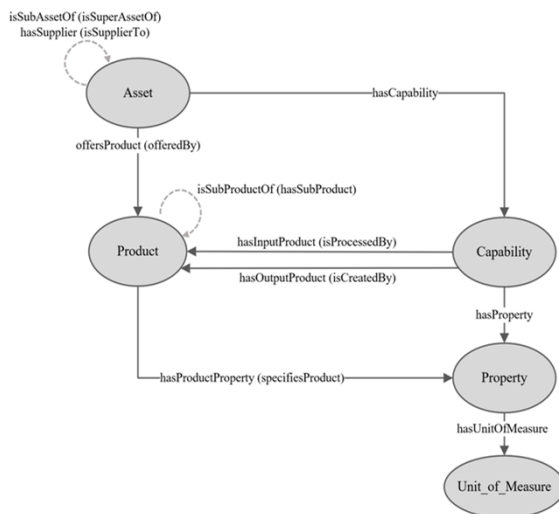
# Supply chain visualization



Source: <https://www.nager-it.de/en/maus/lieferkette>

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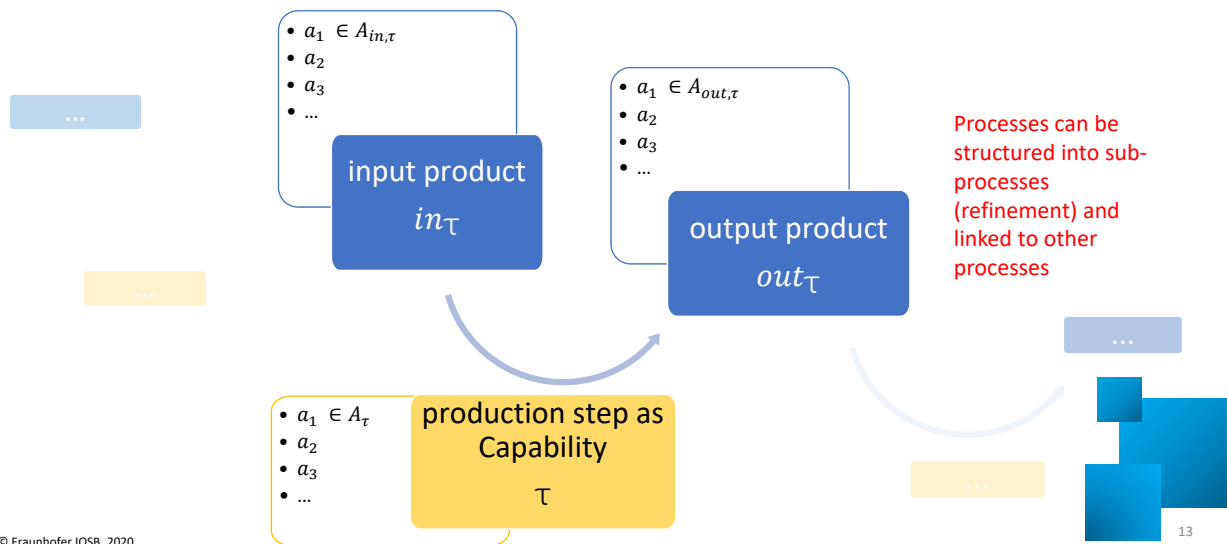
# Core of Smart Factory Web Ontology



- described in terms of
- how the product can be produced (process properties)
  - input and output products and their respective properties

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## General representation of production process



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## SFW Platform Web Services



- Get SFW Capabilities, Properties and Units
- Factory registration
- Factory search

Pay loads of all web services are JSON data structures

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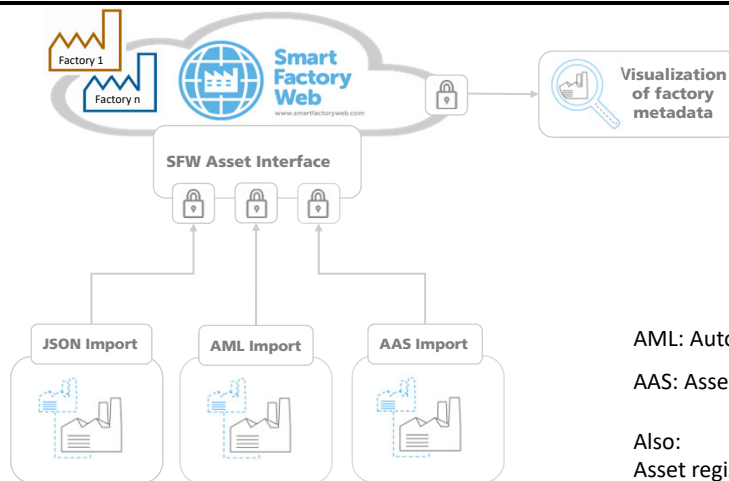
## Get capabilities, properties and units



```

1  {
2    "SFW-Capabilities": [
3      {
4        "Name": "Heating",
5        "WgConceptId": "87938",
6        "Properties": [
7          {
8            "Name": "Material",
9            "Unit": [],
10           "WgConceptId": "154"
11          },
12          {
13            "Name": "Temperature",
14            "Unit": [
15              "(1047) degC",
16              "(106237) degF",
17              "(106236) degK"
18            ],
19            "WgConceptId": "190"
20          }
21        ]
22      },
23      {
24        "Name": "Filling",
25        "WgConceptId": "191",
26        "Properties": [
27          {
28            "Name": "Duration",
29            "Unit": [
30              "(105568) s",
31              "(105569) min",
32              "(105570) h",
33              "(105571) d"
34            ],
35            "WgConceptId": "98381"
36          }
37        ]
38      }
39    ]
40  }
    
```

