AUTOMATION ENGINEERING WITH THE ASSET ADMINISTRATION SHELL

Automating automation engineering

Designing oil and gas or energy plants is a complex, multidisciplinary and multi-organization process involving many documents and a vast quantity of data. A collaborative study with Equinor shows how Industry 4.0, particularly asset administration shells (AASs), speed up and simplify design work.

Designing O&G or energy plants involves a vast quantity of data.

Asset administration shells speed up and simplify design work.

A seamless end-to-end engineering and commissioning workflow emerges.

—
Sten Grüner
Katharina Stark
Mario Hoernicke
Nafise Eskandani
ABB Corporate Research
Mannheim, Germany

sten.gruener@de.abb.com
katharina.stark@de.abb.com
mario.hoernicke@de.abb.com
nafise.eskandani@de.abb.com

John Pretlove
Frank Biringer
Sverre Frøystein
ABB AS Energy Industries
Oslo, Norway

john.pretlove@no.abb.com
frank.bringer@no.abb.com
sverre.froystein@no.abb.com

Daniele Seimonte
Anders Bjørsvik
Equinor ASA
Oslo, Norway

—
01 How AAS implements the digital twin.

The complex, multidisciplinary and multi-organizational nature of plants in the oil and gas and energy sectors presents unique engineering design challenges. In particular, orchestrating many drawings and diagrams, tables, text-like control narratives and other documents can lead to considerable complications. Fortunately, Industry 4.0 – along with modular and model-based automation engineering concepts – can ease cross-organizational information exchanges and data format and semantics interoperability. To demonstrate how these approaches can lead to a continuous engineering workflow in the sectors mentioned, a collaborative study between Equinor – an energy major based in Norway – and ABB was conducted in 2023. The main goals of the study were to:

- Understand what engineering data needs to be exchanged between involved organizations.
- Outline how this data will be represented as an Industry 4.0 AAS.

AAS is a vital concept for implementing a digital twin – ie, a digital model of a physical product, system, or process – for industrial applications →01. AAS is a universal information model that can be accessed throughout an industrial asset's lifecycle.

Automation engineering and modular automation
Along with Industry 4.0 technology, modular production plants are an additional efficiency driver for plant engineering. Here, standardized interfaces are the critical elements for success: Based on a standardized description of process module interfaces, type-specific module-type packages (MTPs), instance-specific intelligent modules and process equipment assemblies (PEAs) can be integrated into a supervisory control system – the process orchestration layer (POL), which might be implemented as part of the distributed control system (DCS). These items form the basis of the modular automation. MTPs, for instance, enable seamless PEA integration and reduce engineering effort and commissioning time.

—
The AAS is a vital concept for implementing a digital twin for industrial applications.

Further, a shift to off-site prefabrication of large conventional plant modules has driven the modular automation concept of the function module (FM) [1]. Compared to standardized MTPs, FMs provide several advantages for conventional plants – such as the ability to deploy the control logic of multiple logical modules in one physical controller.

These topics form the basis of the collaborative study between Equinor and ABB to explore MTP/FM and AAS synergies during plant engineering regarding automated workflow and the usage of AAS infrastructure [2].

Workflow steps and information models
An overview of the cross-organizational workflow created for the study shows which information needs to be exchanged and how this information can be represented as AAS content – eg, as potential submodels or submodel templates →02.

The AAS-solution strategy for the workflow is to generate AASs (and connected assets) as early as possible in the design process – ie, in step 1 – and

HOW AAS IMPLEMENTS THE DIGITAL TWIN

The AAS concept, a cornerstone of Industry 4.0, is governed by Industrial Digital Twin Association (IDTA) working groups and is available as the international standard IEC 63278 as well as a set of IDTA specifications. The AAS specifies a technology-neutral information model that can be mapped to and accessed via different IT protocols and technologies. In a nutshell, the AAS is attached to a physical or virtual asset and structures the asset-related information into so-called submodels, eg, to represent technical data relating to a device. These submodels are independent, use-case-specific containers for the actual "payload" of the AAS – eg, properties or files. The IDTA governs the creation of the submodel templates (there are currently over 80) from different industrial verticals, ranging from device purchasing through descriptions during plant design up to service and lifecycle events during the operational phase of the plant.

