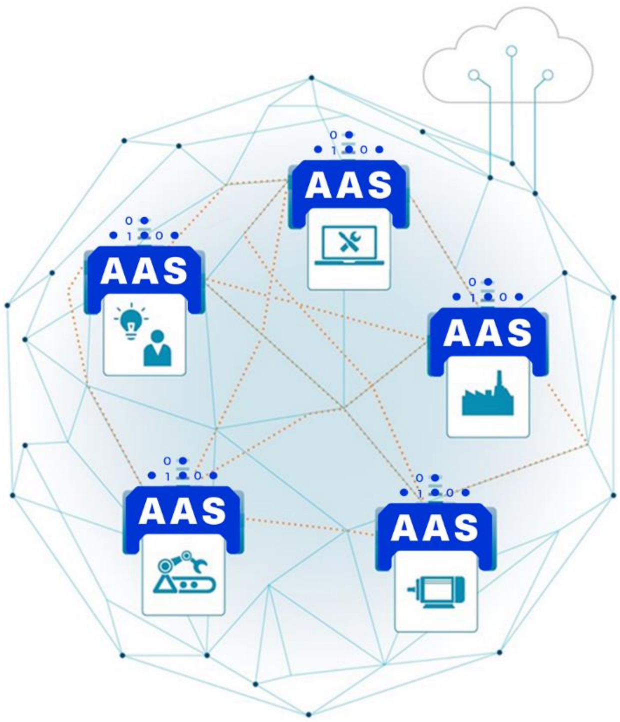
WHITE PAPER

Joint White Paper on common strategy for Interoperability for Industrie 4.0 based on AAS

FIRST EDITION (2022)



Partners

LNI4.0 LABS NETWORK INDUSTRIE 4.0

KOSMO 스마트제조혁신추진단 KOREA SMART MANUFACTURING OFFICE

In cooperation with:

PLATTFORM INDUSTRIE 4.0

STANDARDIZATION COUNCIL INDUSTRIE 4.0

IDTA

This publication is a result of a joint Sub-Working Group "(1) International Standard Development (incl. AAS)" of the Korean-German Cooperation, manifested in a MoU, signed by KOSMO and LNI 4.0 on 4th Dec, 2020.

Signatures:

Korea: KOSMO	Germany: LNI 4.0
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This publication as well as further publications from the cooperation can be obtained from:
<www.LNI4.0> <www. Plattform Industrie 4.0> <www.SCI4.0> <www.industrialdigitaltwin.org>

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1. Introduction and Management Summary

1.1. General Intention and relation to AAS

With the evolution of technology, changes in smart manufacturing and society are rapidly accelerating. Standardization is a key issue for the success of a smart manufacturing vision of the industries in Korea and Germany. Industrie 4.0 (I 4.0) and Industrial Internet of Things (IIoT) require an unprecedented degree of system integration across domain borders, hierarchy borders and life cycle phases. This is only possible if it proceeds from standards and specifications based on consensus. It is critical to consider the standardization as a basis for open and interoperable system architectures for industrial implementation of the vision of smart manufacturing.

Nowadays there is an increasing need for global collaboration. As world leaders in the field of manufacturing technology and production systems, Germany and Korea have made great efforts to promote smart manufacturing research, developments, and industrial implementations. Germany and Korea have agreed to cooperate on standardization in the field of smart manufacturing by sharing the long-term view for smart manufacturing and focusing on common pertinent topics.

The aim of the collaboration between the Labs Network for Industrie 4.0 (LNI 4.0), Standardization Council Industrie 4.0 (SCI 4.0), Plattform Industrie 4.0 and Industrial Digital Twin Association (IDTA), Korea Smart Manufacturing Office (KOSMO) and their Korean partners, enumerate, is to take advantage of the economic potential of digitalization, achieving a smooth transition into the digital age in both countries and maximizing the positive effects on the competitive strength of industry in both countries.

The cooperation has been intensified since 2019. The German and Korean partners agreed to create a common future vision of smart manufacturing standardization and to establish a mechanism for proactive information exchange and to work together transparently.

In a first step, the partners agreed to start using the Asset Administration Shell (AAS) on the basis of concrete concept and test work, to develop various use cases using the AAS in order to achieve a common understanding of the implementation and feasibility of the AAS in an international digitalized context.

In parallel, possible content areas of the standardization of Industrie 4.0 and Smart Manufacturing are examined.

This white paper does not claim to manage interoperability in the context of Industry 4.0 solely with the AAS.

1.2. Reference to signed Memorandum of Understanding (MoU)

This Whitepaper is a joint continuation of the MoU, signed by KOSMO and LNI 4.0 on 4th Dec, 2020 (please refer to chapter 2.4.), and herein especially for the application of the Asset Administration Shell (AAS) in the working group (1) of the Steering Committee mentioned below.

The pre-competitive and non-profit association Labs Network Industrie 4.0 e.V. of Germany and the KOSMO (Korea Smart Manufacturing Office, an affiliated organization of TIPA; Korea Technology and Information Promotion Agency for SMEs) intend to exchange views, goals, strategies, recommendations and best practices regarding digitalization, in particular Industrie 4.0.

The target of the cooperation is to make a sustained effort to promote, facilitate and support joint initiatives within their industry sectors, acknowledging the strength of the innovation capabilities in both countries. This includes the exploration of common interests and joint contribution to the promotion of activities in international organizations in the areas of cooperation mentioned previously.

After the MoU ceremony, Korea and Germany agreed to establish a Steering Committee executive meeting where the experts from both countries exchange the progress of the individual working groups, share their ideas for future harmonization and suggestions for future cooperation and navigate mutual inquiries.

This Steering Committee initiated working groups in three areas:

(1) International Standard Development (incl. AAS)
(2) Gaia-X
(3) Cyber-Security

1.3. Intention and target group of this Whitepaper for the usage of AAS

The Working Group (WG 1) has concentrated first on the AAS to evaluate the general placement of the technology-agnostic approach of the AAS as well as the correlation of the AAS with specific technologies.

The intention of the AAS is to offer an overarching, technology-agnostic metamodel through which various assets, shop floors, etc. can be linked with one another, while at the same time retaining your own, previous communication protocols and interfaces.

The picture below presents the general a rough, logical view of the Asset Administration Shell's structure. The Asset Administration Shell – shown in blue in the following figure – comprises as a metamodel different sets of information.
The AAS includes a number of sub-models to characterize the Asset Administration Shell.
Both the asset and the administration shell are identified by a globally unique identifier.

The integration of different production protocols and different complementary formats will be done via a mapping and corresponding sub template, based on the design rules of the AAS.

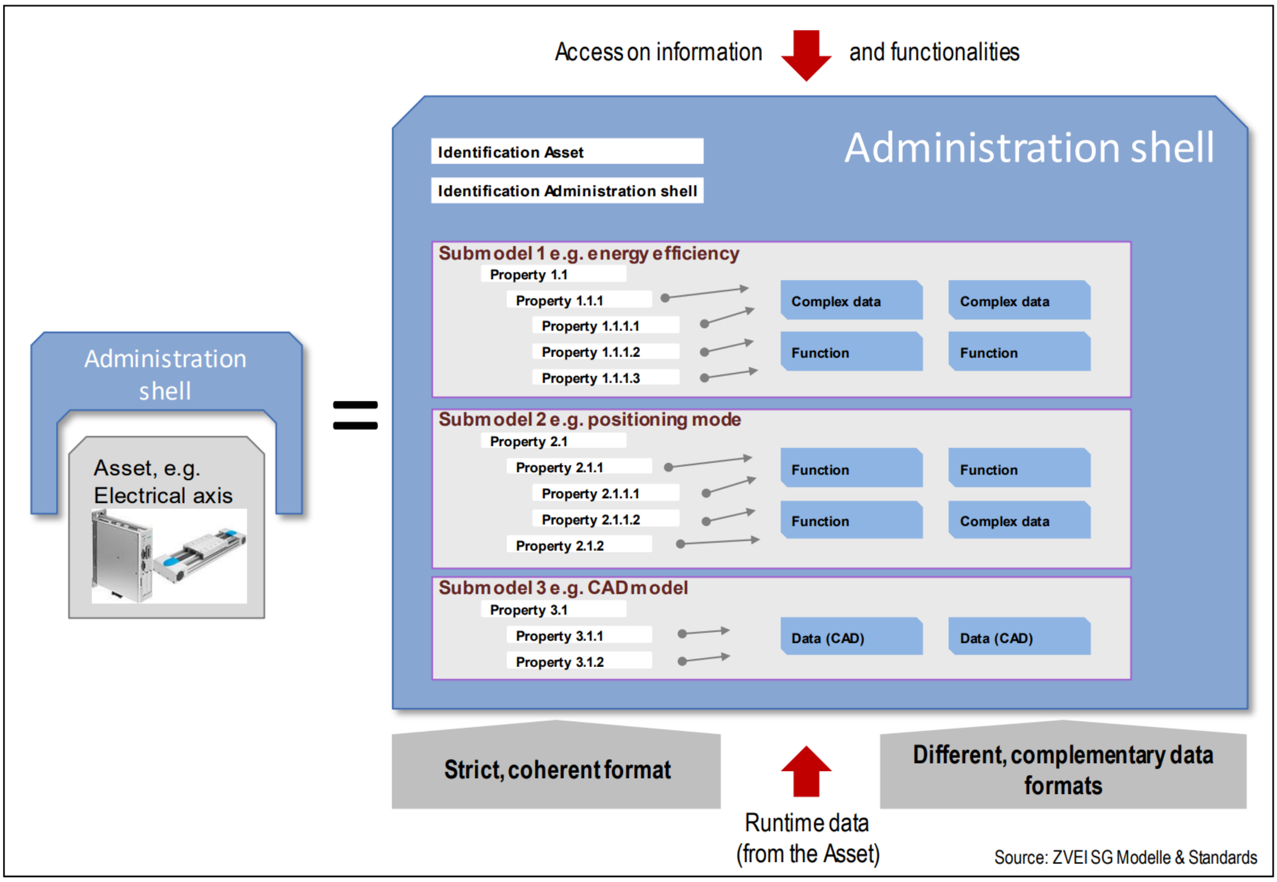

Figure 01: Generic overview of the Data model of the Asset Administration Shell (ZVEI SG Models & Standards)

There with the intention of this Whitepaper from the Working Group (1) is to:

- Summarize of the previous activities for the evaluation of an interoperability with special reference to the AAS
- Demonstrate the possibilities, limits and first experiences for the use of an AAS in the area of smart manufacturing
- Describe the use of the AAS using exemplary use cases
- Summarizing the next activities regarding integration of different production protocols and complementary formats
- Facilitate Testing, Training and Knowledge exchange
- Align in an approach for international use cases & test scenarios
- Coordinate standardization effort in the field of smart manufacturing
- Embed this whitepaper as a milestone in the standardization activities in the field of smart manufacturing

The target groups of this Whitepaper are:

- Small and Medium Companies (SME)
- Strategists in government environment
- Standardization associations

2. Retrospective and achievements of the cooperation since 2019

2.1. November 2019: Korea-German Standards Forum -- Between the Rhein and the Han

Since the announcement of the I4.0 strategy in the German Plattform Industrie 4.0, Korea and Germany have maintained a close cooperative relationship in IEC TC65 and IEC SyC SM regarding standardization of Smart Manufacturing. Based on this collaborative relationship, the '***Korea-German Standards Forum -- Between the Rhein and the Han: keeping the Flow Going through Standardization'* was held on November 28, 2019, in Seoul, Korea,** hosted by KATS. The main agenda of this forum included standard cooperation between the two countries in Smart Manufacturing and Future Mobility, and in particular, the understanding between the two countries was improved in the field of Smart Manufacturing.

2.2. December 2019: Workshop on Cooperation for Industrie 4.0 Standardization between Korea and Germany

On **December 17, 2019**, eleven German delegations, including Prof. Henning Kagermann, visited Korea, and the **'*Workshop on Cooperation for Industrie 4.0 Standardization between Korea and Germany'* was held jointly organized by KATS and KOSMO.** Through this workshop, the vision for Industrie 4.0 based on AAS and Gaia-X has been shared between the two countries.

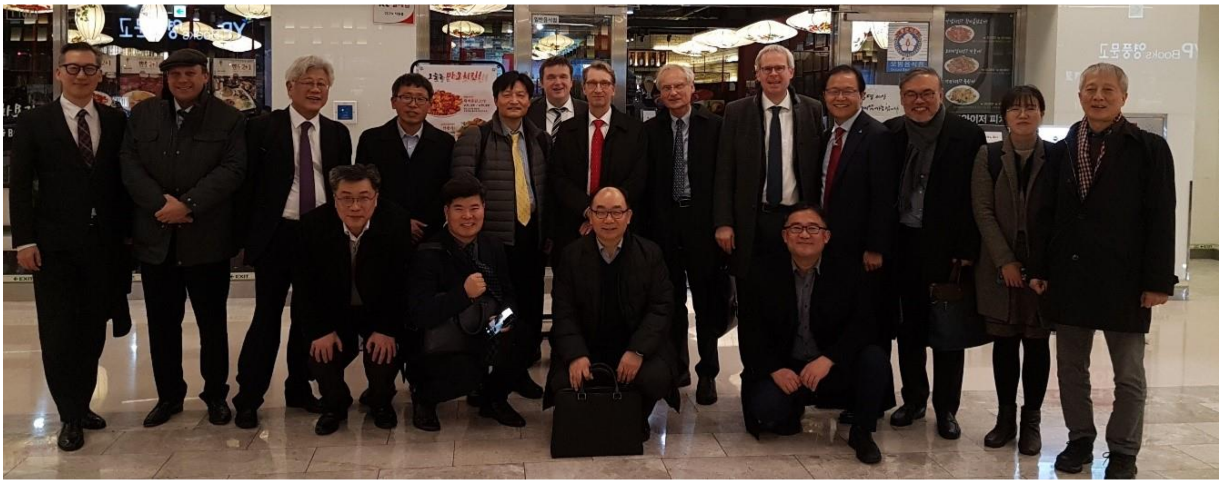

Figure 02: Photo of the participants of Workshop for Industrie 4.0 Standardization between Korea and Germany (KATS+KOSMO)

2.3. October 2020: Korea-Germany Joint AAS Standard-based Smart Manufacturing Data Collection/Storage Forum

[ENG] Korea - Germany AAS Standards based Smart Manufacturing Data Forum 20201013

On **October 13, 2020, the *'Korea-Germany Joint AAS Standard-based Smart Manufacturing Data Collection/Storage Forum'*** was held to share the current status and future plans for the development and utilization of AAS standards in both Korea and Germany. The forum was controlled using an online platform in Seoul, and 350 Smart Manufacturing experts from Korea and 30 Industrie 4.0 experts from Germany participated. Korean experts introduced the 'AAS-based cloud manufacturing data collection and storage pilot project' promoted by the Korean Ministry of SMEs and Startups. In Germany, LNI 4.0, SCI 4.0, and the Federal Ministry for Economic Affairs and Climate Action shared information about the German AAS-based testbeds, the standardization of AAS, and Gaia-X, respectively.

□ **Event Outline**

◦ **Summary**: To hold an online forum to share the current status of Korea and Germany on the development, testing and utilization of AAS standards

◦ **Date**: 2020. 10. 13, 14:00~18:00 Korean time (4 hours)

◦ **Location**: Online Platform (Virtual Conference)

◦ **Attendance:**

- (Online) Experts related to domestic manufacturing standards, A total of around 200 people, including small and medium-sized businesses, about 50 German I4.0/AAS experts

◦ **Details**

- Introduction of strategies and action plans for the dissemination and diffusion of smart manufacturing technologies in Korea
- Introduction of AAS standard-based manufacturing data collection/ storage pilot project
- Implementation of the pilot plant AAS model and introduction of application practice
- Introduction of the proposal to build a testbed for Korea-Germany smart manufacturing interoperability (AAS, Edge Configuration towards GAIA-X)

□ **Event schedule**

Time of the event		Details of the event	Remark
14:00 ~ 14:20	20 min	• Event information	Prof. Seung-Ho HONG, Hanyang University
		• greetings	Mr. Hongyeol LEE, Deputy Director MSS (Ministry of SMEs and Startups)
		• Welcome speech from Germany	Dr. Friedrich Gröteke BMWi (German Economy Ministry)
14:20 ~ 14:50	30 min	• Promotional strategy and action plan for innovation of smart manufacturing in Korea	President Hanku PARK, KOSMO
14:50 ~ 15:20	30 min	• AAS based cloud data collection and storage for SME	Mr. Yu-Chul KIM, CEO, Nestfield (SME)
15:20 ~ 15:50	30 min	• The practice of implementing AAS in the pilot plant in Korea	Dr. Joo-Yeon LEE, KITECH (Korea Institute of Industrial Technology)
15:50 ~ 16:15	25 min	• Break time (Video: AAS-based Plug-and-Produce Demo System)	
16:15 ~ 17:15	60 min	• Testbeds for interoperability in a German-Korean setting: AAS, Edge Management, European data infrastructure (GAIA-X)	Dr. Dominik ROHRMUS, CTO, LNI 4.0, Germany
17:15 ~ 17:30	15 min	• Standardization and interoperability in a German-Korean context	Dr. Jens Gayko, CEO, SCI 4.0, Germany
17:30 ~ 18:00	30 min	• Q & A	Prof. Seung-Ho HONG, Hanyang University

* Online registration information will be announced later

Figure 03: Program of the 1st Korea-Germany Joint AAS Standard-based Smart Manufacturing Data Collection/Storage Forum (KOSMO)

2.4. December 2020: Signing of the MoU for cooperation to fast-track the digital transformation of the industry

On **December 4, 2020, KOSMO and LNI4.0 signed the MOU** for cooperation to fast-track the digital transformation of the industry (Industrie 4.0). Both sides (i) recognize in particular that digitalization and linkage of the production processes along digitalized value chains, a process referred to as "Industrie 4.0", can boost the economies of both countries, (ii) emphasize that cooperation between the industry-driven initiatives, companies, universities, and research institutions in the field of digitalization and Industrie 4.0 might have a positive impact on the competitiveness of their industrial sectors, and (iii) confirm their mutual interest in promoting bilateral relations in the field of Industrie 4.0 and digitizing manufacturing.