## Factory registration



Import assets and sub-assets including production process data

AML: AutomationML

AAS: Asset Administration Shell

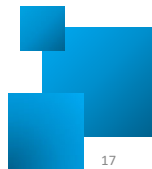
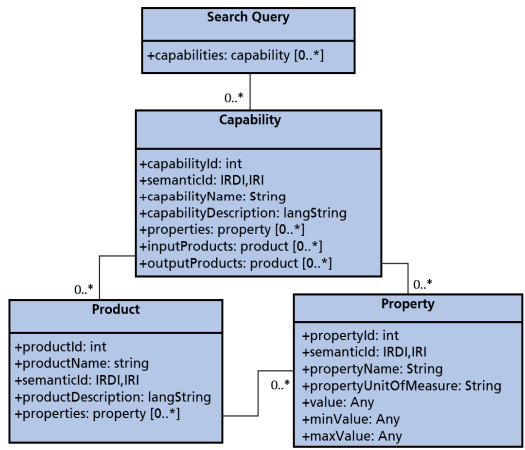
Also:  
Asset registration via web forms



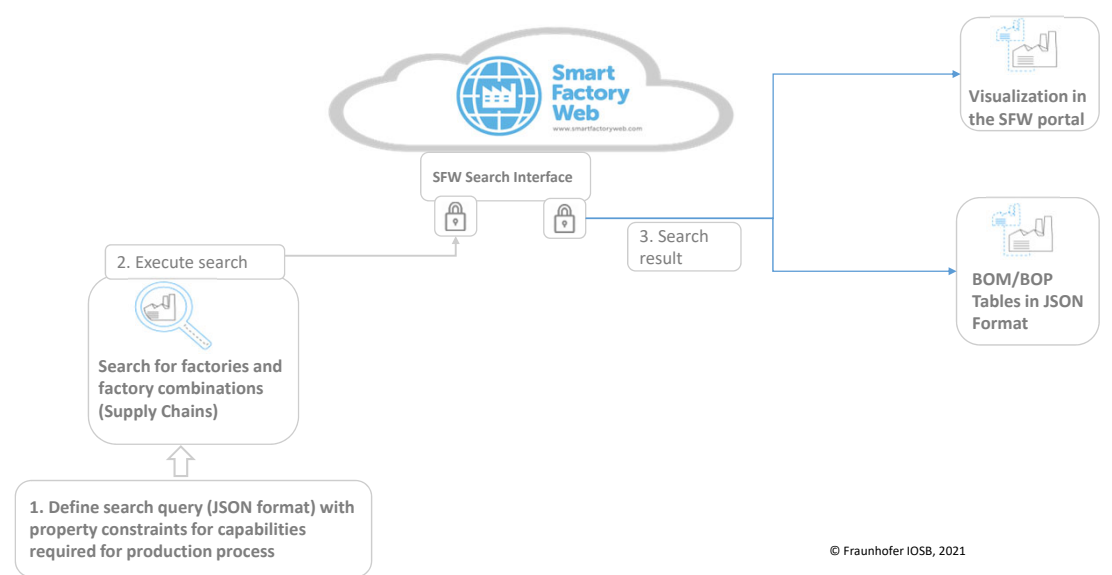
# SFW Search Interface



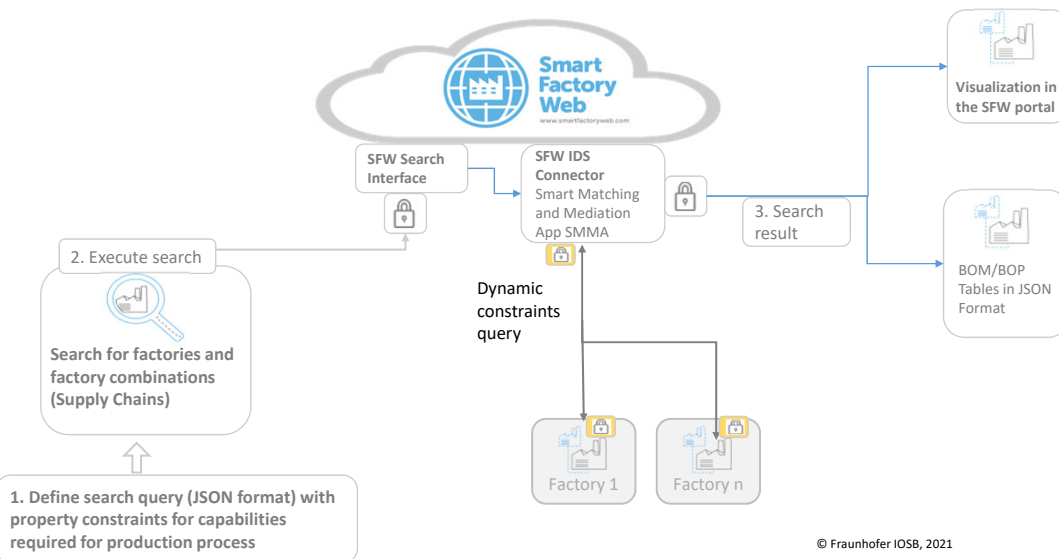
## Smart Factory Web – Search Query Specification



# SFW factory search (basic)



## SFW factory search (advanced)



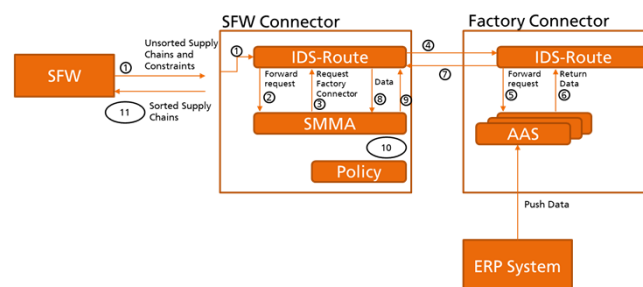
