OPEN INDUSTRY 4.0 ALLIANCE
WHITE PAPER

ABSTRACT

In recent years, practical steps into Industry 4.0 have shown a plethora of IoT platforms being utilized throughout the producing industries. The result of this heterogeneity on the platform level is an unmanageable variety in the solution requirements on the edge and field connectivity levels. Most actors in this field have realized that better interoperability of solutions is mandatory if Industry 4.0 is expected to have a continuing impact.

The Open Industry 4.0 Alliance aims to congregate **leading industry partners** to drive the digitization of the **factory, plant and warehouse** domains and ultimately create an **ecosystem** by linking Information Technology with Operational Technology, while bridging the divide between **operators and manufacturers/OEMs**. This document describes the goals and the purpose of the Alliance.

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1 INTRODUCTION

Industry 4.0 (or Industrie 4.0 in Germany, Industrial Internet of Things / IIoT in North America) promises to create the 4th industrial revolution and to **digitally transform manufacturing in both discrete and process industries**. It has been touted as being able to solve some very compelling challenges that manufacturing companies face in today's market – **from extreme supply, demand and design variability to emerging markets of one and the growing need for rapid innovation**.

However, the digital transformation required to advance the principles of Industry 4.0 – **automation, integration and optimization of processes** – is being stifled by the plethora of heterogeneous solutions that are available and the complexity of onboarding new and existing production equipment into the operations. The digital transformation becomes even more complex when companies consider the overwhelming volume of information that will be generated by intelligent, IoT enabled systems and the analytics resources needed to gain meaningful business and operational insights.

1.1 MARKET SITUATION

The operator reality in the factory, the plant or the warehouse in small and medium-sized enterprises (but also in large companies) is characterized by the variety of things of different classes and manufacturers. Proprietary and closed approaches to connectivity, data management, security and collaboration create additional effort and hamper the rapid and ubiquitous scaling of Industry 4.0 relevant value-added promises.

The opportunity is, however, very compelling. In 2015, The McKinsey Global Institute estimated the value creation potential of factory digitization (also known as Industrial Internet of Things, IIoT, or Industry 4.0) to range from $1.2–3.7 trillion in 2025 [report]. To unlock all this potential of digital transformation, manufacturing companies are eagerly working on product innovation centered around Industry 4.0/IIoT platforms to connect machines and other industrial assets, mostly to the IoT cloud platforms. Funded by venture capital and industrial supplier investments, more than 400 IoT platform offerings and thousands of IoT application start-ups compete at customers, a contest for mindshare, line of business budgets, and proof-of-value realizations. In addition, several alliances between different industry players in areas such as edge computing, industry platforms and test beds, industry standards and other bilateral partnerships have tried to overcome some of these hurdles without any success.

1.2 CHALLENGES IN INDUSTRY 4.0

Operators of factories, plants and warehouses perceive that large automation vendor-led alliances or platform initiatives lack the level of customer support exhibited by smaller, competitive equipment builders, making them reluctant to hand over operational data to their mega-vendor. On the other end, the midmarket alliances are not creating enough impact due to lack of global go-to-market capabilities and limited adoption. It is also apparent that a cloud-only approach will not suffice to address the requirements for security, safety, latency, and relevance of data. The notion of edge computing (orchestrated through the cloud) is a must for any future solution architecture, further complicating the hardware and software life cycle management of platforms, devices, services, applications, and data from a customer perspective.

Practical experience from operational implementation shows that

- digital value-added services are particularly effective if they make data from adjacent applications and domains linkable,
- modern production plants are heterogeneous, i.e. consist of a multitude of machine lines, machines, aggregates and sensors and actuators,
- consequently, no uniform cloud infrastructure and value-added service ecosystem, or one that is supported by a single (albeit large) provider, can be sufficiently distributed in integration, but rather data and digital services from a large number of machine lines, machines, aggregates, sensors and actuators (CPS) from the most diverse manufacturers and thus from the most diverse cloud systems can be linked in a heterogeneous production environment,
- the coverage of data connections, access rights and order data processing contracts easily become a medium project work, which has a considerable impact on the engineering of the physical plant in terms of time and costs.