Both sides intend to exchange views, goals, strategies, recommendations, and best practices regarding digitalization, in particular Industrie 4.0. The target of the cooperation is to make a sustained effort to promote, facilitate and support joint initiatives within their industry sectors, to acknowledge the strength of the innovation capabilities in both countries. This includes the exploration of common interests and joint contribution to the promotion of activities in international organizations in the areas of cooperation mentioned previously.

The cooperation could include, but is not limited to the following topics:

- Asset administration shell (AAS) and OPC UA testing and implementation
- General Industrie 4.0 testing and testbeds
- Industrie 4.0 use cases
- Industrial cybersecurity
- Qualification and training
- Digital Business Models
- Artificial Intelligence (AI)
- GAIA-X specific testing
- Industrial communication (5G, Time Sensitive Network, etc.)

Figure 04: Photo of the MOU Signing Ceremony between KOSMO and LNI4.0 (KOSMO+LNI 4.0)

2.5. March 2021: First Korean/German Steering Committee

After the MOU ceremony, Korea and Germany agreed to establish a Steering Committee executive meeting where the experts from both countries share their ideas for future harmonization.

On March 2, 2021, the first Korea/Germany Steering Committee executive meeting was held to form working groups in three areas: AAS/standardization, Gaia-X, and Cyber-Security.

2.6. April 2021: Hannover Messe “Cross-border interoperability via digital twins in practice ”

https://www.youtube.com/watch?v=vavgaQVNFvE&t=13s

The intention for the presentation at the **Hannover Messe (HMI 2021.04.14)** was to show the ***"Cross-border interoperability via digital twins in practice " -*** in a joint initiative towards a Korean-German AAS Testbed.

Korea is actively mentioned in the AAS Testbed and is in direct exchange and also shown on the map. https://www.hannovermesse.de/produkt/aas-testbed/262823/X505313

Since the Hannover Messe was replaced by an online event due to Covid-19, the Cross-border interoperability via digital twins in practice – the Korean-German AAS Testbed was held as a Live Streaming Event on April 14, 2021. In the Live Streaming Event, participants shared the status of AAS technologies development and testbed in Korea and Germany. Also, a lively discussion took place among the experts from both countries.

What are the benefits of having the cooperation of AAS on the Korean side?
At the beginning of the AAS pilot plant project in Korea, we implemented the AAS technologies using the specifications and published articles from Platform Industry 4.0, Germany. We were not sure whether we were going in the right direction. After cooperating with Germany, we discussed every item with German experts, and we were confident that we are going in the right direction.

How will both countries expand the scope of cooperation in the future?
Currently, we are cooperating in the AAS testbed itself. In the future, we expect that the cooperation will be expanded to; first, we can share Reference AAS repositories, and second, we can develop a common AAS API standard together. And, many more achievements will happen in the future.

12 – 16 APRIL 2021 DIGITAL EDITION

INNOVATION INSPIRATION INTERACTION

HANNOVER MESSE

EXHIBITOR STREAMING LIVESTREAM

Cross-border interoperability via digital twins in practice - the Korean-German AAS Testbed

□ **Live Streaming Event Information**

The Korean-German AAS Testbed Live Streaming Event held during April 14 2021, 09:00 ~ 10:00 AM (CET) has 2 options Hanover Live Streaming Event(25') and Q&A Live Streaming Event(35'). After the Hannover Live Streaming event, the Q&A live streaming event will be conducted on MS Teams Live. The Q&A channel link will be provided to the Hannover Live Streaming Event Channel or Live event, and will be released from April 12.

□ **Event Outline**

◦ Summary: Hannover Messe 2021 – KOR-GER AAS Testbed Live Streaming Event
◦ Date: Hannover Digital Fair (April 12-16 2021)
- Hannover Live Streaming : April 14 2021, 09:00 ~ 09:25 AM (CET)
- Q&A Live Streaming: April 14 2021, 09:25 ~ 10:00 AM (CET)

◦ Location: Online Platform
◦ Live streaming Event Link: Event Link

□ **Event Schedule**

Time of the event		Details of the event	Remark
16:00 ~ 16:02	2' 30	• Opening remarks on AAS	Dr. Dominik Rohrmus, CTO, LNI 4.0, Germany
16:02 ~ 16:07	5'	• Why do you need the AAS and how helps IDTA?	Dr. Birgit Boss
16:07 ~ 16:12	5'	• AAS Pilot Plant project in Korea	Dr. Ju Yeon Lee
16:12 ~ 16:16	5'	• AAS based Plug & Produce testbed	Dr. Won Seok Song
16:16 ~ 16:22	5'	• AAS content delivery from Submodels to standardization	Dr. Michael Hoffmeister
16:22 ~ 16:25	2' 30	• Closing remark on Cooperation of AAS Testbed	Prof. Seung Ho Hong, Hanyang University
16:25 ~ 17:00	35	• Q & A	Dr. Dominik Rohrmus, Prof. Seung-Ho Hong

Ministry of SMEs and Startups · KOSMO Korea Smart Manufacturing Office · INDUSTRIE4.0 · LNI4.0 · Standardization Council Industrie 4.0 · Korean Agency for Technology and Standards · HANYANG UNIVERSITY · NEST FIELD · KITECH

* Inquiry: jj3251@nestfield.co.kr

Figure 05: Program of the Livestream of 'Cross-border interoperability via digital twins in practice – the Korean-German AAS Testbed' held on Hannover Messe (HMI 2021.04.14) (KOSMO+LNI 4.0)

2.7. April 2021: Ministerial Kick-Off Meeting on Smart Manufacturing Cooperation

On April 29, 2021, a kick-off meeting on Smart Manufacturing Cooperation took place together with the ministries from Germany and Korea. The intention was the ministerial confirmation of the procedure in this cooperation as well as the confirmation of the contents of the 3 working groups.

2.8. July 2021: Continuous expert exchange with IDTA

As the IDTA (Industrial Digital Twin Association) was launched in Germany in 2021.

In July 2021 first Korean companies, including Nestfield and LS Electrics, joined IDTA as the first international members, and more Korean companies are planning to follow them. IDTA was launched in Germany in March 2021 as the user organization for the Asset Administration Shell.

Currently, AAS experts from both countries are holding regular meetings once a month to discuss such topics as AAS Open Technology, Use Cases, Training, Marketing, etc. First open-source project from Korea is integrated in IDTAs open-source platform, as a starting point for close joint developments on the AAS.

2.9. December 2021: Second Korean/German Steering Committee

Following the first meeting in March 2021, the second meeting took place on **December 3, 2021**, to share the progress of each working group, proposals for future collaborations, and mutual requests.

2.10. March 2022: 2nd Korea-Germany Joint AAS Standard-based Smart Manufacturing Forum

[ENG] The 2nd Korea - Germany AAS Standards based Smart Manufacturing Data Forum 20220316

On March 16, 2022, the second "Korea-Germany Joint AAS Standard-based Smart Manufacturing Data Collection/Storage Forum" took place and was a good continuation of the first forum from October 2020. It was held as a purely virtual event - forced by Corona - but the best format to connect the 283 Korean and German participants.

The importance of the forum was underlined by greetings from the Korean Ministry for SMEs and Startups and the German Ministry for Economic Affairs and Climate Protection. The economic bridge between Korea and Germany for this cooperation on the administration shell was explicitly made clear by KOSMO (Korea Smart Manufacturing Office) and by the AHK Korea (Korea Foreign Trade Chamber) in their introductory speeches.

The aim of the second forum was to exchange information about the current status of the development and use of AAS standards, to exchange experience in various projects on the Korean and German side and to agree on future plans and, above all, joint, concrete steps for the use of AAS.

While the current status of the specification of the AAS and future plans for the development and use of AAS standards in Korea and Germany were discussed in the first forum, we were able to in the second forum, concrete installations of the Administration Shell will be shown using demonstrators and experiences will be exchanged, as well as concrete implementation tips for companies.

But there was also talk about component and standardization strategies still to be developed and how both sides (Korea and Germany) can work together on this.

The 2nd Korea-Germany Joint AAS Standard-based Smart Manufacturing Forum

2022.03.16 (Wednesday)

- **Event Outline**

Summary : To hold an online forum to share the current status and future cooperation of Korea and Germany on the development, testing and utilization of AAS standard technology

Date : 2022.03.16, 07:30~11:30 CET (4 hours)

Location : HOTEL ELIENA 2F Convention Hall, Online Platform (Virtual Conference)

- **Attendance**

Online : Experts related to smart manufacturing standards and technologies in Korea and Germany.

- **Event schedule**

Time of the event		Details of the event	Remark
15:30 ~ 15:45	15 min	Event information	Prof. Emeritus Seung-Ho HONG, Hanyang University
		Greetings	Mr. Hyun-Jo LEE, MSS, Bureau of SMEs-Smart Manufacturing Innovation Planning/Director General
			Mr. Ernst Stockl-Pukall Head of Division, Digitization, Industrie 4.0 BMWK – Federal Ministry for Economic Affairs and Climate Action
		Welcome speech from Germany	Dr. Martin Henkelmann, President & CEO, The Korean-German Chamber of Commerce and Industry (KGCCI)
15:45 ~ 16:15	30 min	Promotional strategy and action plan for innovation of smart manufacturing in Korea	Han-Ku PARK, President, KOSMO
16:15 ~ 16:45	30 min	AAS-based pilot project in Korea	Dr. Won-Seok SONG, CTO, Nestfield
16:45 ~ 17:15	30 min	Introduction to IDTA	Mr. Meik Billmann, CEO, IDTA
17:15 ~ 17:30	15 min	Break time	
17:30 ~ 18:00	30 min	AAS use cases in Germany	Ms. Anja Simon, CTO, LNI 4.0
18:00 ~ 18:30	30 min	The perspective of AAS standardization in Germany and IEC	Dr. Jens Gayko, CEO, SCI 4.0
18:30 ~ 19:00	30 min	Implementation of the AAS Reference Model and an Application Case for Injection Molding Machines	Prof. Ju-Yeon LEE, SEOULTECH
19:00 ~ 19:30	30 min	Discussion	Prof. Emeritus Seung-Ho HONG, Hanyang University

Figure 06: Program of the 2nd Korea-Germany Joint AAS Standard-based Smart Manufacturing (KOSMO)

2.11. Summary of standardization activities up to now

Since the beginning of the Korean-German Industrie 4.0 cooperation standardization was seen by both partners as key for success. Initially the standardization cooperation was driven by personal contacts of technical experts of both countries. Bilateral meetings on occasion of international standardization meetings supported to establish a trustful relationship.

Topics for standardization cooperation support international standardization work at ISO and IEC but they do not substitute them.

The topics discussed can be grouped into **three levels** or phases:

1. Basic concepts for Industrie 4.0 and Smart Manufacturing,
2. Standards on basic principles of Industrie 4.0,
3. (digital) Standards describing data / data models.

The **first level** is mainly dealing with reference architecture models like RAMI 4.0 (IEC PAS 63088) and the digital factory framework (IEC 62832-series). Related international standardization groups include

- JWG 21 between IEC/TC 65 and ISO/TC 184 Smart Manufacturing Reference Model(s)
- IEC/TC 65/WG 23 (formerly ahG 4) Smart Manufacturing Framework and Concepts for industrial-process measurement, control and automation
- IEC/TC 65/WG 16 Digital Factory
- IEC SyC SM

Activities of the **second level** cover standards for concrete technologies for Industrie 4.0. This includes projects like

- IEC/TC 65/WG 24: IEC 63278-series on Asset Administration Shell
- IEC/TC 65/SC 65E/WG 8: IEC 62541-series OPC Unified Architecture
- ISO/IEC JTC1/SC 41/WG 3: ISO/IEC TS 30168 Internet of Things (IoT) - Generic Trust Anchor Application Programming Interface for Industrial IoT Devices

The **third level** will be important to fill the concepts and technologies of the first and second level with life. This will be a central topic for the future cooperation and is described in section 5.2.

3. Shaping the AAS ecosystem as an essential part for the digitization of industry in Germany

3.1. Plattform Industrie 4.0 and the 2030 Vision for Industrie 4.0

Industrie 4.0 is realized within a broad transformation network in Germany. Plattform Industrie 4.0 operates as the central hub in this digital ecosystem. It is steered and led by the Federal Ministry for Economic Affairs and Climate Action as well as the Federal Ministry of Education and Research together with high-ranking representatives from industry, science, business associations and trade unions. Together, the network makes the digital transformation tangible and creates critical foundations, comprising more than 350 actors from more than 150 organizations. They thereby tap the potential of Industrie 4.0 for achieving sustainability and climate goals.

In 2019, the stakeholders of Plattform Industrie 4.0 defined a holistic approach to shape the digital ecosystem – the 2030 Vision for Industrie 4.0. Industrie 4.0 is understood as a fundamental process of innovation and transformation in industrial production. Working from the specific situation and established strengths of Germany's industrial base, their aim is to create a framework for a future data economy in line with the requirements of a social market economy: emphasizing open ecosystems, diversity and plurality and supporting competition between all the stakeholders on the market. The Vision is primarily addressed to industry and commerce in Germany, but explicitly highlights the importance of openness and a willingness to work together with partners in Europe and around the world.

Interoperability in the 2030 Vision of Plattform Industrie 4.0
Interoperability describes the ability of systems, devices and applications to communicate with one another and work together seamlessly. Open standards are essential components for this. The stakeholders of Plattform Industrie 4.0 have defined three sub-fields for action: Standards and integration, regulatory framework and decentralized systems, and artificial intelligence (Figure 07).

Three closely interlinked strategic fields of action are crucial for a successful implementation of Industrie 4.0: **autonomy, interoperability and sustainability**.

Figure 07: Vision 2030 of the Platform Industrie 4.0 for Industrie 4.0 (Plattform Industrie 4.0)

In concrete several requirements should be met:

- Connectivity: assets use common communication protocols and the same "connector" between the analogue and virtual world.
- Data integrity and cyber security: the processed data remain complete and unchanged, while appropriate integration and protection measures prevent data from being damaged or changed unexpectedly.
- Clear semantics: assets uniformly understand the meaning and content of information. They use the same vocabulary, clearly understand the messages that they exchange digitally and can communicate in such a way that they interact autonomously and complete the tasks to be performed.
- Inclusion of AI: all stakeholders can use and interconnect machine and user data cooperatively. In addition, they can use artificial intelligence to arrive at new solutions and business models.
- Rules on governance and data security/sovereignty: all stakeholders operate under fair and equal conditions in the open ecosystems at a national, European and international level.

The Asset Administration Shell meets these requirements and thus forms an essential basis for the interoperability required: It allows for the digital integration of assets, provides the technical requirements for a decentral organized Industrie 4.0 and, as a freely accessible and interoperable interface, is the implementation of the digital twin. It is also suitable for cloud-to-cloud communication. (→ See also the Plattform Industrie 4.0 position paper on Interoperability)

3.2. Realization of Interoperability and AAS by a broad ecosystem in Germany and globally

The stakeholders of Plattform Industrie 4.0 commit jointly to the three fields of action defined by the 2030 Vision. Their goal is to scale up Industrie 4.0 in Germany, Europe and globally. In dialogue with all the stakeholders in the industrial society, the aim is to establish a framework for action so that – building on the current outstanding position of German industry in global terms, the digital transformation of German industry can take place in a sustainable manner, and Industrie 4.0 can be successfully established throughout a flourishing German Mittelstand.

Hence, activities on enhancing interoperability are implemented through a broad ecosystem. Within the Plattform Industrie 4.0, the Working Groups "Reference Architectures, Standards and Norms", "Technology and Application Scenarios" and "Legal Framework" make central contributions to drive the dimensions of interoperability forward. Together with partners such as LNI 4.0, SCI 4.0 and the Industrial Digital Twin Association (IDTA), Plattform Industrie 4.0 is closely aligned with further entities in the ecosystem (see graph 08 below).

Especially regarding the AAS we are now close to achieving widespread commercial application of the concept. Different levers must be set in motion for this purpose: existing research projects must be coordinated and further research carried out. A transfer concept needs to be developed, while educational measures are also required.