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## Deep dive: Smart Matching and Mediation App (SMMA)



- Developed by Fraunhofer IOSB in EU H2020 project EUR3KA
  - European Vital Medical Supplies and Equipment Resilient and Reliable Repurposing Manufacturing as a Service Network for Fast PAndemic Reaction
  - <https://www.eur3ka.eu>; duration 12/2020 – 11/2022
- Combines concepts / technologies from SFW, PI4.0 AAS and IDS Trusted Connector



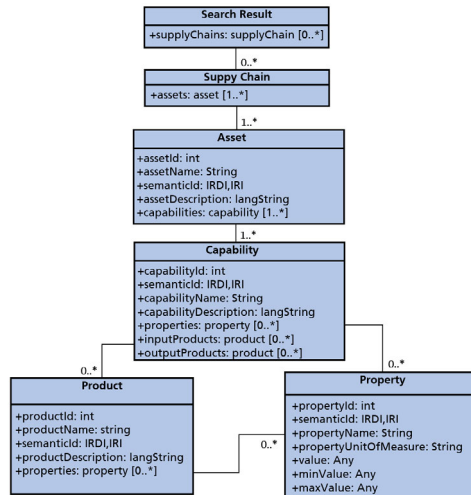
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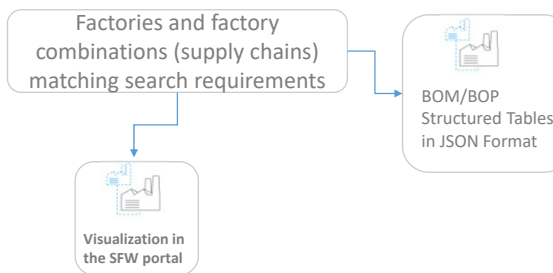
# SFW Search Result