Technically, the AAS can be accessed and exchanged as a file or using request-response interfaces (so-called RESTful APIs with a JSON payload).

01

"As our strategic long-term partner, ABB was able to deliver a state-of-the-art demonstrator to showcase the application of Industry 4.0 technologies in the energy domain. We appreciate the open and unique collaboration opportunity to increase engineering efficiency and quality of delivered projects."

Anders Bjørsvik, Senior Advisor, Automation, Equinor ASA

add submodels and submodel elements to these in the consecutive steps [3]. The following discussion outlines the most important steps of AAS and asset creation.

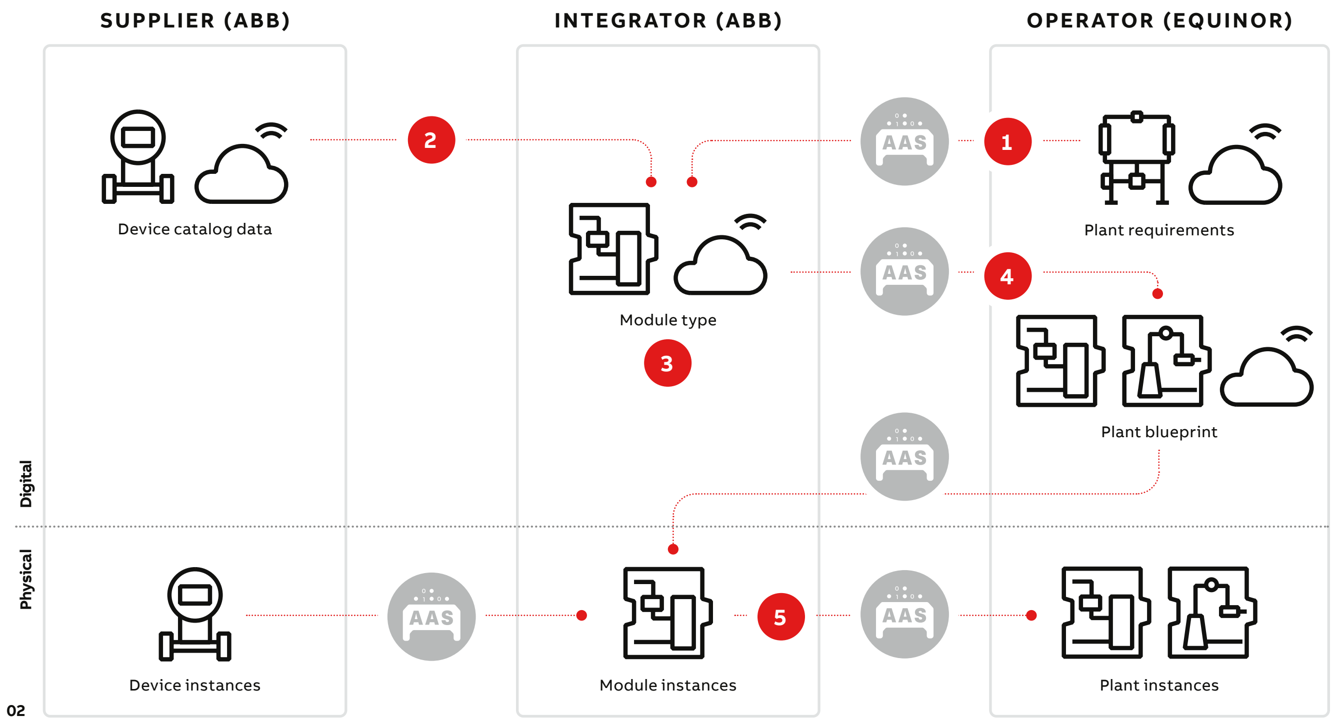
Requirements exchange (step 1)
The initial step of the workflow is the handover of plant requirements from the plant operator to the integrator. These requirements are typically represented as abstract diagrams, eg, process flow diagrams (PFDs), supplemented by a detailed process description written in human-readable language. For the scope of this study, a process segment consisting of a heater, gas treatment and separation system was modeled in Equinor's PFD modeling tool, MIMIR. The process segment was loosely based on a real-world asset of Equinor, both in terms of plant topology and tag names.