Major requirements of operators are easy onboarding of assets, with common data semantics across customer's own edge and Industry 4.0/IIoT cloud platform, enabling a seamless, bi-directional collaboration with multiple asset vendors for contents and data. Currently, if a customer invests in Industry 4.0/IIoT solutions from different vendors on different platforms, the burden to face the challenges described above must be carried by the customer alone. This hinders him to significantly proceed with his Industry 4.0/IIoT strategy.

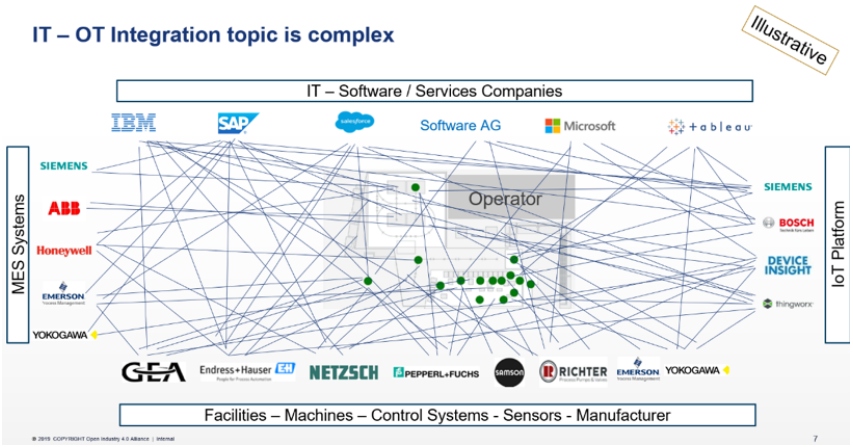

Figure 1: Sample overview of IT-OT-integration complexity.

The typical challenges for operators of industrial assets can be summarized as follows: Digitization is mostly perceived as a **long-term investment and change process**. The often-inscribed disruptive character of the digital transformation is hindered by **missing standards** of the offered IIoT solution platforms. Due to the **lack of standardization**, the **onboarding** of assets is still an effort. This is especially true when it comes to older **legacy assets** in the brownfield. The **security** of the connections and the related aspects of authentication and authorization are perceived as a critical and necessary point; however, the complexity of the topic still causes tentativeness for operators of such solutions. Another aspect of connected cloud-based solutions is **bandwidth and the latency** of the internet connectivity. The amount of data generated by digitalized assets immanently generates the need for local buffering, aggregation and further computation before the results are sent to a connected cloud platform. In an Industry 4.0 implementation of an average production plant, a large number of data must be connected and integrated, the project planning effort is considerable and a standardized workflow does not exist – easily several thousand data records distributed over dozens or hundreds of storage locations are used, the produced data quantities may currently typically grow to the gigabyte range per production day.

Our customers want to put the promises of Industry 4.0 into practice.

“Our customers can expect an open approach from us. For example, our solutions must be able to handle several existing standards in fieldbus technology,”

said Mr. Hans-Juergen Hilscher, CEO Hilscher.

Providers and vendors of cloud-based Industry 4.0/IIoT solutions face related or similar challenges. The **lack of a standardized collaboration platform** often leads to complex point-to-point integrations. Establishing a **remote access connection**, e.g. for support, maintenance and patching to assets on the productions-site, is a complicated organizational and technical endeavor. A scalable commercialization of cloud-based Industry 4.0/IIoT solutions needs a standardized way for the **distribution of software**. To create interoperable and interconnected complex solutions consisting of multiple smaller solutions (e.g. a fully automated welding cell in the automotive industry), the establishment of a **standardized communication layer** is always associated with high efforts.