## Smart Factory Web – Search Result Specification



# Search result example



<p><b>Meltblown-Vlies Supplier</b> Heating (Input: Polycarbonate) (Output: Fibers) Blowing (Input: Fibers) (Output: Meltblown-Vlies)</p>	<p><b>Mask-Clip Supplier</b> Banding (Input: Vlies) (Output: MaskClip)</p>	<p><b>FFP2 Manufacturer Karlsruhe</b> Cutting (Input: StoffsBand) (Output: ElastischBand (FFP2 kompatibel)) Stamping (Input: MaskClip, Meltblown-Vlies) (Output: StoffsBandMask) Gluing (Input: StampedMask, ElastischBand) (Output: FFP2-Mask)</p>
--	--	---

```

1  | 1  | 2  | 3  |
2  | 4  | 5  | 6  |
3  | 7  | 8  | 9  |
4  | 10 | 11 | 12 |
5  | 13 | 14 | 15 |
6  | 16 | 17 | 18 |
7  | 19 | 20 | 21 |
8  | 22 | 23 | 24 |
9  | 25 | 26 | 27 |
10 | 28 | 29 | 30 |
11 | 31 | 32 | 33 |
12 | 34 | 35 | 36 |
13 | 37 | 38 | 39 |
14 | 40 | 41 | 42 |
15 | 43 | 44 | 45 |
16 | 46 | 47 | 48 |
17 | 49 | 50 | 51 |
18 | 52 | 53 | 54 |
19 | 55 | 56 | 57 |
20 | 58 | 59 | 60 |
21 | 61 | 62 | 63 |
22 | 64 | 65 | 66 |
    
```

```

"supplyChains": [
  {
    "FactoryName": "Factory1",
    "FFWFactoryId": "",
    "FactoryImage": "",
    "Capabilities": [
      {
        "Name": "Cap1"
      },
      {
        "Name": "Cap2"
      },
      {
        "Name": "Cap3"
      }
    ]
  },
  {
    "FactoryName": "Factory2",
    "FFWFactoryId": "",
    "FactoryImage": "",
    "Capabilities": [
      {
        "Name": "Cap1"
      }
    ]
  },
  {
    "FactoryName": "Factory3",
    "FFWFactoryId": "",
    "FactoryImage": "",
    "Capabilities": [
      {
        "Name": "Cap2"
      }
    ]
  },
  {
    "FactoryName": "Factory4",
    "FFWFactoryId": "",
    "FactoryImage": "",
    "Capabilities": [
      {
        "Name": "Cap3"
      }
    ]
  },
  {
    "FactoryName": "Factory2",
    "FFWFactoryId": "",
    "FactoryImage": "",
    "Capabilities": [
      {
        "Name": "Cap1"
      }
    ]
  },
  {
    "FactoryName": "Factory5",
    "FFWFactoryId": "",
    "FactoryImage": "",
    "Capabilities": [
      {
        "Name": "Cap2"
      },
      {
        "Name": "Cap3"
      }
    ]
  }
]
    
```

Factory 1	Cap1, Cap 2, Cap 3
-----------	--------------------------

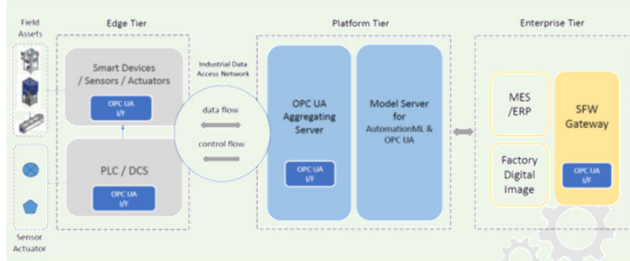
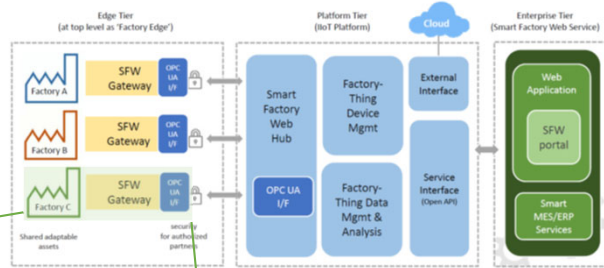
Factory 2	Cap1
Factory 3	Cap2
Factory 4	Cap 3

Factory 2	Cap1
Factory 5	Cap2, Cap3

# Implementation View: Testbed Architecture Planes



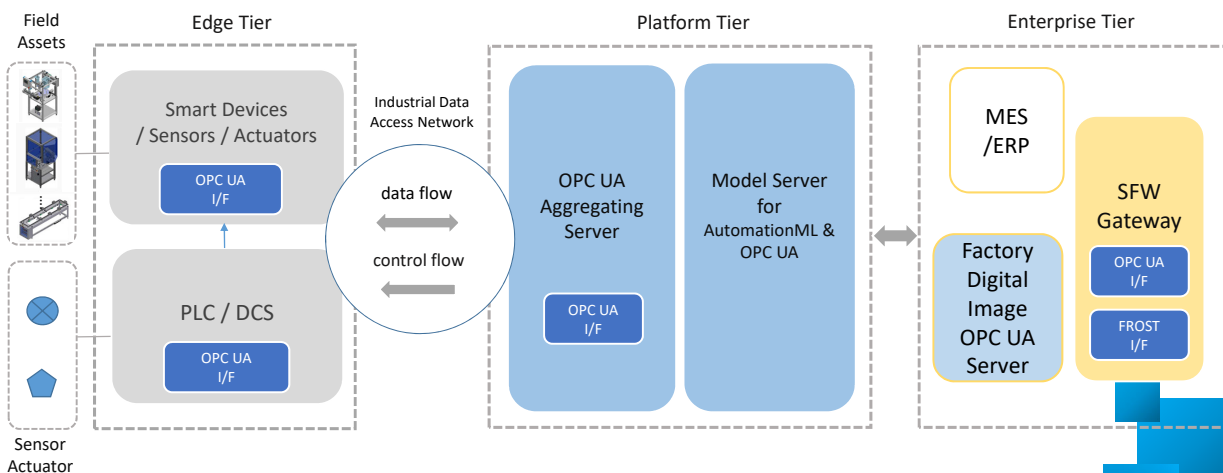
- Upper Plane: Smart Factory Web (SFW)