A PFD design base is especially useful for handling high-level service abstractions required by the modular automation methodology. Well defined high-level services (eg, heating or filtering) are a foundation of the demonstrated modular engineering workflow.

The container in the PFD modeling tool holds different aspects of the specified system – such as the functional and locational aspects of the physical plant elements. Each aspect is structured hierarchically to break down the system into subparts →03–04.

A crucial component for maintaining a continuous digital thread throughout each aspect of the engineered system is the creation and preservation of identifiers for the system and its individual elements. In the case of the diagrams in Equinor's PFD modeling tool, unique internationalized resource identifiers (IRIs) are created for elements of the diagram and represent asset identities used within the AAS domain.

An AAS representing the whole MIMIR project is created that contains the following submodels (compare with the left column of →05):



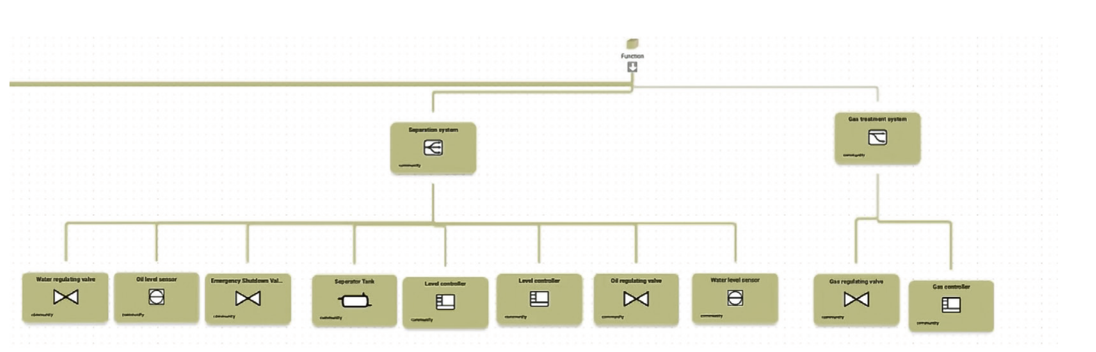
02 An example engineering workflow.

—
03 A MIMIR diagram showing a functional breakdown of a plant containing a separation and a gas treatment system with further subcomponents.

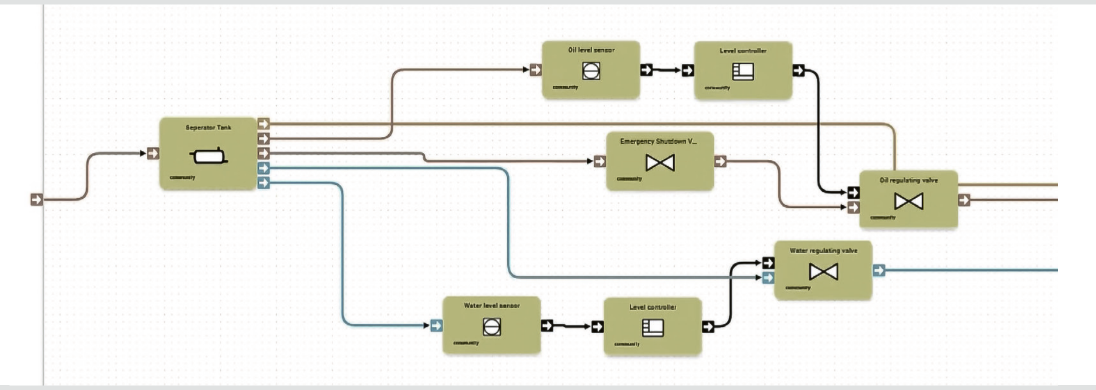
—
04 Cross-element connections between subcomponents of the separation system showing mass flow, electrical connection, etc.

—
05 Three AASs representing hierarchical elements of a MIMIR project instance (representation using AAS-GUI tool from Eclipse BaSyx™).