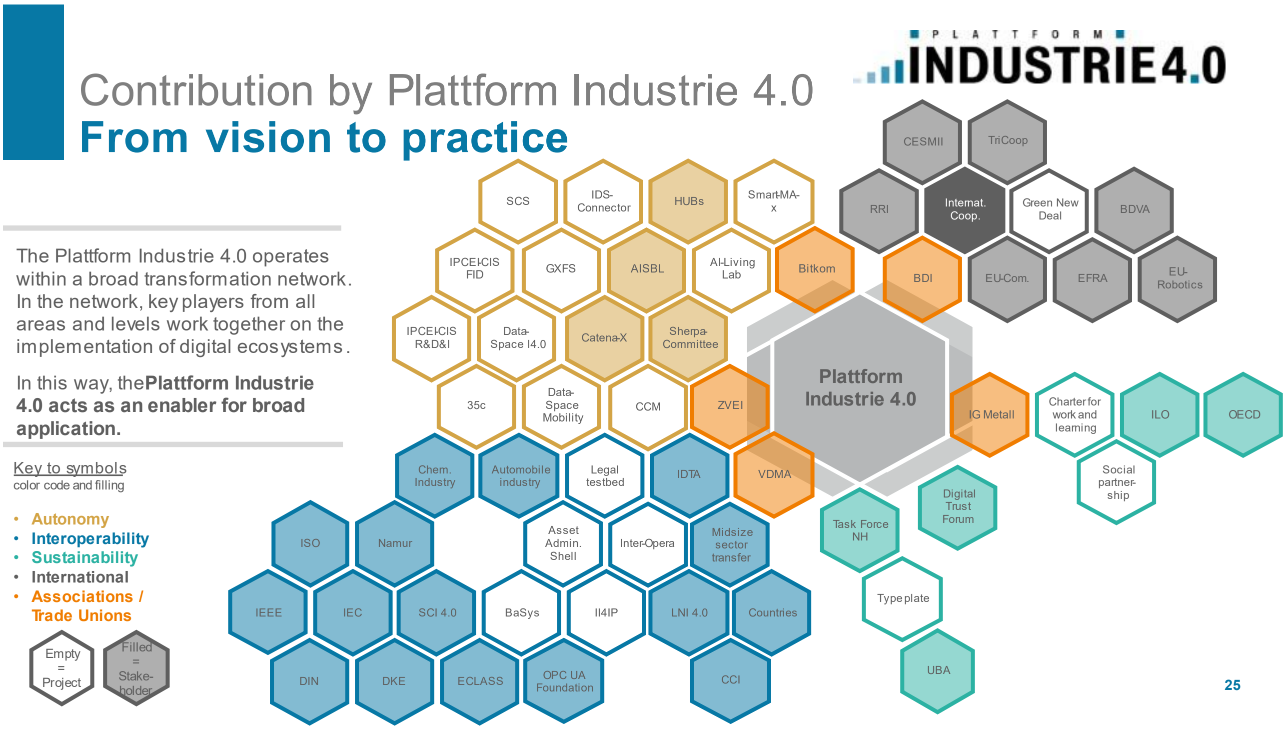

Figure 08: Contribution of Plattform Industrie 4.0 from vision to practice (Plattform Industrie 4.0)

A selection of exemplary projects and practical examples are shown in the following sections.

3.3. Example Project "AAS networked"

https://vwsvernetzt.de/ + https://aasnetworked.com/

The intension and target of this project "AAS networked" is to ensure the interoperability of different Implementations of the VWS of different companies and institutions, based on the technology of the AAS and to be proven by a virtual testbed and demonstrators. In the course of the project, proof of the functionality and general validity of the AAS concept and its specification should be provided.

The essential tasks of the project "AAS networked" are:

- Evaluation of different implementation technologies of the Administration Shell
- Ensuring interoperability between different implementations
- Preparing of an AAS ecosystem with Registry and authentication
- Validation of requirements, concepts, specifications and implementations based on "VWS in detail" and VDI/VDE 2193
- Support of open source and test
- Providing of best practice use cases for the implementation of the AAS
- Specification and construction of an infrastructure for the integration of different VWS implementations or physical demonstrators
- Derivation of further actions (specification gaps, need for standardization, etc.)
- Research:
    - Increase the semantic interoperability of software components with physical assets (CPS)
    - Life cycle support based on digital twins

These tasks are broken down into the following subtasks:

1. Concept for the interoperability of administration shells
2. Development of a demonstrator to illustrate the possible applications
3. Provision of a testbed to support developments
4. Implementation and commissioning of the IT infrastructure of the virtual test bed

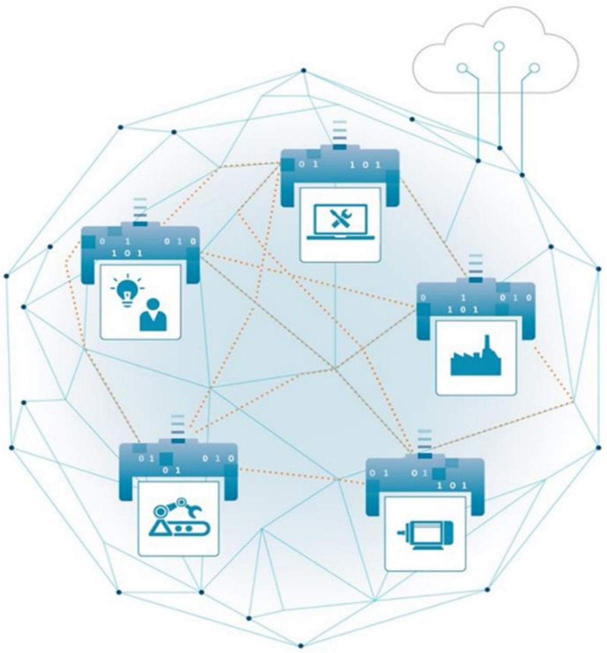

Figure 09: AAS networking icon (Project "AAS networked" / OvG University Magdeburg)

As a generic basis of the "AAS networked" project, the subdivision of the **3 different AAS communication types** are promoted:

- AAS Type 1: passive AAS as a file for exchange between partners in the value chain
- AAS Type 2: reactive AAS with API to the information model for an application of a partner in the value chain
- AAS Type 3: proactive interaction between AAS using Industrie 4.0 language

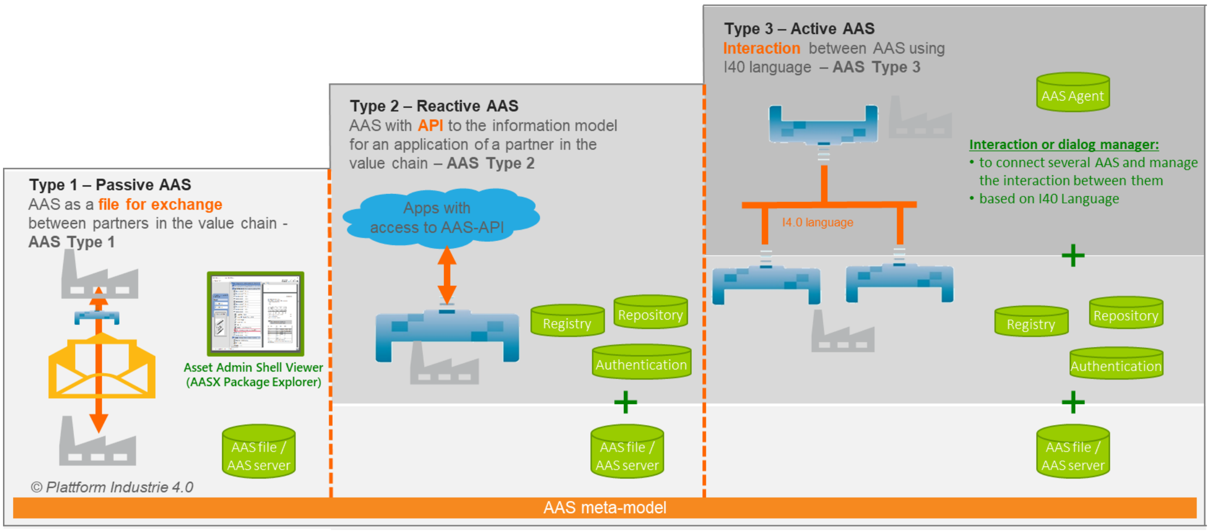

Figure 10: Overview of the 3 different AAS communication types (Project "AAS networked" / OvG University Magdeburg)

Stage 1 of the project "AAS networked " is a German wide Demonstrator of order driven production, which presents a first Industrie 4.0 Ecosystem.

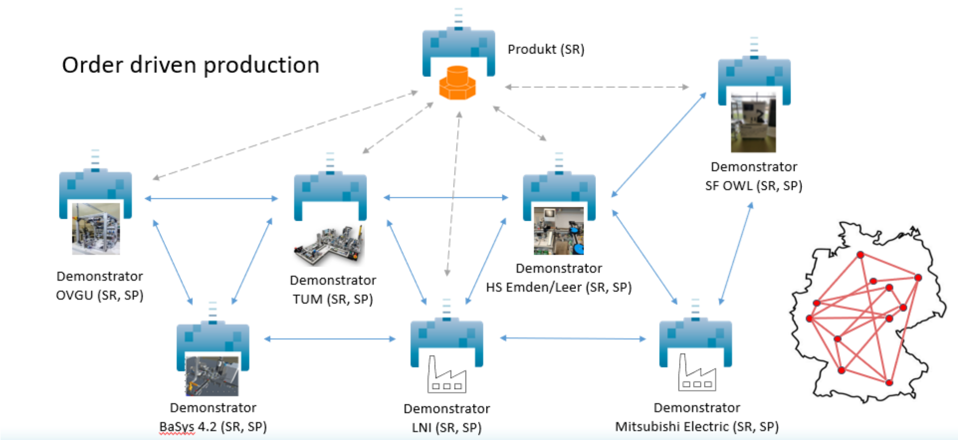

Figure 11: Overview of the connected demonstrators (Project "AAS networked" / OvG University Magdeburg)

One of the relevant use cases in Industrie 4.0 is **order-controlled production.**
Order-controlled production means that the focus is on the product, it knows its requirements in terms of the required process steps and their characteristics, and thus proactively coordinates its own production using negotiation or other processes. From a company-wide perspective, depending on the order situation, it is possible for manufacturers to flexibly and automatically integrate external production capacities as services without using their own investment funds.

On the other hand, you can also offer your own means of production and thus increase the utilization of your production.

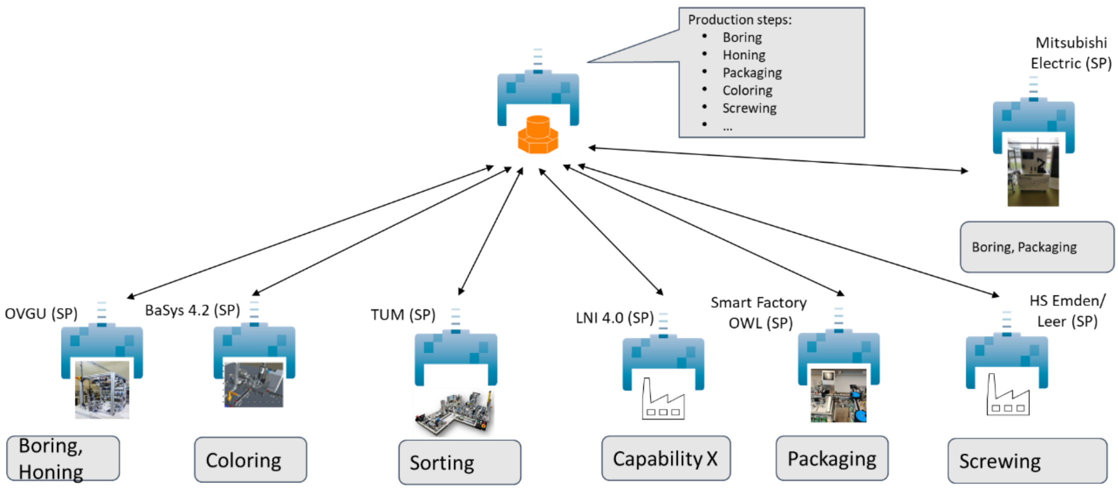

Figure 12: Vision of the German wide Demonstrator of order driven production (Project "AAS networked" / OvG University Magdeburg)

A prerequisite for fulfilling this use case is the creation of dynamic relationships between the providers and consumers of these services. One way to achieve this is the use of administration shells, the **Industrie 4.0 language** and the **interaction protocol "tendering procedure"** both based on current standards.

As a further result of the "AAS networked" project the Industrie 4.0 language was developed. The I4.0 language is intended to unify / standardize the interactions between I4.0 components.

It is not a formal definition of another communication protocol. Rather, it is a language in the linguistic sense that describes various aspects of communication. Regardless of the communication protocol used, the three language components "vocabulary", "message structure" and "interaction protocols" are introduced.

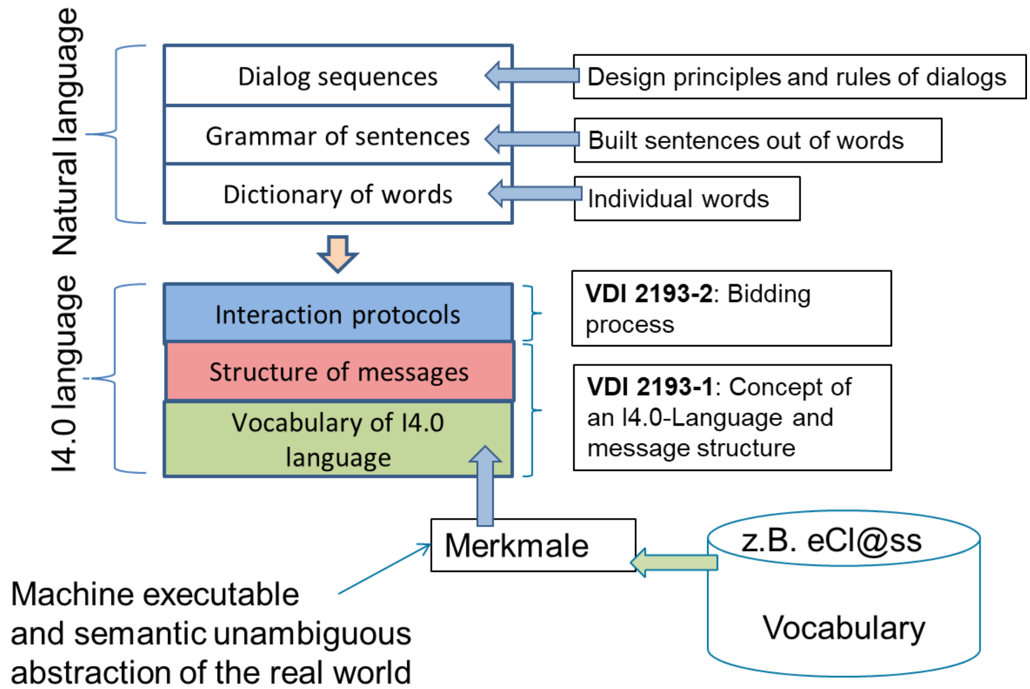

Figure 13: Generic overview of the Industrie 4.0 language (Project "AAS networked" / OvG University Magdeburg)

The insights and experiences gained during the development of the interaction concept were taken into account when expanding the concept of the administration shell.
The concept of supposedly proactive administration shells was supplemented by an **interaction or dialog manager.** The interaction manager implements different interaction patterns that are supported by VWS and controls the dialog flow.

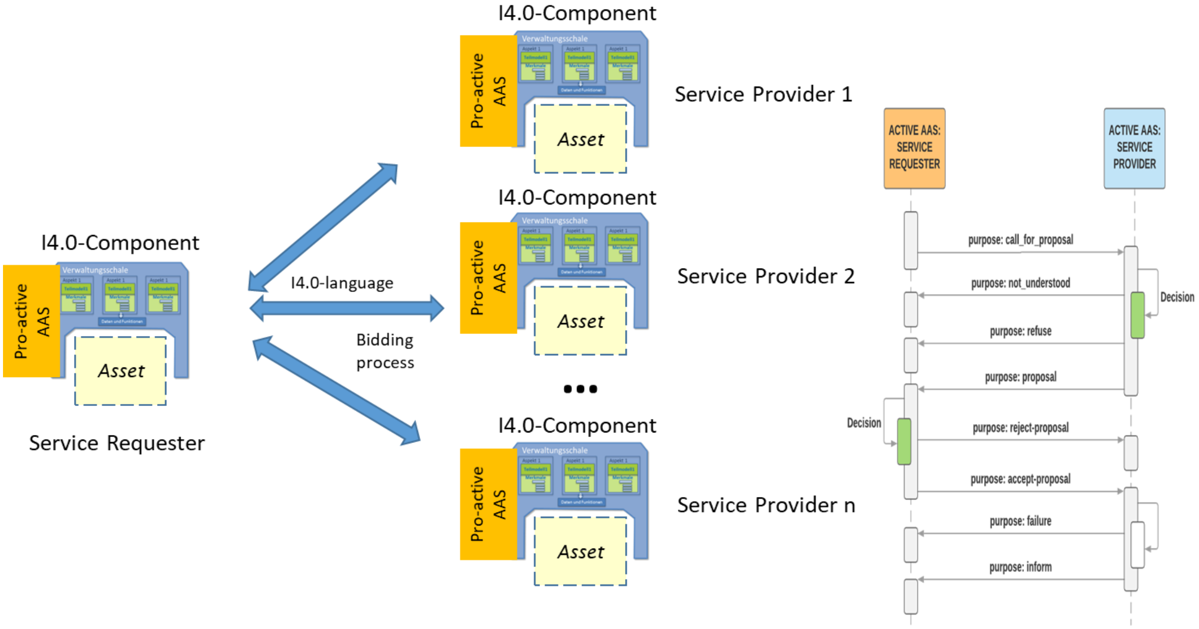

Figure 14: Interaction principle (Project "AAS networked" / OvG University Magdeburg)

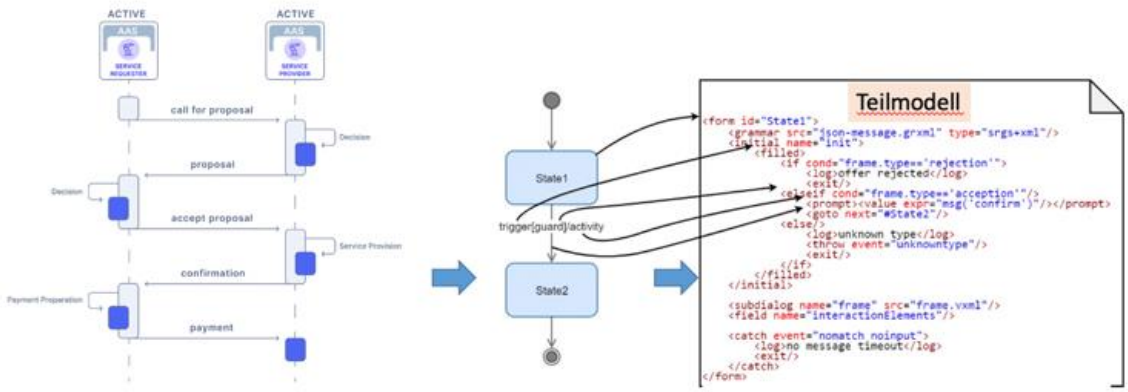

Figure 15: Formalized description of any, sometimes also specific interaction patterns (Project "AAS networked" / OvG University Magdeburg)

For the implementation of the AAS there is an **infrastructure** required, which requires a registry, an authentication server and a repository.