- Lower Plane: Model Factory

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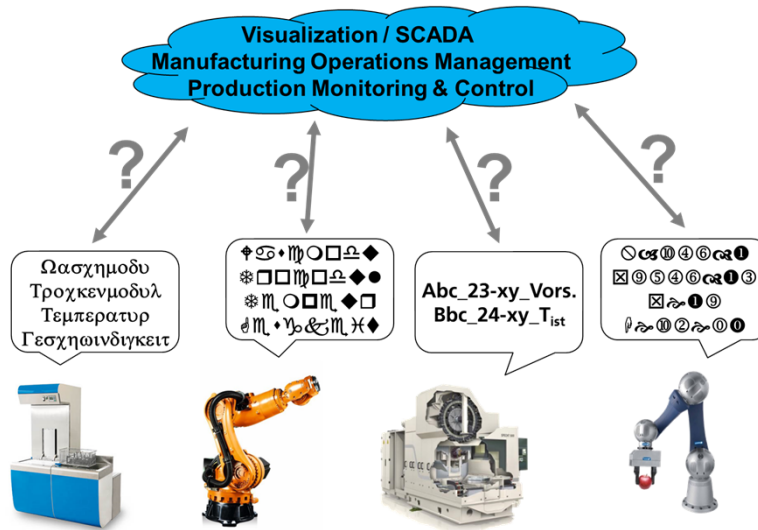
# Testbed Architecture lower plane: Model Factory



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FROST: Fraunhofer SensorThings API Server

# Today's problem for IIoT: semantic interoperability



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## Standards in Smart Factory Web (1)

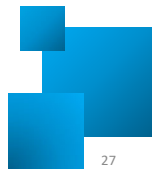


SDO	Standard name / ID	Standard Description	Horizontal technology / application vertical	Usage recommendation	IIC Liaison	Notes
IEC SC 65E	IEC 62541	OPC UA	manufacturing	Connect applications to controllers	OPC Foundation	
IEC SC 65E WG9; AutomationML Association	IEC 62714	AutomationML	manufacturing	system engineering		
OPC Foundation and AutomationML association	OPC 30040	Companion Specification "OPC Unified Architecture for AutomationML"	manufacturing	system engineering	OPC Foundation	Led by Fraunhofer IOSB
DIN	DIN SPEC 16592	Combining OPC Unified Architecture and Automation Markup Language	manufacturing	system engineering	DIN, OPC Foundation	Led by Fraunhofer IOSB
OPC Foundation, ZVEI and Plattform Industrie 4.0	work in progress	Companion Specification "OPC Unified Architecture for Industrie 4.0 Asset Administration Shell (I4AAS)"	manufacturing		OPC Foundation	Co-led by Fraunhofer IOSB

## Standards in Smart Factory Web (2)



SDO	Standard name / ID	Standard Description	Horizontal technology / application vertical	Usage recommendation	IIC Liaison	Notes
Open Geospatial Consortium (OGC)	OGC 15-078r6 V1.1	<b>SensorThings API, Part 1: Sensing</b>	Sensor networks, smart cities, environment	Access sensor data	OGC	Fraunhofer IOSB is Co-Chair of Sensor Things SWG
DIN	DIN SPEC 16593-1:2018-04 <sup>(2)</sup> DIN SPEC 16593-2 (work in progress)	RM-SA - Reference Model for Industrie 4.0 Service architectures Part 1: Interaction-based Architecture Part 2: Bootstrapping and Registry	manufacturing	system engineering	DIN	Led by Fraunhofer IOSB
DIN	DIN SPEC 27070	Requirements and reference architecture of a security gateway for the exchange of industry data and services		Secure, trustworthy communication	IDSA, DIN	

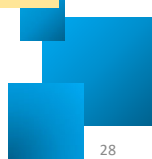
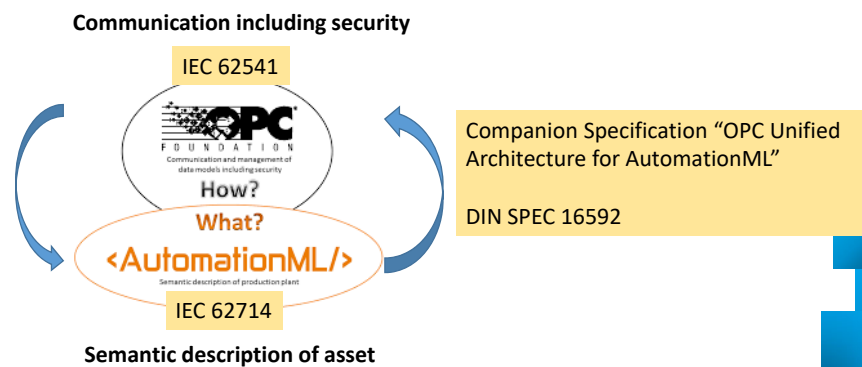