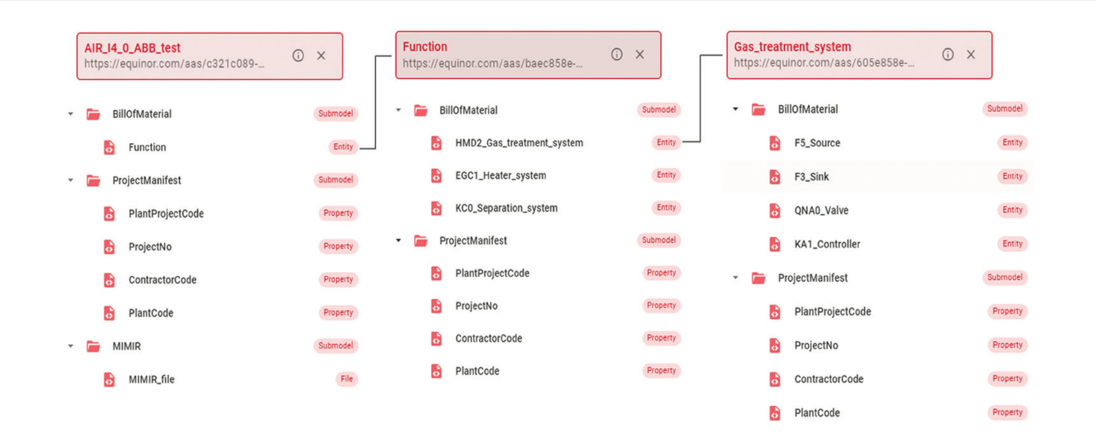
—
06 A high-level representation of device-type AAS containing, among others, OPC UA Nodeset files corresponding to the OPC UA information model of device instances.