Administration shells can be designed as a file, with a classic client-server interface (reactive VWS) or as a proactive administration shell.
While the file-based VWS can be managed in file folder systems, the reactive/proactive VWS each require a runtime environment via which they can make their interfaces available. The **AASX server**

is one way to provide this software infrastructure.
There can be several administration shells in the AASX server, so that access is possible via an interface and VWS repositories are also created.

The security reference implementation of the" AAS networked" testbed is used for practical testing of the security concepts for AAS including **authentication**, based on the discussion paper "Secure Download Service" from the Industrie 4.0 platform.

A registry for the AAS implemented according to the LIA Registry Semantic Protocol offers several AAS the possibility of storing their communication endpoints in the registry in order to make them retrievable for other AAS.

Access is based on the ID of the registered AAS. In addition, the **registry** offers an optional online administration of the registered AAS in order to ensure that the other AAS stored in the registry can be reached. According to the concept of semantic protocols, the communication between the registration AAS and the AAS using the registration is done by exchanging messages according to the I4.0 language.

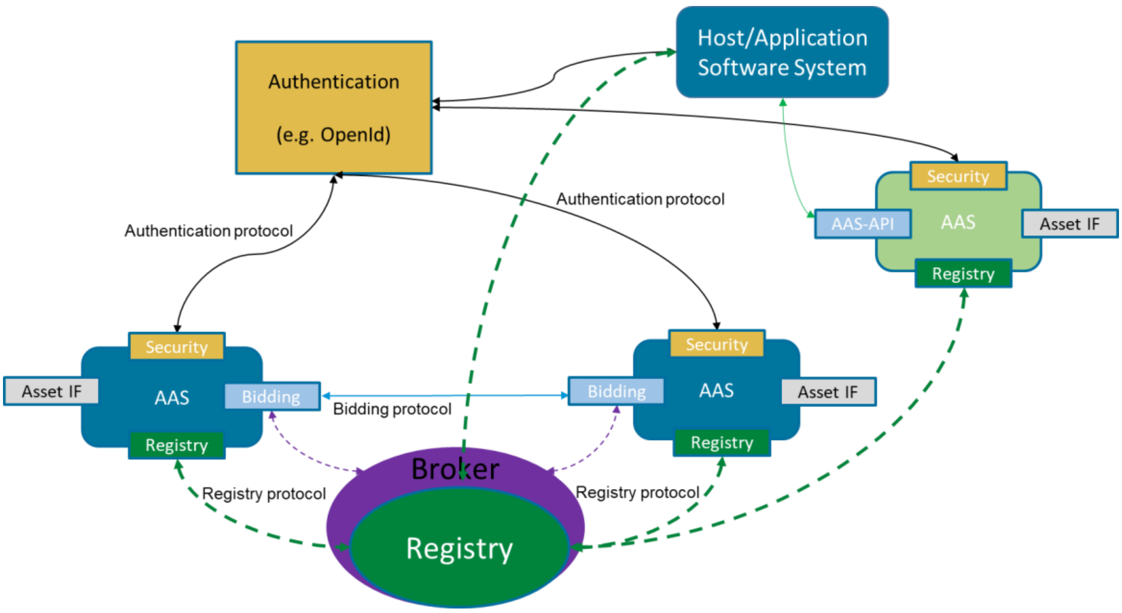

Figure 16:
Overview of the administration shell infrastructure (Project "AAS networked" / OvG University Magdeburg)

Stage 2 of the project "AAS networked" is to build-up of an international network of connected AAS demonstrators.
The targets of this international AAS demonstrators are to leverage synergies and experiences between the participants in the evaluation and testing of different Use Cases (based on AAS Types 1,2,3), to test a network between internationally distributed locations and entities and to test the integration into different shopfloor environments!

You are cordially invited to participate in this international demonstrator! Refer to figure 17.

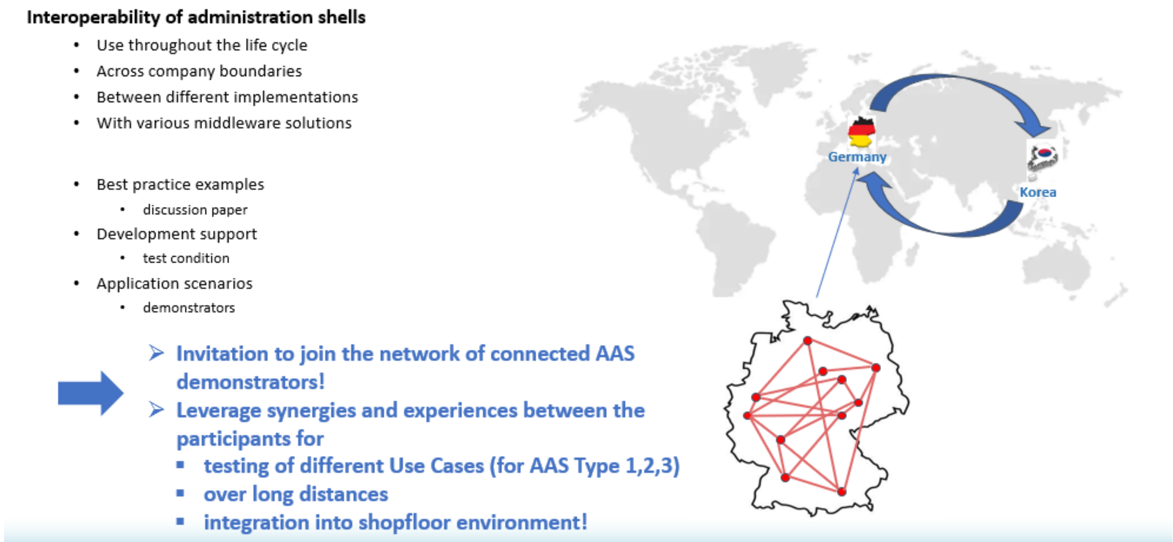

Figure 17: Invitation to Korea to join the project AAS networked (LNI 4.0 + Project "AAS networked" / OvG University Magdeburg)

<u>Contact information for the project "AAS networked":</u>
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3.4. Example Project "BaSys 4.2"

https://www.eclipse.org/basyx/

The **project BaSys** 4.2 develops the **open-source Industrie 4.0 middleware Eclipse BaSyx**. Eclipse BaSyx is the open-source platform for next generation automation. It implements key concepts defined by Platform Industrie 4.0, such as the Asset Administration Shell as standardized foundation for digital twins. Our mission is to provide a free software platform that enables all interested parties, large and small companies, research institutes, academia, and interested persons, to participate in and to shape the fourth industrial revolution to:

- Realize Industrie 4.0 ecosystems with digitized value chains and digital twins
- Support the efficient production of small lot sizes
- Enable quality and compatibility assurance of Industrie 4.0 solutions
- Provide a platform to share knowledge and experiences regarding the Industrie 4.0

As Industrie 4.0 is a software revolution, we provide the necessary open-source and free software components for setting up a compatible and standard conforming Industrie 4.0 solution, and to develop software products.

The basis for the offer of the open-source and free software components is the following generic system architecture:

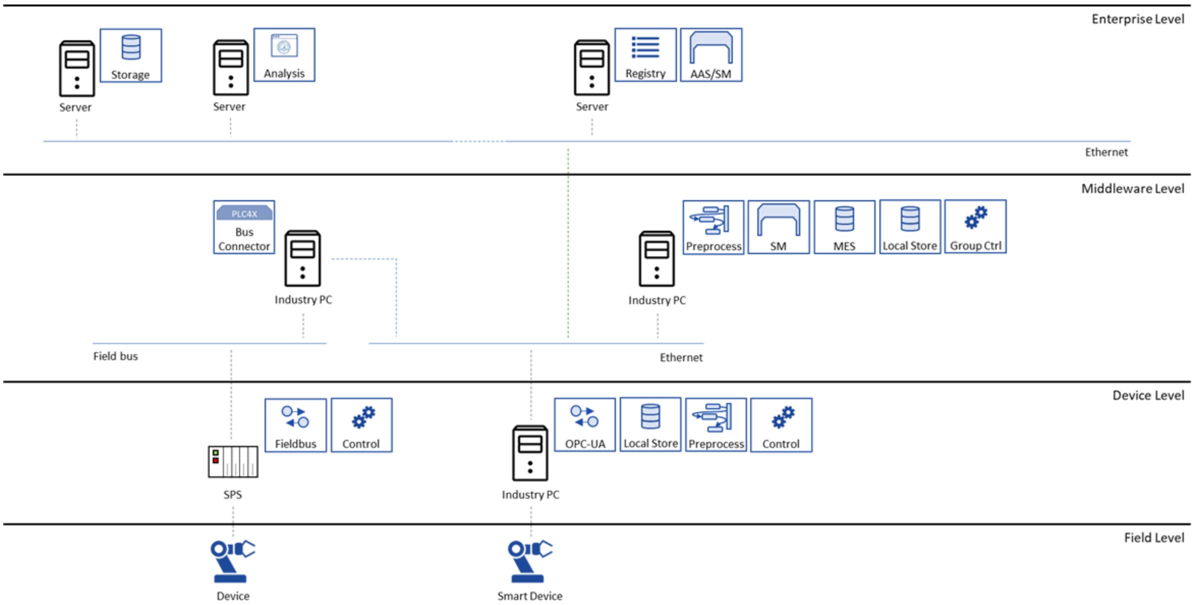

Figure 18: Generic system architecture of the middleware Eclipse BaSyx (Project Basys)

In order to support users all over the world to make Industrie 4.0 happen, the open-source Eclipse BaSyx middleware realizes the following major components and provides reference implementations as containers:

- **Asset Administration Shells (AAS):** Asset Administration Shells (AAS) are the foundation of the Digital Twin with unified interfaces for all kinds of manufacturing assets. Eclipse BaSyx supports type 1, 2 and 3 AAS that enable static data, live data, and active negotiations.
- **Decentralized deployments:** AAS sub models implement specific data models and services that structure different use-cases. AAS sub models tailor the generic AAS to the specific needs of an asset.
- **Repository server:** The repository server hosts Asset Administration Shells and sub models. Eclipse BaSyx supports the distributed deployment of AAS sub models to different repositories, and thus enables data-preprocessing and data storage close to the process, if necessary.
- **Registry:** The registry locates AAS and sub models based on its ID, and connects to the repository that hosts an AAS or a sub model. Eclipse BaSyx registries support the dynamic registration of assets and therefore can track digital twins that follow the product through the manufacturing process.

Data provider: Connect your existing OPC-UA, MQTT, and http servers, and integrate legacy field bus systems such as Modbus and Ethernet/IP. Harmonize all your data sources in AAS sub models.

- **Control components:** Control components provide a harmonized interface for accessing device services and provide feedback regarding a device state.
- **Orchestrators:** This optional component enables the efficient production of small lot sizes. It orchestrates individual manufacturing processes for products based on product descriptions (recipes) and calls AAS services or invokes control components to control the production process.
- **Technology compatibility kits (TCK):** The TCK ensures API compatibility of Industrie 4.,0 components. Currently, TCKs exist for AAS, AAS sub models, repositories, and registries.

- **Software Development Kits (SDK):** Do you want to develop and Industrie 4.0 application that uses Asset Administration Shells and Sub models? Or do you want to develop an entirely new Industrie 4.0 component? Our SDKs give you a head-start!

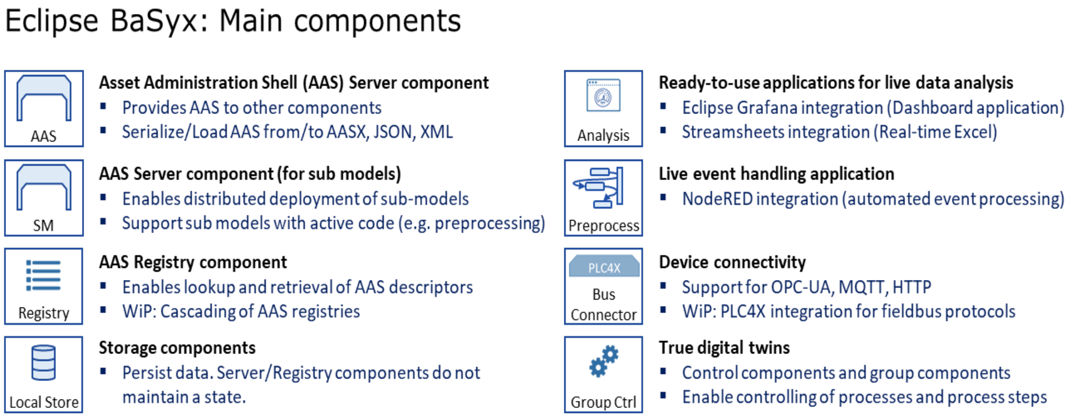

Figure 19: Eclipse BaSyx reference implementations as containers (Project Basys)

We want to provide a platform for the continuous exchange of experiences with Industrie 4.0 – using Eclipse BaSyx or any other software. We therefore organize exchange workshops where interested parties discuss and chat about their experiences with the digitized production.

Contact information for the project "BaSys 4.2":

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Division Manager Embedded Systems
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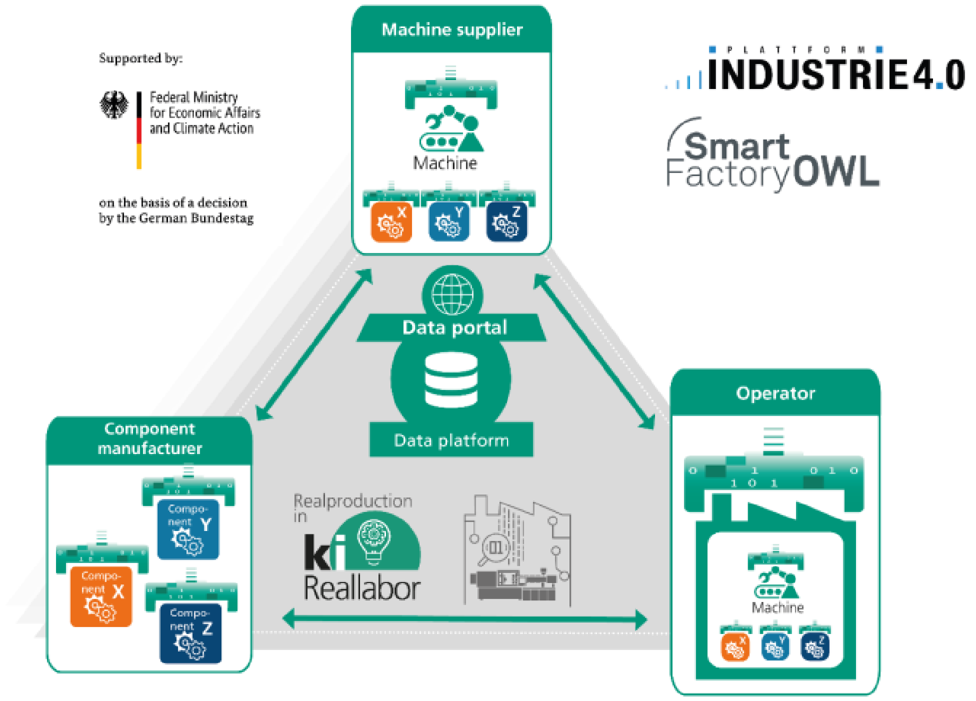
3.5. Example Project "AI Real Lab of the Smart Factory OWL"

Plattform Industrie 4.0 - Collaborative data-driven business models: Collaborative Condition Monitoring – How cross-company collaboration can generate added value (plattform-i40.de)

In the AI Real Lab of the SmartFactoryOWL the use case "Collaborative Condition Monitoring (CCM)" was created. The aim was to answer the question of how CCM (Collaborative Condition Monitoring) can generate added value in cross-company cooperation.