## Integrated Standards AutomationML and OPC UA



- Generation of OPC UA server from AutomationML
- Exchange of AutomationML models via OPC UA

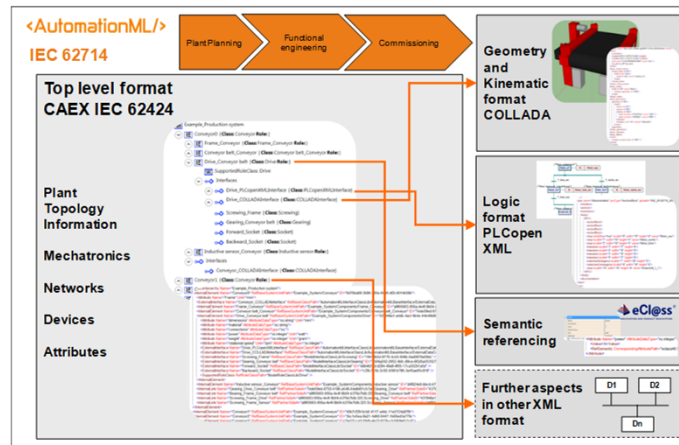
Benefit: simplified creation of information models in AutomationML and OPC UA



## AutomationML: an IEC Standard



- Open, vendor independent, XML-based data format for storage and exchange of plant engineering information
- Goal: Interconnect engineering tools of different disciplines in a heterogeneous tool landscape



## SensorThings API



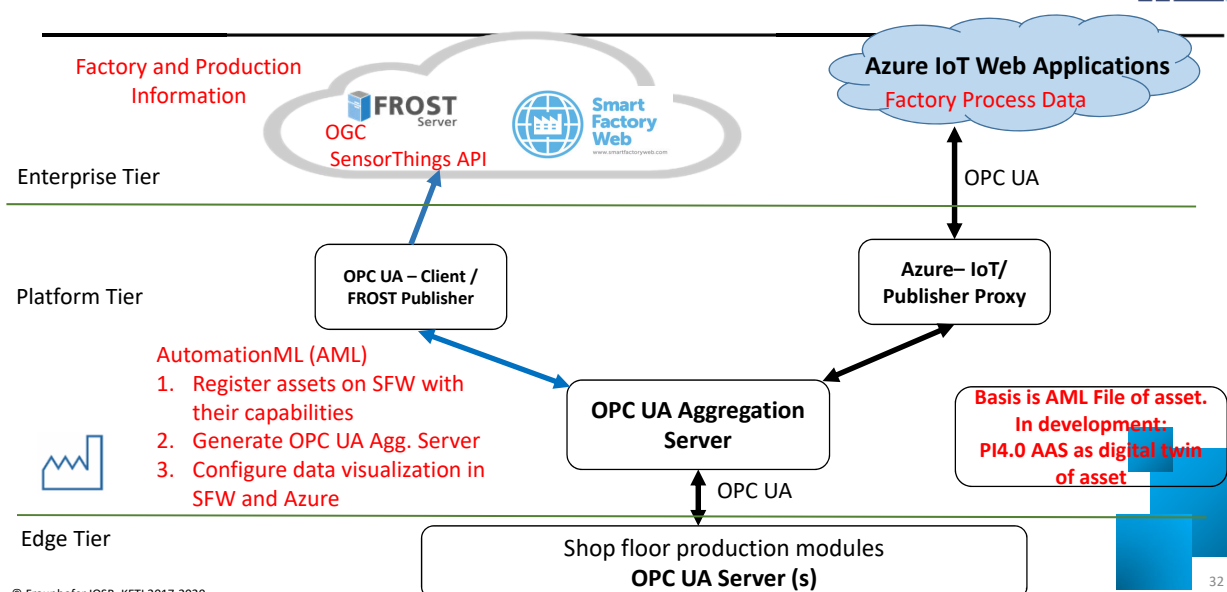
- OGC Standard
  - Fraunhofer IOSB is Co-Chair Sensor Things SWG
- Part 1 Sensing: Manage and retrieve *observations* and *metadata* from IoT sensor systems; metadata includes time and *location* tags
  - Based on ISO 19156 (ISO/OGC Observations and Measurements) **O&M Model**
- Transfer sensor data streams to a server over HTTP or MQTT
- SensorThings API server has standardized interfaces for spatiotemporal queries
- In Smart Factory Web: used to collect additional sensor data about machines and their environment
- <http://www.opengeospatial.org/standards/sensorthings>
- <https://www.iosb.fraunhofer.de/servlet/is/78641/>
- [https://en.wikipedia.org/wiki/SensorThings\\_API](https://en.wikipedia.org/wiki/SensorThings_API)