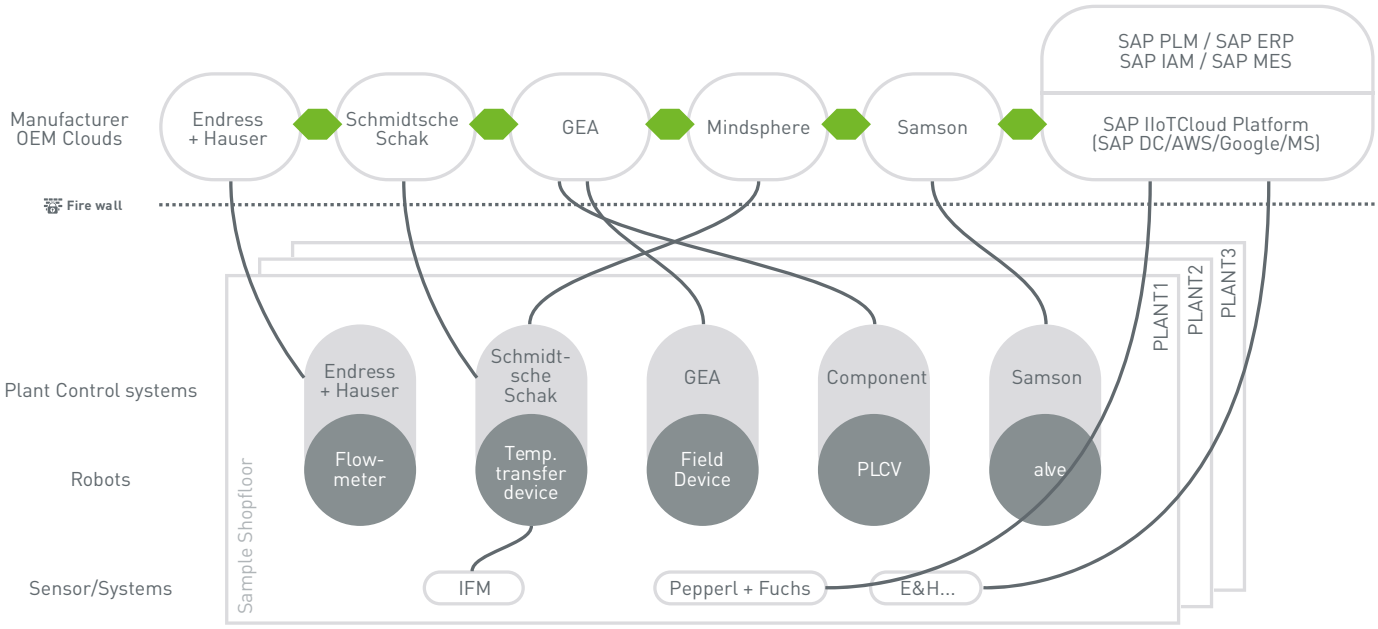

Figure 2: Deeper cooperation between IIoT platforms and OT providers – a common challenge for OEMs/manufacturers.

A direct interaction of the different service providers to solve the linkage dilemma does not lead to a satisfactory solution despite a multitude of bilateral interfaces, since no continuous data availability can be achieved in the general case and essential life cycle services for the plant components are not continuously available for operators. Also, not all participants have equal access to private know-how-bearing applications and data on all levels of the IoT platforms (CPS [sensors/actuators], edge, local [on premise] cloud, hypercloud). These are the main reasons for the sluggish spread of Industry 4.0 implementations in practice.

In sum, the benefits of Industry 4.0 are theoretically described and tested in pilot plants. For a comprehensive implementation in practice, especially for SMEs, which simply cannot deal with the lack of technical, organizational and legal environmental conditions, the sum of the individual detailed problems is retarding the introduction of the new Industry 4.0 technologies.

2 WHY OPEN INDUSTRY 4.0 ALLIANCE?

The charter of the Open Industry 4.0 Alliance is to institute an alliance of innovative asset manufacturers (including asset digitization enablers) that adopts standards-based common semantic data models to enable the immediate instrumentation of smart assets in the end-to-end production life cycle of an operator while bringing together the required critical mass of industry players. With a vision to simplify the deployment and integration of intelligent assets into the operations of an operator to a near "plug-and-play" level and provide pre-integrated high value solutions from Alliance members that can operate with operator-desired architecture openness.

An architecture that is presented by the Open Industry 4.0 Alliance and implemented by its members appears advantageous and is sketched prototypically: an open, scalable ecosystem with the following layers:

- Edge Connectivity (to the world of physical things),
- Edge Computing,
- Operator Cloud and
- a central repository for asset information and semantics.

Key principles are open interfaces, an open edge application layer and cloud application layer for the operator of a facility (either locally or in the cloud), data custodianship, role-based authorization for data access and private data and algorithms at every level for each provider and subscriber.