The answer was Share and use data across company boundaries:

- Creating added value through multilateral data sharing
- Share and use operational data in the form of time series
- Testing of Gaia-X Federation Services1 based on W3C2 technologies in a realistic production environment
- Authentication via Gaia-X Identity & Trust using Decentralised Identifiers (DID) and Verifiable Credentials (VC)
- Increase discoverability and usability of data (Gaia-X Federated Catalogue & AAS Registry)



Source: Based on Plattform Industrie 4.0

Figure 20: Overview of the scenario for cross-company cooperation (SmartFactoryOWL / IDTA)

The use case "Collaborative Condition Monitoring" (CCM) deals with the collection and multilateral sharing and use of operating data, among other things, to optimize the reliability and service life of machines and their components in a value network consisting of component manufacturers, machine manufacturers and machine operators. Machines typically contain different components from different manufacturers. One of the challenges is to find the components in operation in the IIoT and to be able to access their generated data easily and securely.

AAS enables cross-manufacturer data exchange and reduces data engineering efforts

The variety of products in operation leads to a high degree of heterogeneity in terms of communication technologies and information models. This is accompanied by high efforts for so-called data engineering (data integration, building up data understanding, data pre-processing, etc.). The Asset Administration Shell (AAS) reduces these efforts: As a standardized Industrie 4.0 interface, it enables simple data integration (e.g., via REST API) and as a standardized Industrie 4.0 information model, it offers the possibility to semantically annotate operational data and make it machine-interpretable. This enables new services such as AI solutions to automatically connect data sources with the appropriate services.

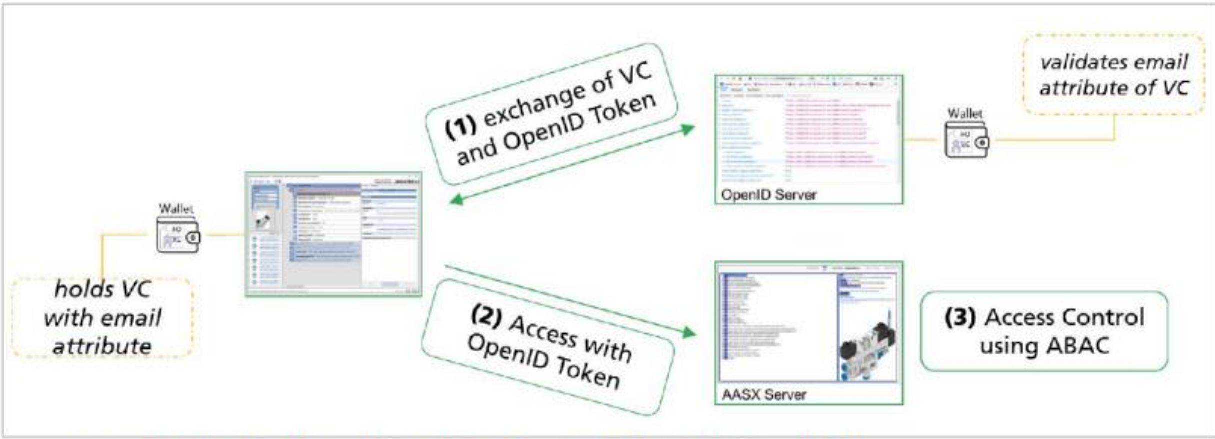
GAIA-X Federation Services enable a trusted data space for Industry 4.0

In addition to the basic requirement of interoperability by means of an Asset Administration Shell (AAS), multilateral data exchange is based on a trusted data space.
The Gaia-X Federation Services describe a toolbox consisting of the areas "Identity & Trust", "Federated Catalogue", "Sovereign Data Exchange" a Verifiable Credentials (VC) and "Compliance" to build trust and interoperability and ensure that participants retain sovereignty over their data. They form the basis for the Industrie 4.0 data space.

In the area of Identity & Trust, CCM relies on Self Sovereign Identities (SSI) 3and the Trust over IP (ToIP) 4stack, for example.
Access control uses attributes from so-called Verifiable Credentials, which can be issued and verified decentrally and sovereignly by the parties involved in the value network. This makes it possible to include new types of attributes that could not previously be mapped with the X.509 standard.

AAS applications exchange this information via so-called SSI digital wallets. It is even conceivable that each asset or its AAS has its own wallet to hold, issue or verify required proofs and further attributes. The only basic requirement is a connection to a corresponding SSI digital wallet.
In order to exchange historized data as a CSV file in a performant, sustainable and interoperable way, a tailored sub-model defines important semantic enrichments to exclude implicit interpretations and to define an explicit mapping between operational data and column entries.

The AAS Registry is another building block that enables the discovery of administrative shells. Conceptually, however, the Gaia-X Federated Catalogue is also considered, which is an even more powerful tool that allows complex queries.



Access control using SSI technology with existing OpenID authentication infrastructure
The OpenID server can verify that the VC was issued by the component manufacturer and has not been modified.

Figure 21: Usage of the toolbox from Gaia-X Federation Services (SmartFactoryOWL / IDTA)
(VC = Verifiable Credentials, ABAC = Attribute Based Access Control)

Contact information for the project "AI Real Lab of the Smart Factory OWL":
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KI Real Labor Lemgo
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3.6. Example Project "AAS for Brownfield"

The objective of the project "AAS in Brownfield" is the implementation of the AAS in a typical Brownfield environment of a shop floor.
An existing production line - a Demo Center of the Center Mittelstand digital in Hanover - was used as a typical representation of a Brownfield shopfloor. The case of this shopfloor is the production of a ballpoint pen.
This production line consists of different machines with different tasks and maturity levels regarding "smart" data networking.

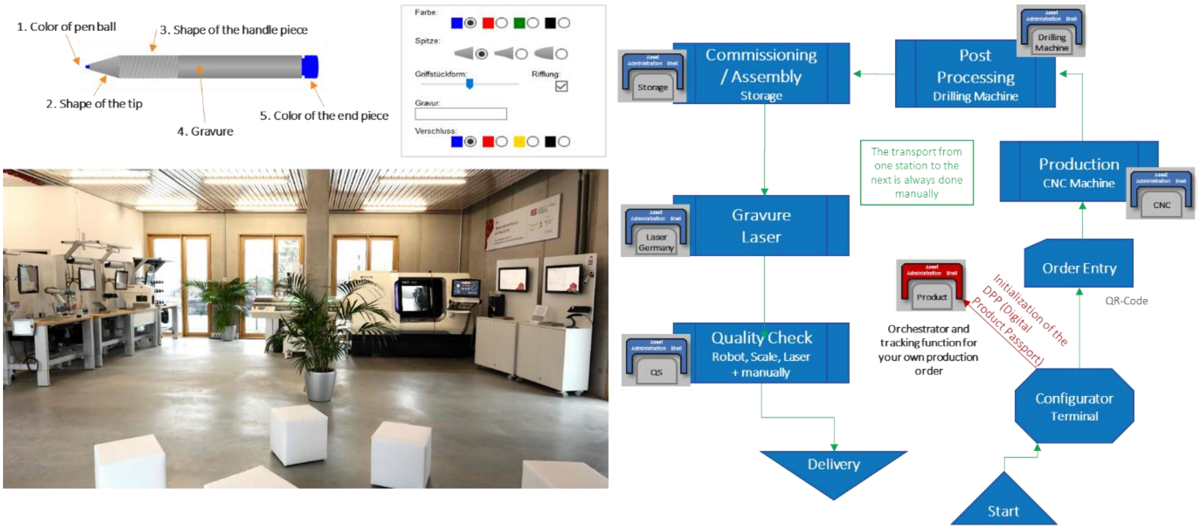

Figure 22: View into the Demo factory and general concept for the AAS (LNI 4.0 and Center Mittelstand digital in Hanover)

As the AAS becomes an integral part of the entire organization, the general starting point for integrating an AAS in a brownfield as well in a Greenfield environment are the questions:

- **Why?** What is the target, which I want to reach with the implementation of the AAS?
- **How?** How can an efficient and appropriate approach to realizing/implementing the AAS look like?
- **What?** What has to be done in detail for the integration of an AAS?

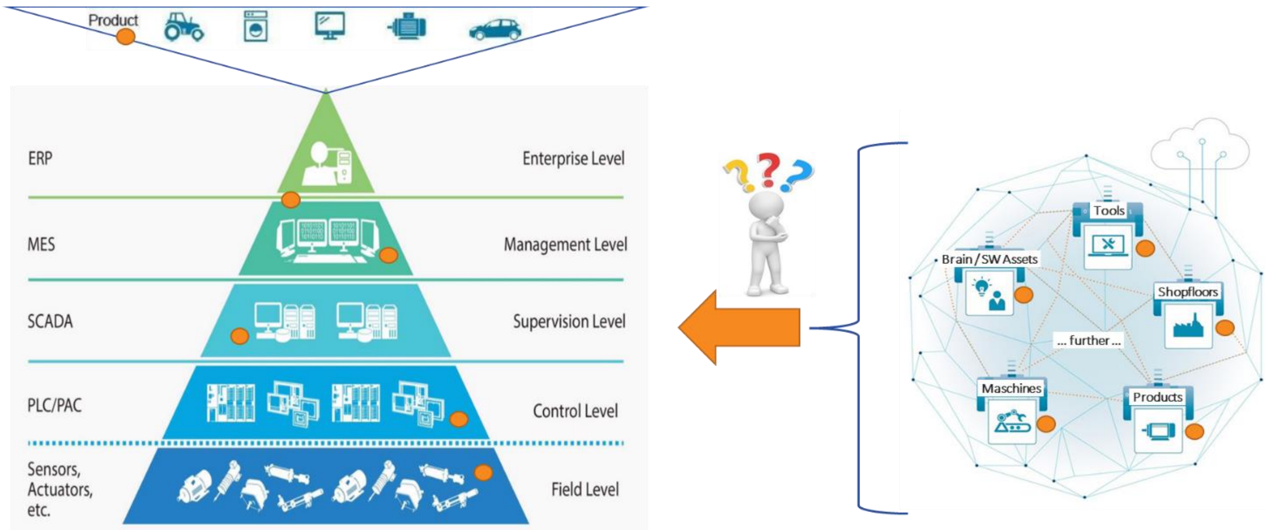

Figure 23: AAS as integral part of a company (LNI 4.0 and Center Mittelstand digital in Hanover)

If you look at this complex structure, there is a navigation needed, that should be worked through step by step in order to be carry out an AAS integration holistically.

---

0. Why? Why and for what purpose will the AAS be used / implemented?

a. Where are you today with your company in terms of global interoperability?
b. Where do you want to be with your company?
c. What is the way there? What contribution does the AAS provide on this path?
d. What values/impacts and benefits do you want to gain from using the AAS?

1. Expansion level of the AAS - which expansion level of the AAS should be used for your purpose?

a. Type 1 – Passive AAS as a file
b. Type 2 – Reactive AAS with API to (superordinate) information models
c. Type 3 – Active AAS which supports I4.0 language
d. Is there a gradual update from one type to another possible? With what effort?

2. As-is systems - with which the AAS should be integrated or cooperate?

a. What existing target systems are there in your specific brownfield / shop floor?
b. Which other applications run via the network in your specific brownfield/ shop floor and with what priority, time criticality and workload to the network?
c. Which data models are already being used in your specific brownfield/ shop floor?
d. How does data contracting between the different systems take place? (Data usage rights, data security agreement, ...)
e. Which interfaces are used to integrate the AAS into the existing Brownfield systems, or which interface requirements must be met?
f. Which data storage systems / repository structures already exist in your specific brownfield/ shop floor?
g. How is the workflow orchestrated and which orchestration platform is suitable for this?
h. What do today's existing data backup routines look like? (High level, administrative)

3. Assets – to be included?

a. Which descriptions and data models are already available for the respective assets?
b. Which data is available from which source (digital, analog-from the asset clamp, etc.)? in what quality? At what frequency?
c. Where is this data delivered to? Where is this data stored today? (Asset-related, centrally, cloud, etc.)

4. Networking on the existing brownfield/ shop floor?

a. How are the assets integrated into the shop floor communication today? (Which protocols and interfaces are used, etc.?)
b. What network segmentations exist on the shop floor and at what point are they controlled? Which communication has proven to be the most suitable for your specific brownfield / shop floor - taking into account the requirements from the AAS?

5. Products - to be included in the AAS installation?

a. What data must be delivered from the shop floor (from the machines, etc.) to the product / the product AAS?
b. What are the differences if the product is HW or SW?

6. AAS – Specifics

a. Which AAS components are required for the integration into your specific brownfield/ shop floor?
b. How and where are the individual AASs re-used, which are generated and used on the shop floor?
c. What are the AAS repository requirements for the storage system in your existing brownfield / shop floor?

7. Networking between different Brownfields / shop floors?

a. How can the shop floors be networked with each other?
b. How can a tender for production orders be carried out directly between shop floors via the AAS?

8. Make or Buy

a. What absolutely has to be done in and from of your specific brownfield / shop floor?
b. Which components of the AAS can already be booked / purchased as a service on the market?

Figure 24: Navigation Guide - status April 2022 – work in progress (LNI 4.0 and Center Mittelstand digital in Hanover)

After working through all these questions of navigation - the resulting system overview for the concrete brownfield shop floor in the "Demo Center des Center Mittelstand digital" in Hanover is the following - including many detailed notes and comments for the AAS implementation but also for the update of the shop floor to be 'smart'.

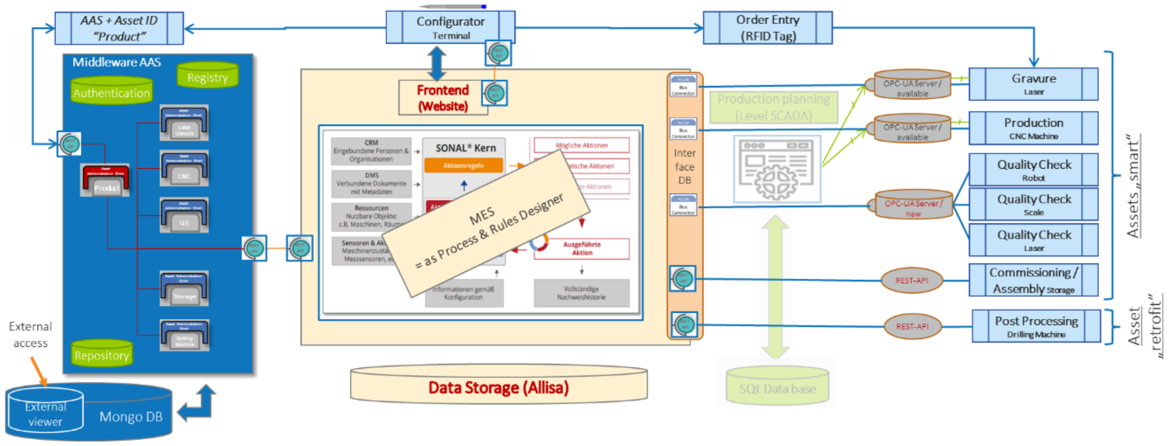

Figure 25: System Overview of AAS-integration into a brownfield Demo factory (LNI 4.0 and Center Mittelstand digital in Hanover)

As a general conclusion - a specifically tailored installation of the AAS is not just another tool, but above all represents an entry point into the future Industrie 4.0 and must therefore support the future role of your company in Industrie 4.0!

- **Why**? Support and realize the role of your company in Industrie 4.0 by using the AAS!
- **How**? Define a specific approach for the implementation of the AAS in your company!
- **What**? Specify in detail the best-fitting implementation for your specific brownfield!

Contact information for the project "AAS for Brownfield"":

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4. The strategy of Smart Manufacturing in Korea

4.1. Vision of Smart Manufacturing Innovation

The vision of smart manufacturing innovation is to sell products produced by Korean manufacturing companies in the global market to obtain a lot of profit, and to distribute the profits to employees to improve the quality of life of employees. This will enable the people to lead a more prosperous and leisurely life.

The government has established a three-step strategy. The key KPI is to raise the national status by raising Korea from 5th to 4th in the global manufacturing competitiveness comparison ranking by 2030.

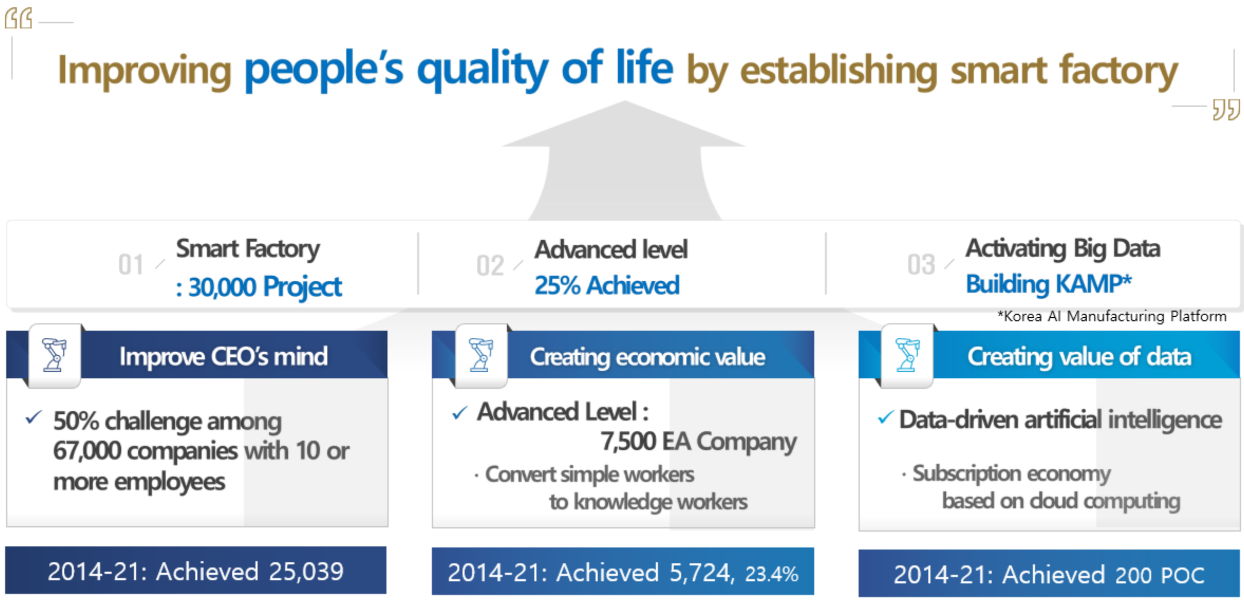

Figure 26: Vision and strategy of smart manufacturing innovation in Korea (Smart Manufacturing Innovation Policy (KOSMO)

4.2. Smart Manufacturing Innovation Promotion Strategy

In the second stage, the smart factory construction support project, which started in 2014 as the first phase, supports 30,000 companies, 50% of which are 67,000 SMEs. This can be said to serve as a starting point for employees working in SMEs to have a challenging spirit to respond to "the new manufacturing era of the 4th industrial revolution" and to feel confident to achieve results. In particular, the 7,500 companies (25% of 30,000 companies) are focusing on raising them to the advanced level.