## Open Source components

- OPC UA
  - For implementations of Aggregated Servers in Testbed
  - open62541 <https://open62541.org/> : Fraunhofer IOSB responsible for core architecture
  - Cooperation OSADL, Kalycito and Fraunhofer IOSB to develop OPC UA Pub / Sub over TSN
    - <https://www.iosb.fraunhofer.de/servlet/is/81756/>
    - OSADL: Open Source Automation Development Lab, [www.osadl.org](http://www.osadl.org)
- SensorThings API
  - FROST: Fraunhofer Open Source Sensor Things API Server
  - <https://github.com/FraunhoferIOSB/SensorThingsServer>



## Factory Integration into the Cloud





## Published IIC White Paper



- Usage of Standards in the Smart Factory Web Testbed, 2020-06-29  
[https://www.iiconsortium.org/pdf/Usage\\_of\\_Standards\\_in\\_Smart\\_Factory\\_Web\\_TB\\_White\\_Paper\\_2020-06-29.pdf](https://www.iiconsortium.org/pdf/Usage_of_Standards_in_Smart_Factory_Web_TB_White_Paper_2020-06-29.pdf)
- Architecture of Smart Factory Web and principal concepts
  - Assets, capabilities, properties
- Factory registration
- Cloud integration
- Details of usage of AML, OPC UA and SensorThingsAPI
  - Modelling of entities in Smart Factory Web
  - Recommendations for mapping between information models
- Annexes on OPC UA, SensorThingsAPI and Assets in PI4.0

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## Ecosystem Smart Factory Web – Outlook



PLATFORM  
**INDUSTRIE4.0**

Platform Industrie 4.0  
Asset Administration Shell  
Technology Mappings OPC UA, Automation ML

IIC Testbed  
Negotiation  
Automation Platform  
(NEC)



Technology Training &  
Consultancy for industry

INTERNATIONAL DATA  
SPACES ASSOCIATION

IDS-Industrial  
community,  
IDS Connector to  
Smart Factory Web

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# Reference Architecture Model Industrie 4.0 (RAMI4.0) ... in a nutshell (YouTube)

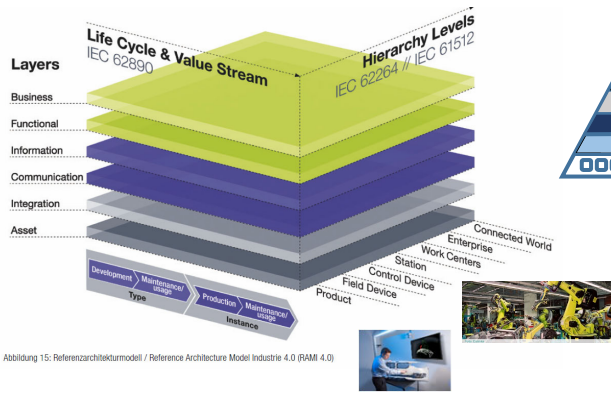


Abbildung 15: Referenzarchitekturmodell / Reference Architecture Model Industrie 4.0 (RAMI 4.0)

Plattform Industrie 4.0/Hrsg. BITKOM, VDMA, ZVEI:  
Umsetzungsstrategie Industrie 4.0 – Ergebnisbericht, Berlin, April 2015

Details of the Asset Administration Shell –Part 1: The exchange of information between partners in the value chain of Industrie 4.0 (Version 3.0RC01), 2020-November