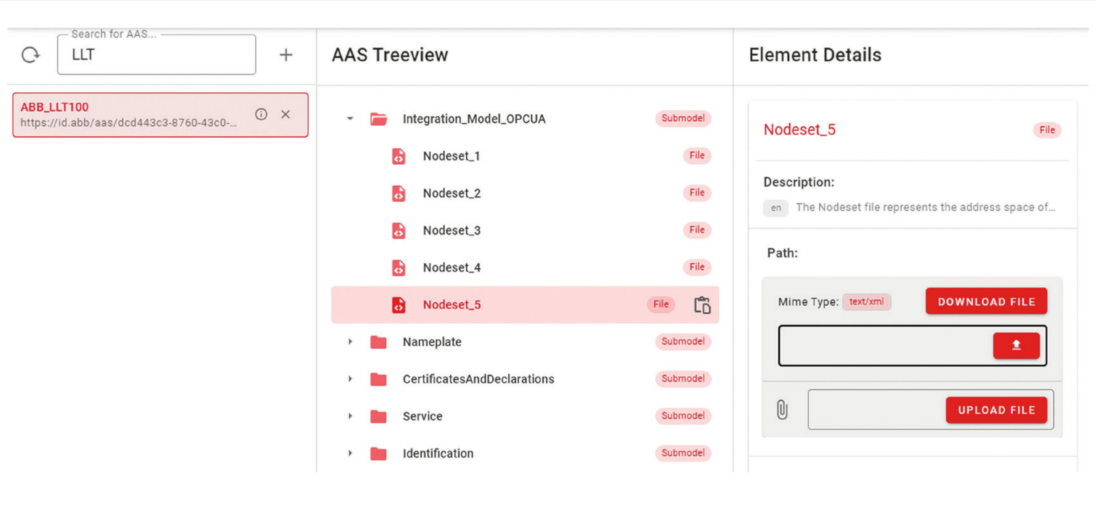
03



04



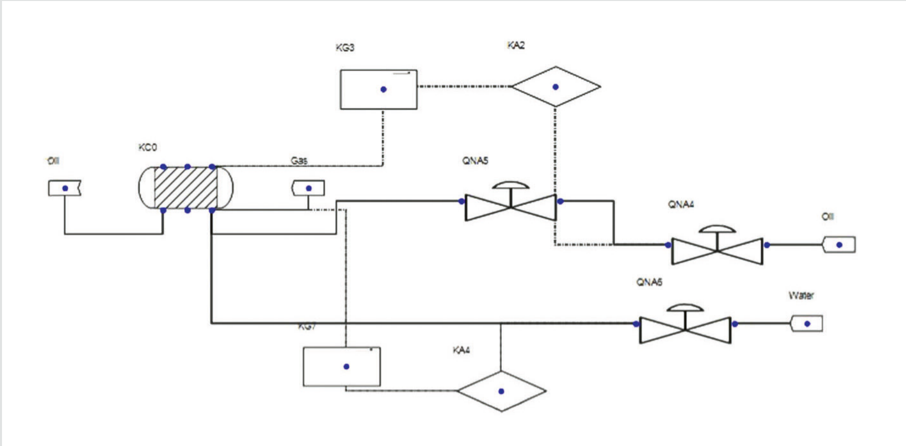
05



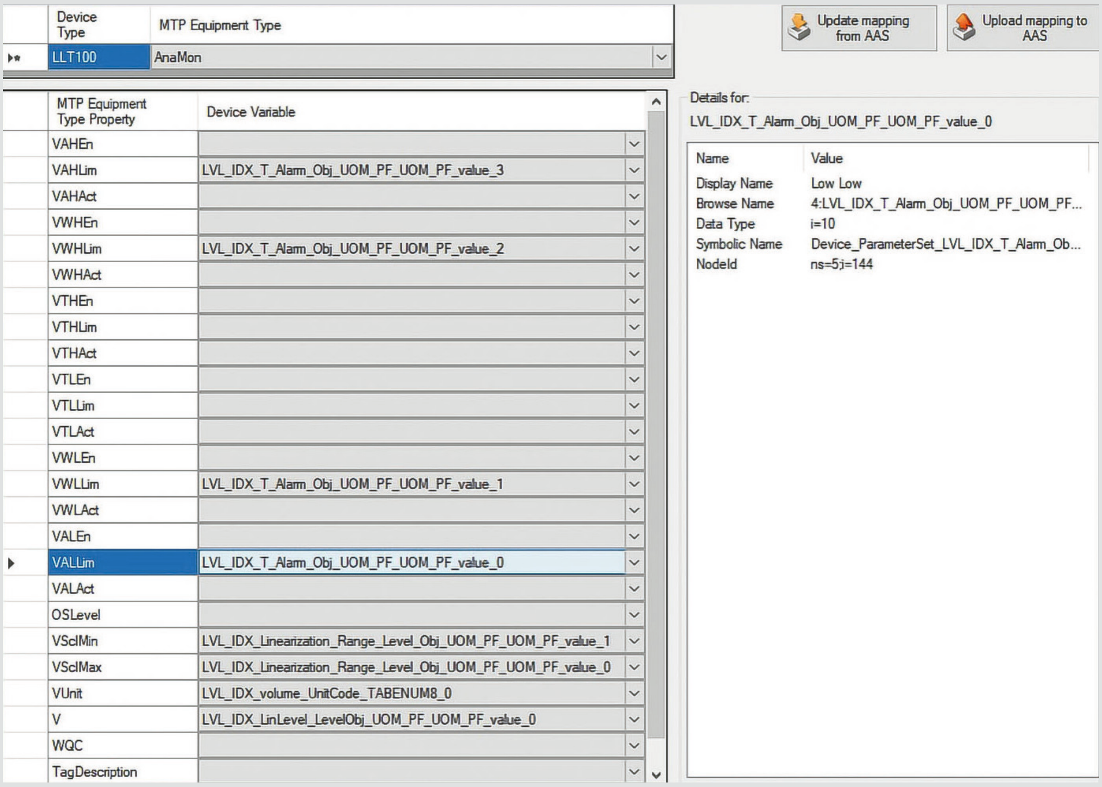
06

—
07 Preliminary module HMI for the separation system generated from the MIMIR template.

—
08 Mapping of OPC UA PA-DIM variables obtained from the AAS submodel to MTP/FM block abstractions.



07



08

- MIMIR submodel: contains the MIMIR file as a file submodel element.
- Project manifest submodel: contains meta-information about the project related to the specification, such as plant project code.
- Bill of material submodel: the standardized IDTA submodel contains the hierarchical breakdown of elements within the MIMIR project.