In the second stage, the "Korea AI Manufacturing Platform" KAMP was built exclusively for SMEs to collect and store manufacturing raw data in the cloud computer while building a smart factory from 2020 and introduce and utilize AI solutions.

In the third phase, the current government's national tasks will be completed in 2022, and in preparation for the new government, a new smart manufacturing innovation policy is being established to build a digital economy system centered on SMEs for the next 50 years.

The main content is predicting the lifespan of products produced by SMEs and establishing policies around the business of developing future foods and pioneering new markets.

4.3. The status of smart manufacturing innovation

Looking at the progress of the first stage smart factory construction project, the smart factory cannot be achieved with a single investment project, so the maturity level of the smart factory is set to level 4 and is being promoted.

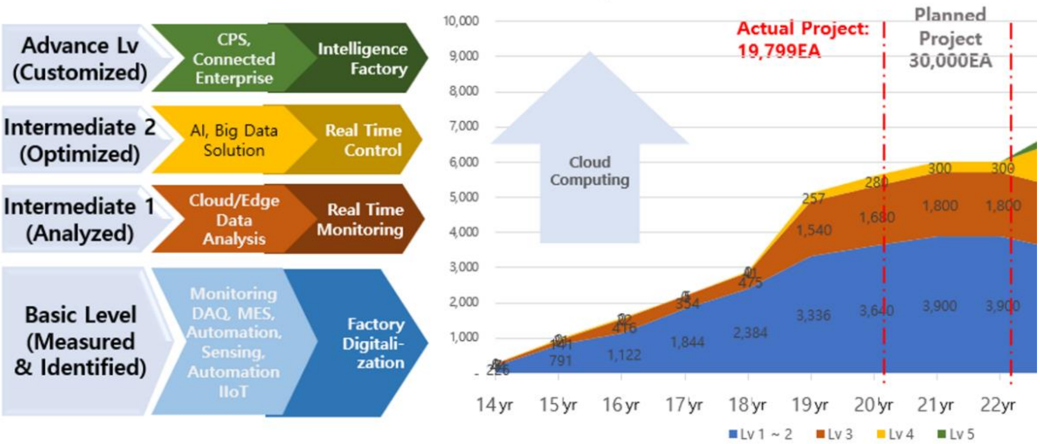

Figure 27: The status of smart manufacturing innovation in Korea (Report of KOSMO)

The Basic Level is to partially automate the production of products by hand, with the computer replacing what was written by a human. Implementing factory and office automation by introducing solutions such as robots and MES to the production floor. As a result, it is a business that converts simple workers into knowledge workers.

Intermediate 1 Level collects all data measured from automated facilities in real time, stores it in a big database of cloud computing, observes all places in each production site in real time, and finds improvement points and takes the action.
This is the stage of converting labor-intensive processes into technology-intensive automated factories and introducing ERP systems to transparently manage financial and accounting information.

Intermediate 2 Level is the stage to introduce and operate the latest solutions such as Big Data, AI, and AR/VR to utilize the data collected and stored at the factory. The AI brain takes over the 24-hour monitoring, analysis, and action of the human, and the human sees the result of the AI judgment, then finally makes a decision and takes action quickly.

The last Advanced Level is the Connected Enterprise stage, which builds AI-based smart factories for each company and creates autonomous production factories that create new values by sharing necessary information among value chain companies.

If you look at the performance of each company promoted until 2021, most of them are at the basic level, and 23% are at the Intermediate 1st and 2nd level. From 2021, we will focus on investing in manufacturing companies that are in the basic stage and strive to raise more than 25% of the companies to the advanced level by 2022.
The quantitative results of the research and analysis of 7,903 tasks carried out for 5 years from 2014 to 2018 are as follows. There were many process improvements, such as a 28.5% increase in productivity, 42.5% in quality improvement, 15.5% in cost reduction, and 16.4% in delivery time.
As for employment, the average company increased by 2.85 people, resulting in 19,431 new hires (6,818 introduced companies x 2.85 people), and sales also increased by 7.4%. The industrial accident rate decreased by 6.1%, resulting in management improvement.

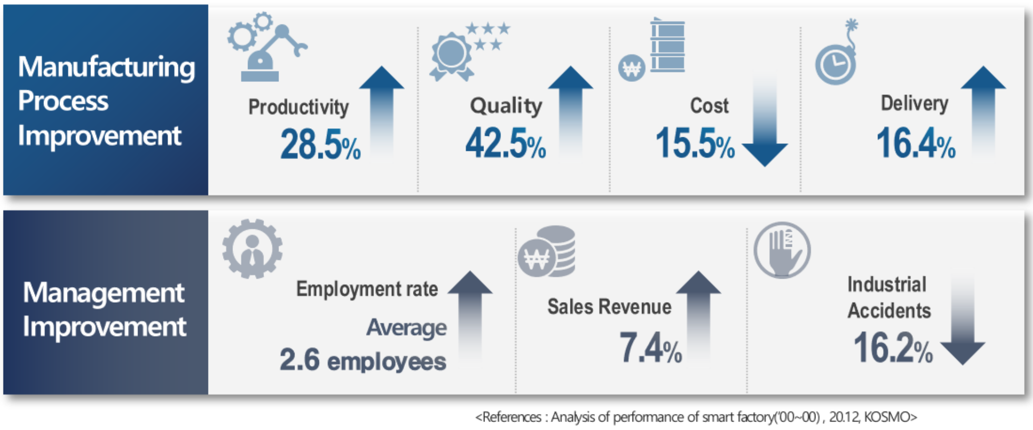

Figure 28: Results of Performance Analysis (KOSMO)

Looking at the characteristics of Korean SMEs, the number of companies that produce finished products and sell them to consumers is small, and most SMEs are LSE's parts manufacturing partners that produce finished products and are in the Tier 1 to 4 stages. Even if productivity increases by 28.5% by building a smart factory in these SMEs, sales increase by only 7.4%. This means that, no matter how high the productivity, the more products are produced, and the direct sales and linkages are very small unless more finished products are produced.

In order to solve this problem, from 2021, we have created and supported a digital cluster project that builds smart factories centered on SMEs in the supply chain that supply parts mainly for finished products. It has been building a smart factory at Level 4 or higher for 3 years between a representative company and a subcontractor in the supply chain. By sharing necessary data among these companies, they are building and operating a smart manufacturing joint platform that can zero inventory and improve quality and yield.

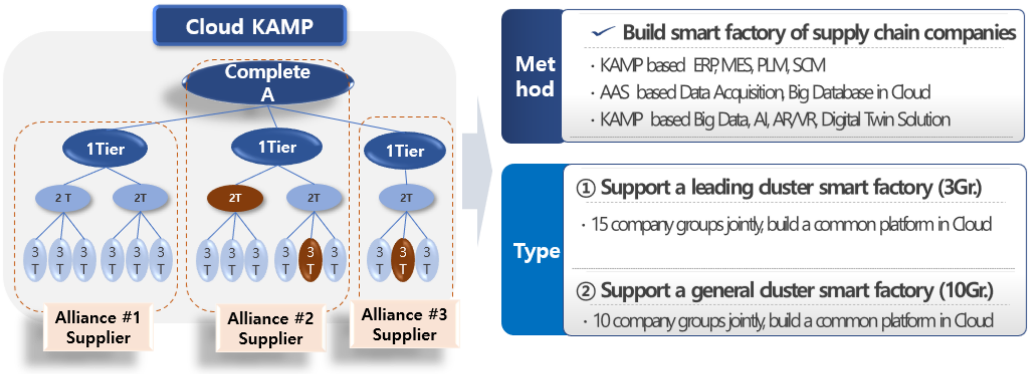

Figure 29: Platform-based Digital Cluster Program (KOSMO)

Overall, the economic effect of building a smart factory is as follows.

4.4. Three steps toward the smart manufacturing for Industrie 4.0

First, creation of process improvement effects by building a smart factory

The MES system replaced the tasks of performing simple repetitive tasks at the production site or office, that is, production planning and real-time performance management, and the ERP system for cost, finance, purchasing, and human resource management tasks.

In addition, a PLM system to design and develop products, an SCM to manage customers and suppliers, and FEMS were introduced to save energy. It is natural to see the process improvement effect of QCD as a result of its introduction. By letting computer solutions take the place of human work, performance is bound to be created. Because the solution replaces people, people can focus on other creative tasks in that time, allowing the company to focus on more sustainable development. QCD improvement activities for companies that produce existing products are a keyword that companies must continuously innovate because they improve reliability with customers, create profits by reducing costs, and provide momentum for sustainable growth.

However, Korean SMEs remain at the level of LSE's vertical partners, so they are small because they focus on consignment production that simply processes and assembles rather than develops and sells independent products that can create their own profit model. In this situation, the government supported what SMEs could not dare to dare because they did not have professional manpower, and 6,818 out of 67,000 SMEs built smart factories, creating many achievements. Without the support of the government, small SMEs would not be able to challenge innovation, and LSE would have made a lot of profit by systematically implementing experts centered on continuous QCD improvement.

Second, the change of manufacturing environment from simple workers to knowledge workers

Although there are quantitative outcomes such as process and management improvement, computers and robots are changing life patterns from simple workers to knowledge workers by replacing simple and repetitive tasks on behalf of humans.

From 1954 to 1964, the baby boomers worked more than 16 hours a day to transform a poor country into a prosperous one, greatly contributing to economic development, raising the value of the lives of the Korean people, and approaching the ranks of advanced countries. They educated their children so that they do not work as hard as me, and they have grown into human resources who carry out the mission of continuously growing the country for future generations. However, they do not want to do simple repetitive work on the manufacturing site or 3D work that is dangerous, dirty, and difficult. In other words, the level of value of life is high, so they do not want to do simple work at the manufacturing site.

For this reason, 580,000 foreign workers at the production site come to Korea to work on their behalf and operate SMEs. However, they also do not want to do difficult and dirty work as their level increases. One of the factors that Korean young people are reluctant to work in SMEs is that they do not want to work in a work environment that performs simple repetitive, or 3D work. While building a smart factory, simple repetitive tasks and dirty, difficult, and dangerous 3D tasks were replaced with robots, Automatic Guided Vehicles, automated machines and IT systems on the production site.

What people do in offices or factories is improved by the introduction of automation and digitalization, and as simple workers are converted into knowledge workers, young workers are increasingly seeking employment in SMEs. In the past, labor-intensive industries were mostly processed, assembled, and produced in overseas factories to reduce costs and then re-imported to Korea.
However, as problems in various aspects such as raw material supply and demand increase as we enter the era of Corona 19, innovation in manufacturing and reshoring through somatization are being revealed.

In the end, the manufacturing industry will change to the closest point of contact between producers and consumers, that is, direct production in regions with many users. As the manufacturing and working environment is changing, the ‘smart factory’ is emerging as a key factor.

Third, increase in employment in manufacturing companies

Many people say that the number of manpower should be reduced while building a smart factory, and how does the manpower of manufacturing companies increase? very questionable. The answer is no.

As simple repetitive tasks and 3D tasks are eliminated in production sites and offices, fewer people do simple repetitive tasks. People who used to do simple and repetitive tasks receive education to process tasks using a computer, and by working with a computer, acquire the functions and new skills learned empirically and have a change of mind, and work in a comfortable office. It boosts your abilities, boosts your self-esteem, and lets you do other creative things in your spare time because the computer takes over.

While people feel the desire for achievement, they can remotely monitor the production site, further reduce cost, increase productivity, and create value that increases quality. Knowledge workers can do productive work, can create new businesses, and focus on dreaming of the future, while managers watch employees change and recruit new talents for future sustainability. Smart young people who were previously reluctant to work for SMEs are now improving their work environment, focusing on creative work in offices and labs, and focusing on shaping their future.

In addition, since the company has high productivity and improved quality, secondary parts suppliers that have been supplying only to Hyundai Motor Company are now receiving love calls from global companies such as Benz and GM to supply them. As sales increase, we are introducing smart manufacturing innovations and solutions to expand factories, hire more people, and build more sophisticated smart factories. Therefore, it is natural that the number of companies that have built smart factories is increasing by 2.8 people on average.

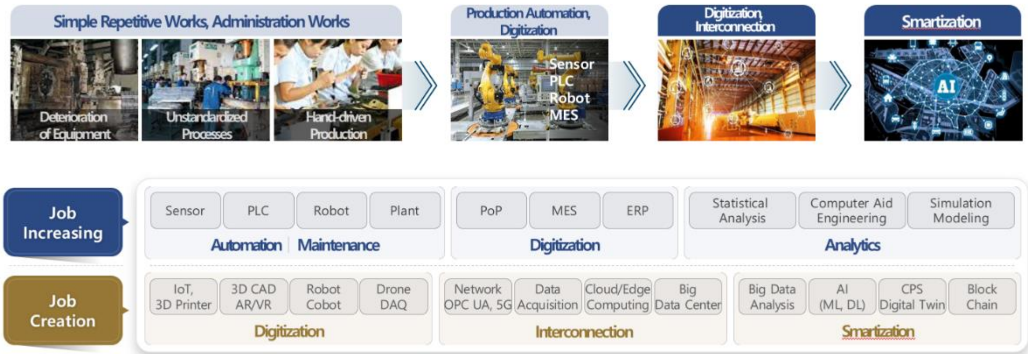

Figure 30: Job Creation Strategy with Smart Factory (KOSMO)

In addition, in the case of a supplier, it is said that it takes 10 manpower for automation and digitalization design, manufacturing, and commissioning to save one manpower for a manufacturing company. Companies that design, manufacture, and supply plants and companies that design and develop IT solutions such as ERP, MES, PLM and FEMS are seeing an increase in jobs as their businesses increase. In order to design, develop, and supply the latest solutions such as IIOT, AR/VR, COBOT, DAQ, AI, Big Data, and CPS to manufacturing sites, many startups are increasing, and new jobs are increasing. As manufacturing companies build smart factories, an average of 2-4 new jobs are created per supplier.

In the second phase, from 2020, we are carrying out the business of operating all computing resources in the manufacturing company's own computer room until now by converting it to a cloud computing environment. If you operate your own computer room, it becomes an economic burden that requires a lot of money to hire IT manpower for production-oriented companies, replace outdated computers every 5 years, introduce security solutions, and operate the computer room. In order to solve this problem, all companies conducting government-supported projects in the future are supporting them to operate at an economical cost with enhanced security by operating computing resources in a cloud computing environment.

In addition, companies with different solutions for each industry collaborate with each other and operate SaaS software that allows “Plug & Play” between solutions as One Package. If ERP is introduced and then MES, SCM, etc. are newly introduced, it is possible to solve the problem of costly communication with the existing system.

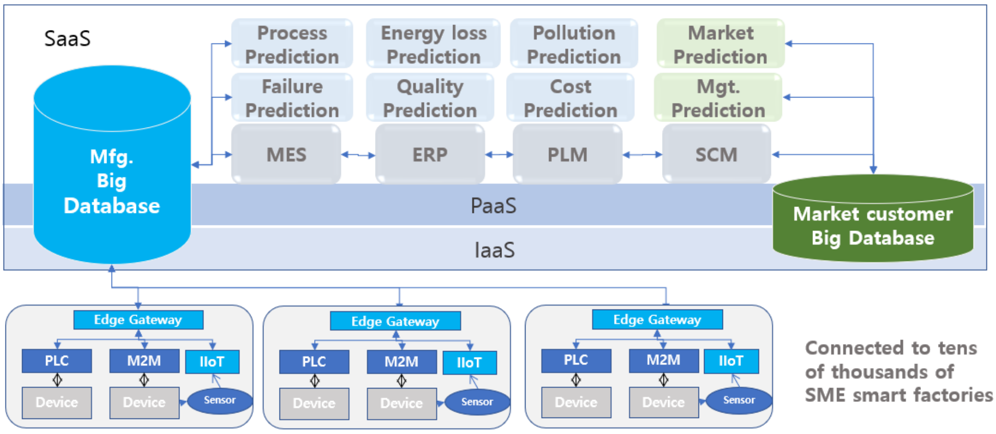

Figure 31: The Future Model of Smart Factory (KOSMO)

The smart factory construction project, which proceeds to the advanced level, automates 3D work or simple repetitive tasks, collects manufacturing raw data measured from automated facilities and processes, and stores it in the cloud computer. When data is accumulated for more than one year, cutting-edge solutions such as AI, Big Data, AR/VR, and Digital Twin are introduced and utilized.