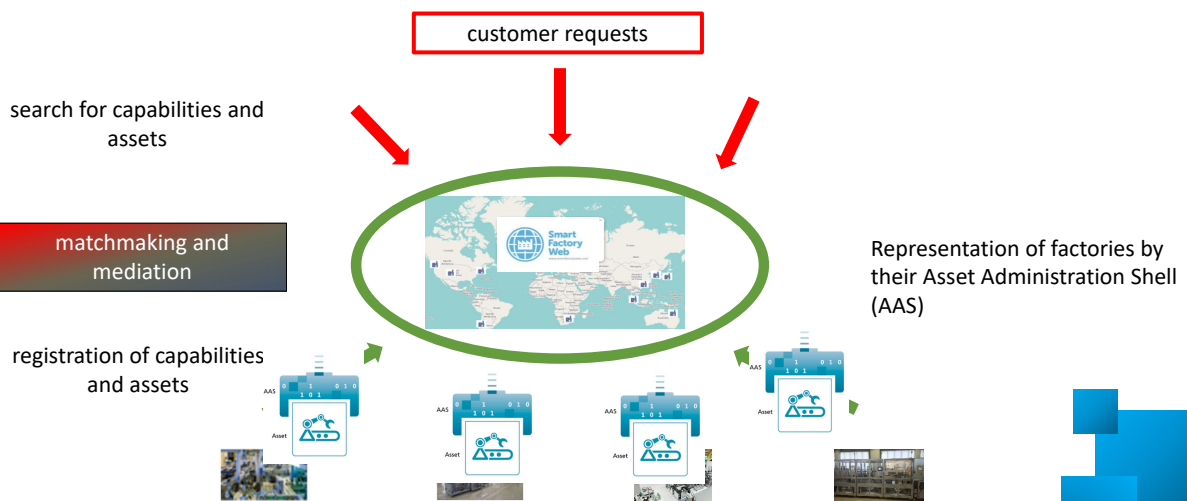
Asset type hierarchy:

- Connected World
- Enterprise
- Work center
- Station
- Control device
- Field device (sensor/actuator)
- Product

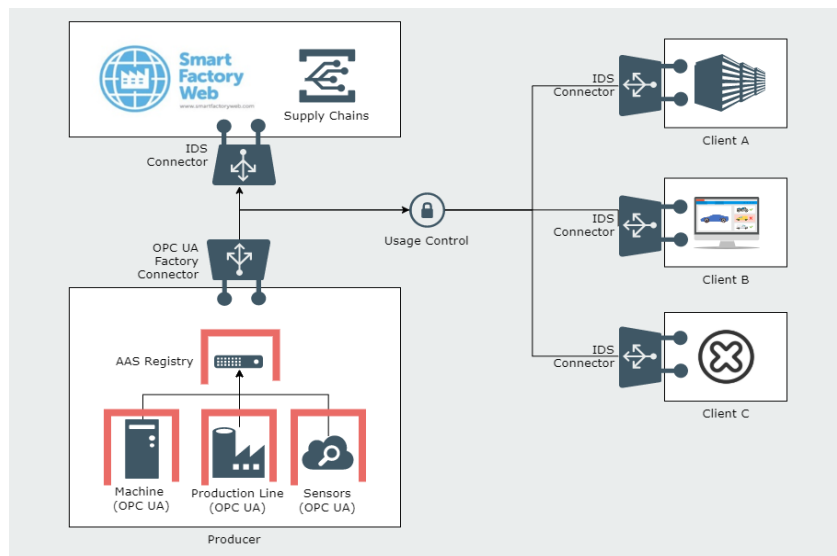
uniform representation



# Towards a marketplace for manufacturing



## Integration AAS / IDS



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## Why is the Smart Factory Web Testbed important to IIC, Plattform Industrie 4.0 and IDS-I?



- Web of cooperating factories open for additional facilities, experiments and partners
- Addresses architectural and interoperability issues on two planes: the level of the Smart Factory Web as well as within a factory
- Extensive testing of standards / concepts of OPC UA, AutomationML, AAS and IDS. Usage scenario “Order driven adaptive production” that combines Plattform Industrie 4.0 application scenarios “order controlled production” and “adaptable factory”.
- KETI and Fraunhofer as applied research organizations are in an excellent position to transfer technologies and promote the IIC brand to industry;
- Established project eco-system

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## Call for collaboration via [www.smartfactoryweb.de](http://www.smartfactoryweb.de)



### Statement of General Interest

- want to be informed progress in the Smart Factory Web testbed

### Statement of Training Request

- interested in training events (workshops, webinars, ...)
- requests information on customized training

### Statement of Investment

- want to actively contribute in at least one of the participating smart factories
- like to provide HW/SW components to be integrated
- interested in providing financial and engineering support

### Statement of Smart Factory Integration

- want to offer a further smart factory to be registered or integrated into the Smart Factory Web
- terms and conditions to be negotiated on a case by case basis

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## Selected Publications



- 2021:
  - Usländer, T.; Schöppenthau, F.; Schnebel, B.; Heymann, S.; Stojanovic, L.; Watson, K.; Nam, S.; Morinaga, S. Smart Factory Web—A Blueprint Architecture for Open Marketplaces for Industrial Production. Appl. Sci. 2021, 11, 6585. <https://doi.org/10.3390/app11146585>
- 2020:
  - A Compilation of Testbed Results - Toward Best Practices for Developing and Deploying IIoT Solutions. An Industrial Internet Consortium White Paper, Version 1.0, 2020-02-20; [https://www.iiconsortium.org/pdf/Compilation\\_of\\_Testbed\\_Results\\_2020\\_Feb.pdf](https://www.iiconsortium.org/pdf/Compilation_of_Testbed_Results_2020_Feb.pdf)
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# Thank You



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