Exchange of device type information (step 2)
The next workflow step involves exchanging device type information (actually, catalog information) between device vendors and the engineering company. In the prototype implementation, an AAS of a device type was used that contained, among other things, submodels from the IDTA describing technical specifications and contact information related to the particular device type [4].

A further extension of this submodel set from the prestudy is a proposal to include a submodel containing OPC UA Nodeset files, which represent the information model of the future device's OPC UA server to be installed in the physical plant →06.

Engineering of the system parts (step 3)
In the next step of the cross-organizational engineering workflow, MTP module engineering

is taken as a proxy for various parts of the final plant. Additionally, FMs [1] can be used for modular-like automation of physically monolithic plants.

Instead of reusing existing module definitions from module vendors, new FM definitions (and a corresponding MTP submodel) are generated from the requirements provided by the operator in the form of a MIMIR system definition. To achieve this goal, the prototype modular engineering tool was extended to:

- Import MIMIR files and corresponding assets from AAS type 2 servers via a RESTful API.
- Process MIMIR files using a custom MIMIR file parser to map functional entities, such as the separation system, and MIMIR assets, such as valves or vessels, into the corresponding MTP library objects.

Tag names are inherited from the MIMIR specification. Element placement automatically generates the preliminary human-machine interface (HMI) layout of the FM →07. The placement and connection topology of the elements correspond to the layout in →04.

In a subsequent step, additional equipment – laser level or flow transmitters, etc. – can now be added to the module type definition. Here, the AASs of the device types from the previous step play an important role.

To use the device type within the MTP module or FM package, a mapping between the information model of the device (eg, PA-DIM, a manufacturer-independent information model with a structured hierarchy for standardized data access for devices) and the library element of MTP needs to be performed. Here, one makes use of the OPC UA Nodeset files supplied along with the device type →08. The mapping (right-hand side of →08) is also stored within the AAS of the device and can be reused over multiple projects.

Design review and commit to design (step 4)
The prototype used an MQTT event broker (a message coordinator) and distributed AAS registries to carry out change events between the organizations involved. Furthermore, a distributed version control system allowed for the review and sign-off of snapshots of the whole system – ie, all relevant AASs and submodels.

Plant commissioning and preparation for operations (step 5)
In this step, the types of modules (FMs or MTPs) are instantiated and interconnected to build the final plant topology. The study uses the ABB orchestration designer tool to create instances from existing MTPs or FMs out of FM definitions. Separator instances are constructed using FM extensions (configuration options, alarm filtering, etc), while the oil heater uses a standard compliant MTP definition.

A smooth workflow
The study implemented a realistic cross-company information workflow during the engineering process. It showed how different standardized and proprietary information models can be interlinked and extended over the lifecycle of the plant and its components. Furthermore, the viability of cross-standard interfaces – eg, referencing from an AAS submodel to OPC UA elements – was proven. This enables the concept of “bring your own model,” allowing the linking and the re-use of different digital models within an Industry 4.0 workflow, thus assuring the security of digitalization investments.

—

The study created an end-to-end engineering and commissioning workflow with no significant technical roadblocks.

The importance of asset identity preservation along the engineering lifecycle should be emphasized. While this matter appears trivial for existing physical devices, the identification of engineering entities such as piping and instrumentation diagrams and their elements is challenging.

The most significant achievement of this collaborative study between Equinor and ABB was the creation of an end-to-end engineering and commissioning workflow with no significant technical roadblocks. The work gives valuable insights for both automation and Industry 4.0 communities and might be used as a blueprint for other industry-lead evaluations of Industry 4.0 applications in practice. •

—
References

[1] S. Grüner et al., “Products have a digital twin and you can find it too!,” *ABB Review* 03/2021.

[2] M. Hoernicke et al., “Modularizing engineering,” *ABB Review* 02/2024.

[3] K. Stark et al., “AAS-enabled Engineering Using MTP: A Practical Approach,” *atp magazin.* Volume 65, number 11–12, pp. 64–70, 2023.

[4] S. Grüner et al., “Towards asset administration shell-based continuous engineering in process industries”, at *Automatisierungstechnik.* Volume 71, number 8. https://www.degruyter.com/document/doi/10.1515/auto-2023-0012