Companies that use similar equipment to collect and store raw data from manufacturing sites have the same sensing items and data properties for each equipment provided by international standard CDD, eCl@ss, OPC-UA information model, etc. AAS (Asset Administration Shell) has been introduced to enable collection and storage. Cloud Service Providers in Korea do not have specialized knowledge and solutions for AAS, so KOSMO creates and provides manuals to create AAS Templates for each equipment and process through fieldbus communication from PLC/DCS systems at manufacturing sites.

In addition, we have developed an AAS-based OPC-UA communication solution that collects and stores data from each company's Edge Gateway PC and transmits it to the cloud computer's big database in real time and is providing it as an open source to suppliers.

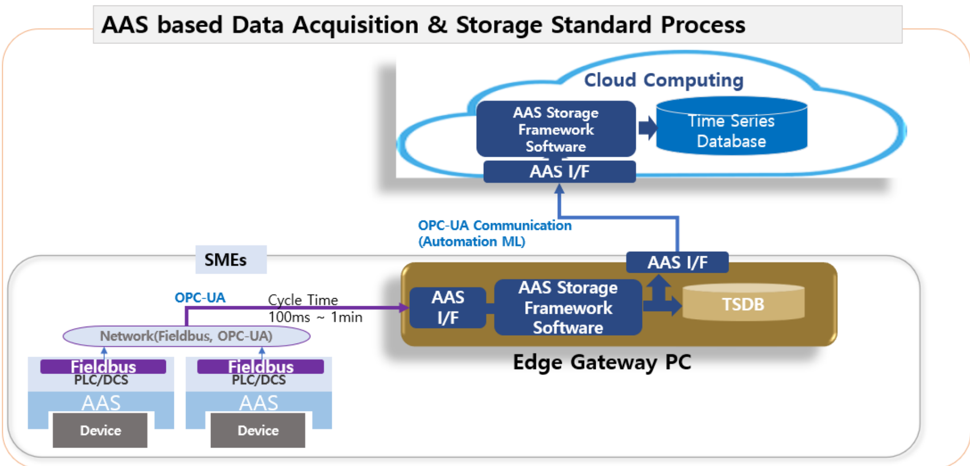

Figure 32: AAS based Data Acquisition and Storage Standard Process (KOSMO)

Smart factories in Korea will build an AI-based decision-making system such as sales/demand forecasting and production scheduling based on data processed in ERP, MES, SCM, FEMS, and PLM generated by manufacturing companies.

In addition, startups will be nurtured to develop solutions that predict equipment and process abnormalities using raw manufacturing data, predict quality based on process conditions, and predict energy loss and environmental pollution based on facility conditions.

By automating 3D, simple and repetitive tasks at the production site, and using Big Data measured from automated facilities, AI solutions are introduced so that AI replaces human monitoring, analysis, and judgment. Humans see the results of AI judgment, make a final decision, and then take action quickly.

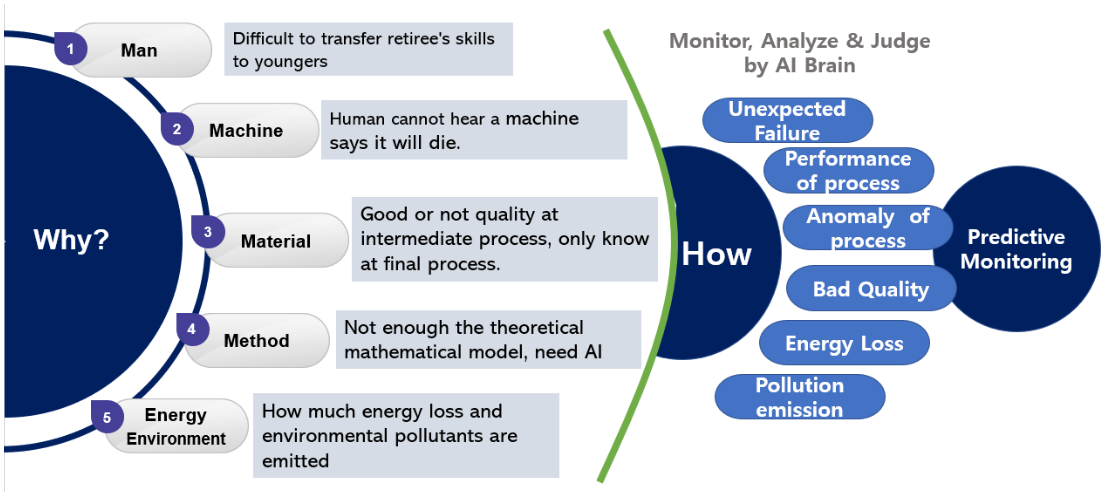

Figure 33: Why, How and What for AI (KOSMO)

4.5. Practical Implementation of Smart Manufacturing – AAS-based Pilot Plant Project

[ENG] A pilot project for AAS based cloud data collection and storage

One of the smart manufacturing strategy goals in the Ministry of SMEs and Startups in Korea is to expand cloud-based data-centric SMEs to up to 30,000 by 2022. However, no standardized data management system currently exists for SMEs in Korea. Without a standard, each SME must spend a considerable cost building its data management system.

Data consistency is of the utmost importance to analyze and utilize the data acquired from different SMEs. With the data consistency, each SME will be free from the dependency of the solution on a specific vendor. In addition, SMEs will share some expensive high-end solutions such as DT (Digital Twin) and AI (Artificial Intelligence) and create new values by sharing data from common equipment or processes of different SMEs.

The Ministry of SMEs and Startups launched AAS (Asset Administration Shell)-based PPP (Pilot Plant Project) in Korea to overcome the obstacle mentioned above. KOSMO (Korea Smart Manufacturing Office), the organizer of the PPP, selected Nestfield Co. Ltd., the first Korean member of the IDTA, as the leading developer of the AAS-based PPP. During the 1st stage of the PPP in 2020, an AAS-based data acquisition and storage system was developed and successfully installed in two pilot plants, Shinwoo Costec and Huons (see Fig. 1).

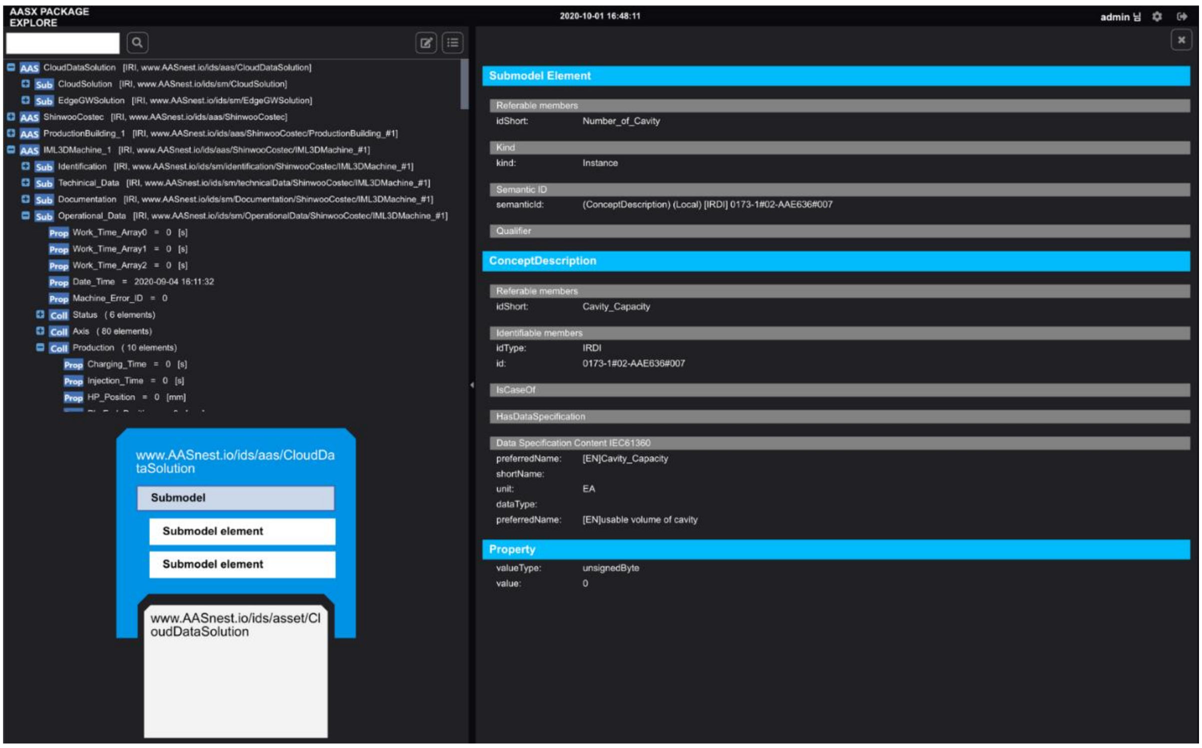

Figure 34: Screenshot of AASX for AAS-based data acquisition & storage *(AAS-based Pilot Plant Project/KOSMO)*

For example, in the case of Shinwoo Costec, we collected data from a single factory consisting of 8 identical equipment. A single piece of equipment consists of eight AAS components, including PET 3D IML, injection machine, blow machine, label machine, product injection mold, blow mold, and label (see Fig. 35). We tested and validated the acquired AAS standard-based operation data and stored them in the cloud. Figure 36 shows an example of real-time data being processed as 2D and 3D graphics and provided in the form of a dashboard. To promote AAS technology to Korean SMEs, we developed and distributed guideline documents to implement AAS-based data acquisition & storage solutions and executed an AAS education program targeted to vendors and users.

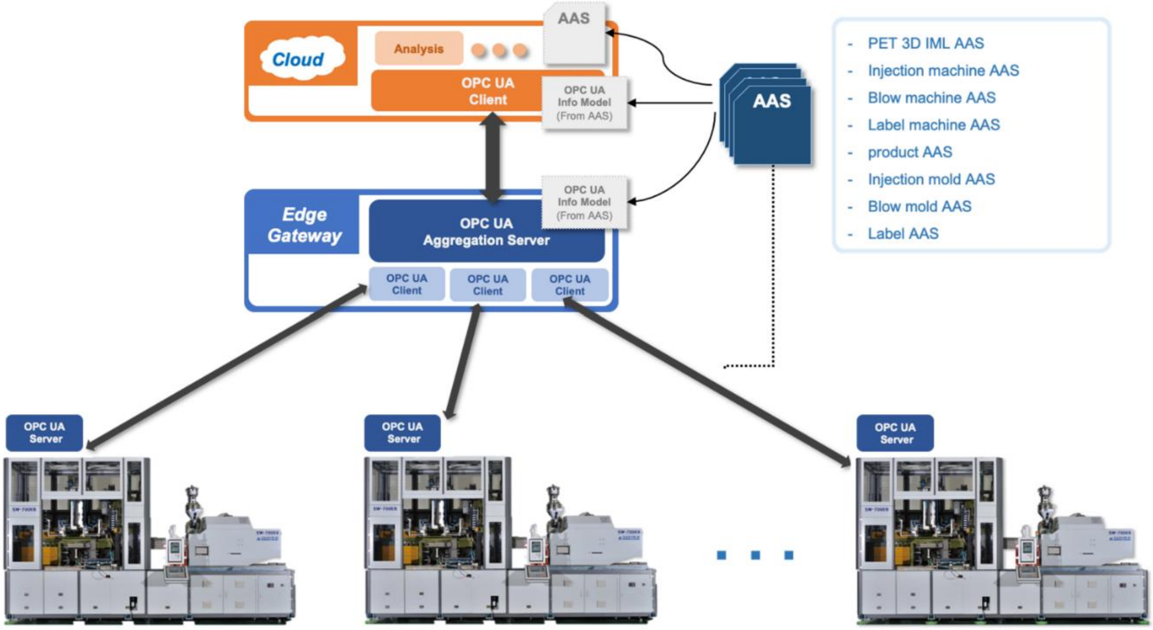

Figure 35: The 1st AAS-based Pilot Plant in Shinwoo Costec *(AAS-based Pilot Plant Project/KOSMO)*

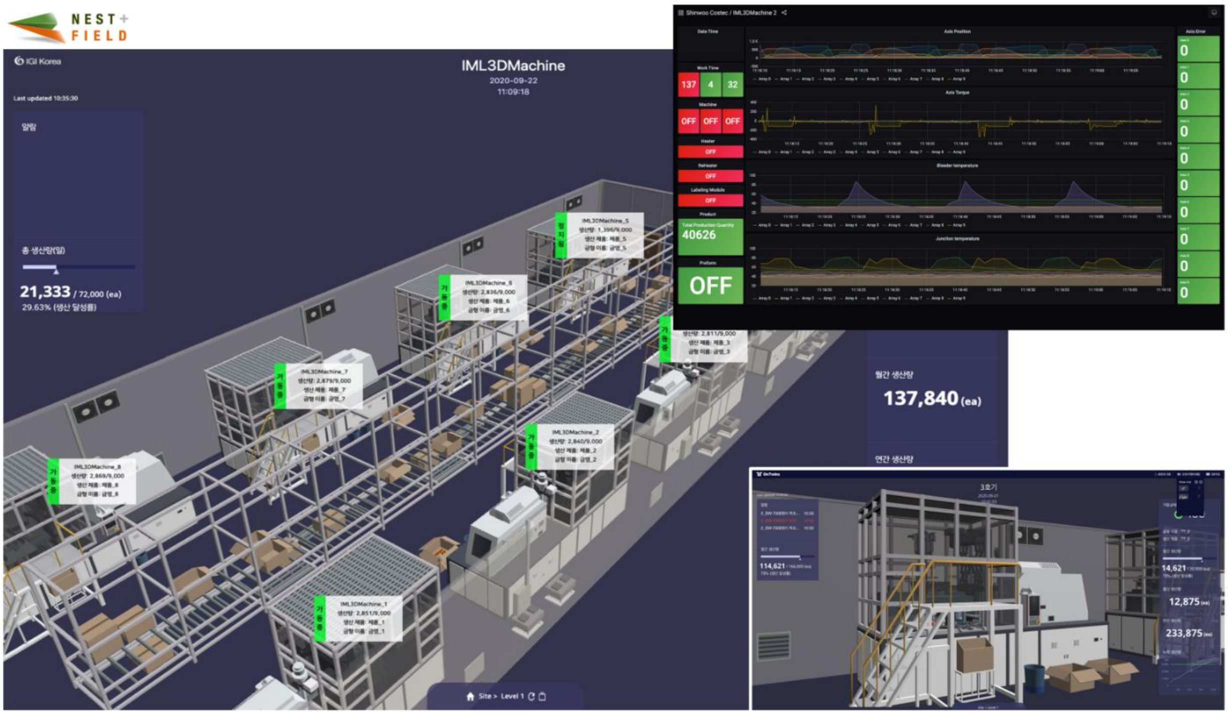

Figure 36 AAS-based real-time data acquisition in the Shinwoo Costec *(AAS-based Pilot Plant Project/KOSMO)*

After the success of the 1st stage of the PPP, we noticed the necessity to expand the advantages of AAS to the whole life cycle of production. In the 2nd stage of the PPP, we plan to expand the development of AAS-based standard technologies to the entire life cycle of the production process, including commissioning, operation, management, prediction, decision-making, control, etc. (see Fig. 37)

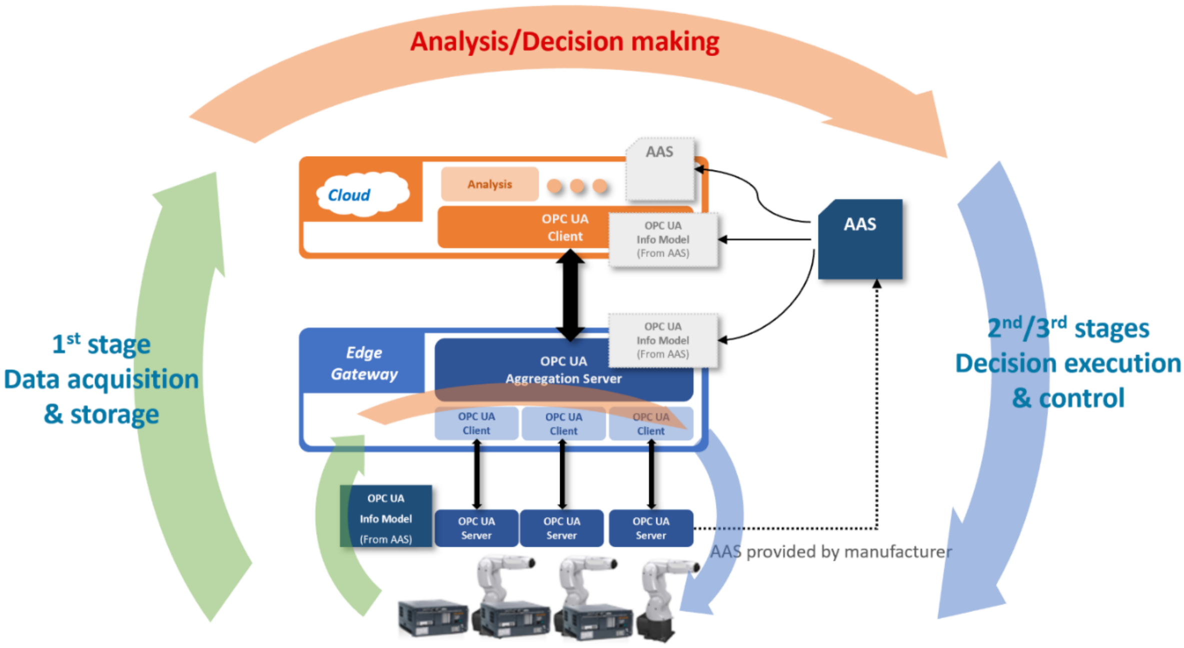

Figure 37: AAS-based data acquisition, storage, analysis, decision-making & execution *(AAS-based Pilot Plant Project/KOSMO)*

In the 2nd stage of the PPP, we also plan to provide an AAS reference model for essential assets in Korean SMEs to promote standardized smart manufacturing solutions effectively. Now, we are building a "Reference AAS model repository" so that various vendors and service enterprises can widely utilize it. We start from the widely used assets which are essential, inevitable, and disruptive potential (e.g., PLC, robots, AGV, CNC, RFID, etc.). To this end, we are currently developing an AAS reference model for a 6-axis articulated robot shown in Fig. 5. In the future, we will expand the scope of PPP to cover a broader type of industry (e.g., injection molding, welding, packaging, thermal treatment, inspection, etc.).

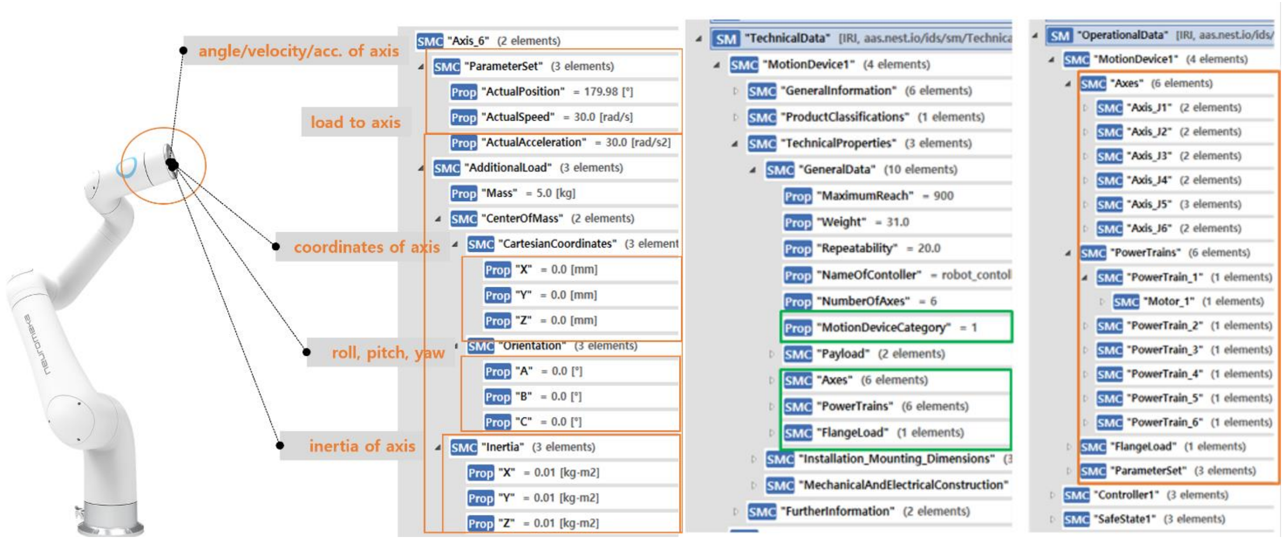

Figure 38: Reference AAS model for a 6-axis articulated robot *(AAS-based Pilot Plant Project/KOSMO)*

By using the standardized AAS technology, the Korean SME customers will be free from the dependency of the solution on a specific vendor, which causes high expenditure for installing, maintaining, and building additional equipment and facilities. Using the off-the-shelve AAS-based components, Korean SMEs will have more chances to access expensive high-end solutions previously exclusively possessed by large companies. Korean SMEs will also reduce the delivery's follow-up service cost by remotely managing and maintaining the product using the standardized AAS interface and improve the competitiveness of the Korean SME manufacturer's products by adopting digital twin technology of AAS-based components.

5. Outlook

5.1. Guiding Principles and cornerstones for Industrie 4.0 interoperability in the cooperation between Germany and Korea

The jointly agreed guiding principles for global interoperability between machines, shop floors and companies essentially consist of 3 points:

1. Sovereignty of the industry in the sense that dependency on central actors is reduced.
2. Alignment with decentralized / individually decided data storage for the producers and users of the data.
3. Use of international standards for referencing and harmonization.

The implementation of the Guiding Principles requires 4 basic cornerstones / common approaches for Industry 4.0, preferably based on the following standards:

a) a uniform identification of the assets (IEC 61406),
b) a unified information model (IEC 63278-1),
c) the use of uniform semantics (IEC 61360-x, library ECLASS / CDD),
d) and the application of well-known and tried and tested techniques in cyber security (OpenID Connect).

Three concrete joint action fields and approaches have been identified to realize the cornerstones:

- Chap. 5.2: Cooperation in the Standardization activities for Industrie 4.0
- Chap 5.3: Jointly driving forward the industrial implementation based on standardized procedures and commonly developed tools
- Chap 5.4: Cooperation in Piloting, Plug fests and Workshop activities for new activities

5.2. Cooperation in the Standardization activities for Industrie 4.0

As mentioned in section 2.11. the topics of Korean-German Industrie 4.0 standardization cooperation can be grouped into three levels or phases:

1. Basic concepts for Industrie 4.0 and Smart Manufacturing,
2. Standards on basic principles of I4.0,
3. (digital) Standards describing data / data models.

Foundations for the first level are made and future standardization activities will focus on maintenance of published concepts. For the second level we will see several new parts of standards series like IEC 63278 (IEC/TC 64/WG 24) for Asset Administration Shell. Beginning of 2022 new work item proposals for parts –2 and –3 of IEC 63278-series are under ballot:

- IEC 63278-2: Asset Administration Shell for Industrial Applications – Part 2: Information meta model
- IEC 63278-3: Asset Administration Shell for Industrial Applications – Part 3: Security provisions for Asset Administration Shells

Further parts are planned and under discussion including interaction principles (“I4.0 language”).

A key element for future cooperation will be to fill the concepts and technologies of the first and second level with life. This includes the standardization of information model and covers the work of recognized standardization bodies like ISO and IEC but also consortia standardization activities (see section 5.3 for roll-out of AAS).

At IEC/TC 65/SC 65E/WG 2 “Properties” there are activities to extend IEC Common Data Dictionary (CDD) in the process domain and it is planned to standardize AAS submodel templates as for example digital nameplate. Semantic properties as described in IEC CDD are an important basis for sematic interoperability and their future relevance is expected to be growing. Besides IEC CDD there are dictionaries from other organizations like for example ECLASS e.V. (www.eclass.eu/en/index.html).

From users of AAS there is the request of a seamless integration of different dictionaries. In other words, semantic properties from different dictionaries shall be accessible using standardizes mechanisms. This includes for example standardized formats for data exchange and interfaces for data access. For this purpose, a cooperation project between ISO, IEC and ECLASS has been initiated to achieve a COMmon Data repOsitory (“COMDO”). An implementation of the concept developed in COMDO is planned for the future and could be part of Korean German standardization cooperation.

Upcoming activities for standardization of information models include

- Digital Nameplate
- Product Carbon Footprint (see IEC/adhoc Group 94 Product carbon footprint data for the electrotechnical sector)
- Digital Product Passport

These projects and activities could be supported by Korean German standardization cooperation and further topics could be introduces based on the cooperation.

5.3. Jointly driving forward the industrial implementation of the Asset Administration Shell

The Korean and German community is working intensively on the exchange of Asset Administration Shell (AAS) reference implementations, accompanied by a close exchange of experts between KOSMO and the Industrial Digital Twin Association (IDTA). By jointly designing reference implementations and contributing information model repositories, the foundation is being laid for a solid industrial application of this new technology. The common goal of the collaboration is to make the AAS available as an international open standard for the digital twin for the industry and to facilitate its use.

IDTA is the user organization for the AAS and provides various AAS samples (http://www.admin-shell-io.com/samples/) and open-source projects (https://github.com/admin-shell-io) on its repositories. Joint collaboration in the various working groups on various components, templates, open-source software, etc. is expressly desired. Future goal is to integrate the developed repository to provide an overall picture. This will be of great opportunity SMEs to ensure advanced technologies for smart manufacturing using the new AAS technology.

Korean and German AAS community is working intensively on the exchange of AAS reference implementations, accompanied by a close exchange of experts between KOSMO and IDTA.

KOSMO is establishing a plan to provide an AAS reference model for essential assets in order to promote the use of smart manufacturing technologies to Korean SMEs. To this end, KOSMO is currently building a "Reference AAS model repository" that can be used jointly by various vendors and service enterprises. The cross-collaboration in various working groups on various components, templates, open-source software, etc. is expressly agreed.

Korean SMEs are able to the common AAS reference model in developing their AAS model. They do not need to develop their own AAS model from scratch. They only need to find the relevant AAS model in the "Reference AAS model repository" and then transform it to fit their assets. Making it easy for Korean SMEs to create an AAS model for their assets will allow them to quickly adopt advanced technologies that were previously only available to large enterprises, which will also improve the international competitiveness of Korean SMEs.

Further field of activity is the exchange and synchronization of training contents of the training programs on KOSMO and IDTA.
Additionally, IDTA is creating certification guidelines for the use of AAS in industrial applications. A close exchange with the Korean community on the use of the criteria is desired.

The future target is, to connect Korea's "Reference AAS model repository" and Germany's "Repository" are operated in connection with each other, it will be of great help to SMEs in both countries to secure advanced technology for smart manufacturing using AAS' new technology.

MoU between KOSMO and IDTA Scheduled for the Hannover Fair June 2022.

In order to further foster, deepen and intensify the exchange of experts between KOSMO and IDTA in the future, both organizations will sign a MoU at the Hanover Fair. The goal is to jointly coordinate and shape the design of AAS reference and information models in the expert committees.

5.4. Cooperation in Piloting, Plug fests and Workshop activities

The Cooperation for the further rollout and operational use of the AAS has several dimensions - in addition to standardization and the sharing of reference models, the exchange of experience and joint test activities also play a major role.

This exchange of experiences and joint testing activities should have a technical focus and can be implemented through various formats:

a. **Jointly definition of Use Cases**
b. **Piloting of jointly defined use cases** on the demonstrators on both sides
c. **Common plug fests and workshops** to test technical interconnection and specific functionalities on different devices and demonstrator and to to exchange experiences and implementation recommendation

All activities are based on use cases - that's why we propose the following ISO/IEC/IEEE use case approach.

a. Jointly definition of Use Cases

Use cases are an instrument to build a bridge, from the driving challenges facing the manufacturing industry to the appropriate possible technical solutions. Use cases also offer the possibility to derive new requirements for standardization.
The motivation of using such a use case approach is based on the fact that in the international community, it is broadly accepted that new standardization activities are particularly useful when driving use cases behind them are formulated and clearly understood. In this respect, an internationally uniform understanding of use cases in the context of I 4.0 and IIoT is a central starting point in that cooperation.

For a description and architecture of use cases, the methodological/ conceptual approach based on ISO/IEC/IEEE 42010 is recommended and can be used holistically but also selectively.
It is important to know at which level you are exactly with your use case and what the specific use case can cover, what range it can serve and what cannot.

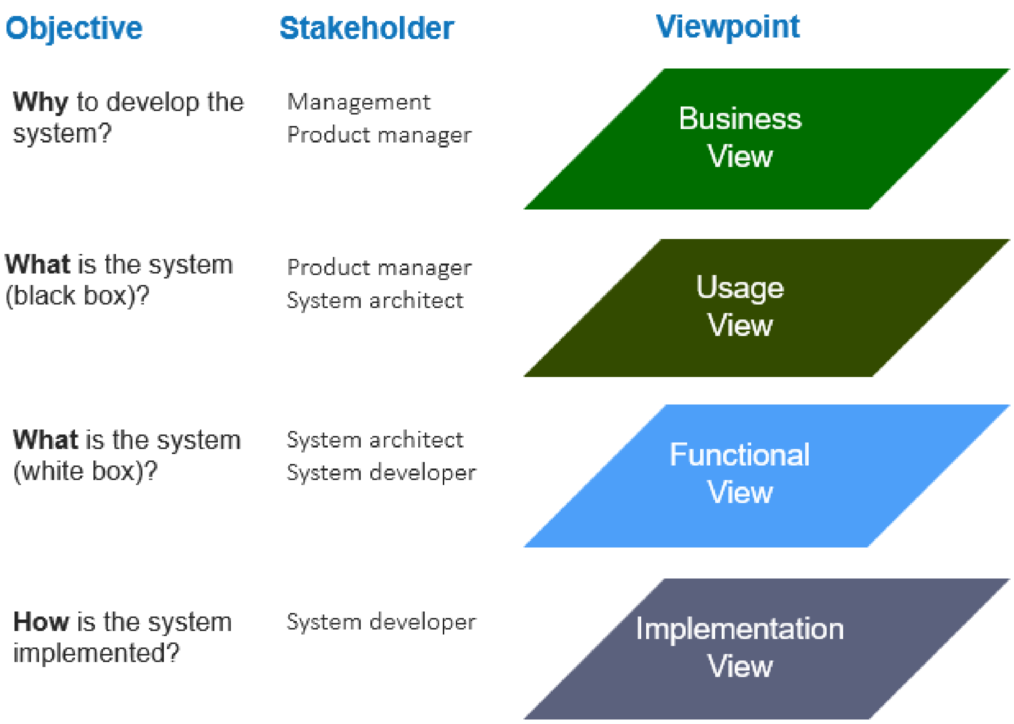

Figure 39: Use case approach based on ISO/IEC/IEEE 42010. *(Source / Copyright)*

Furthermore, the mapping of the use cases along the RAMI 4.0 (reference architecture model Industrie 4.0) is recommended in order to enable orientation and localization of the use cases for the business, but also for the standardization activities.

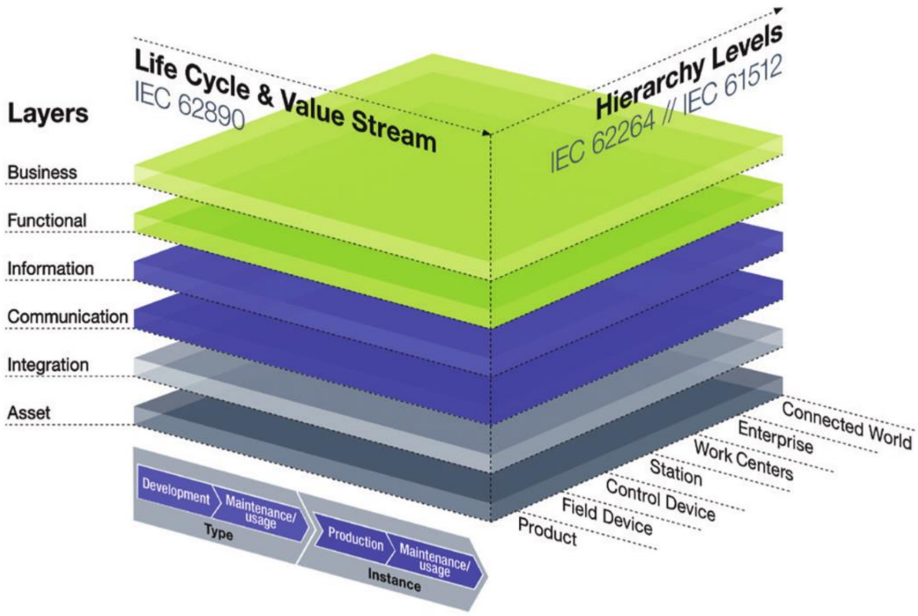

Figure 40: RAMI 4.0 (reference architecture model Industrie 4.0) *(ZVEI e.V. / Plattform Industrie 4.0)*

<u>Next steps for the Use case approach – by using agile mode elements:</u>

1. Use Case identification on generic level with reference to Industrie 4.0 properties/ functionalities and RAMI 4.0
2. Use Case identification for concrete and representative operative business scenarios
3. Use Case description (with reference to methodological/ conceptual approach ISO/IEC/IEEE 42010) see above

4. Identification of technical realization and implementation of Use cases in own testbeds of each side
5. Virtual tests, workshops / plug fests etc. for improvements, lessons learned and input for standardization
6. Expand the cooperation to share Reference AAS repositories and for joint development of AAS API standard

b. Piloting of jointly defined use cases

After the alignment of the jointly defined use cases, these are implemented out, piloted and tested in the respective own demonstrators on both sides. First of all, a piloting in the respective own lab is important and then, in a second step, networking and testing with other demonstrators will follows.

Here we have a proven basis with the project "AAS connected" (see chapter 3.2).

Building on this, the jointly defined use cases are not only networked horizontally, but also vertically in depth in order to evaluate all Alysers (see RAMI 4.0) and relevant technologies.

c. Common plug fests and workshops

The Intension of testing, plug fest and workshop activities is the promoting of technical cooperation and improving interoperability.

Interoperability will become a critical issue as different vendors implement their own AAS models. Therefore, it is necessary to verify the interoperability of the AAS models of assets implemented by Korean and German enterprises through the AAS plugfest. To this end, it is proposed that the two countries hold a regular plugfest for AAS. This is expected to act as a cornerstone for establishing a plugfest for all AASs implemented in all enterprises around the world in the future.

In the workshop, we will bring together the experts on different, subject-specific topics and technologies, talk about experiences and exchange about possible solutions.