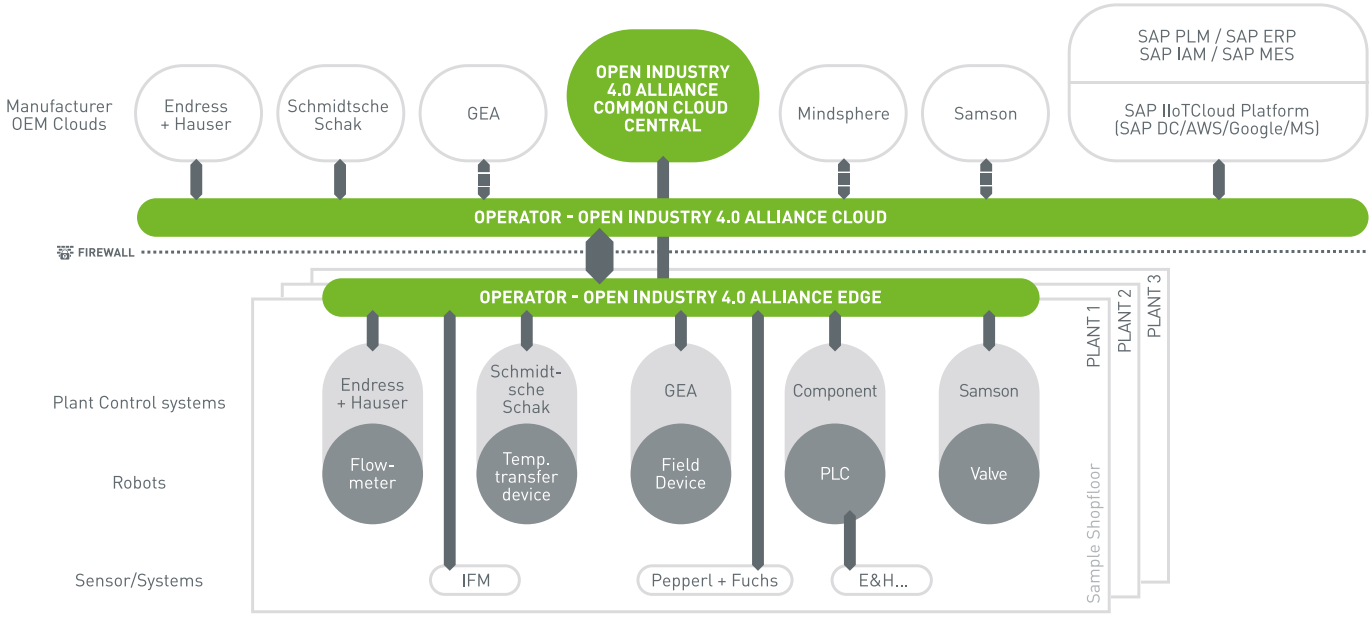

Figure 3: An open yet holistic approach to edge connectivity, cloud computing and asset management is required.

2.1 A VIABLE ECOSYSTEM

The ecosystem of the Open Industry 4.0 Alliance has ONE focus – "Create Customer Value". In order to achieve this, the ecosystem consists of all the essential roles for driving and enabling digitization of the processing plants, warehouses and factories of customers (operators). The contribution of the ecosystem is the Industry 4.0/IIoT relevant modular solution and professional service offerings. The major roles are summarized as:

- **Operators:** End customers who operate industrial assets in discrete and process industry as well as logistics
- **OEMs/ Manufacturers:** Makers of industrial equipment – production assets, lines, machinery, modules, and robotics
- **Technology Providers:** Those for software (IaaS, PaaS) and hardware (edge devices), IT and OT, automation technology providers (systems, components, sensors, actuators, controls, PLCs) who enable digitization
- **Application Providers:** Companies providing relevant software applications with their industry/domain specific expertise
- **System Integrators:** Companies offering system integration services in OT (Operational Technology) and IT (Information Technology)
- **Service Providers:** Companies providing services throughout the life cycle of an industrial facility
- **Connectivity Providers:** Companies offering solutions & services for industrial connectivity

"Our customers demand an open, compatible collaboration in which each company contributes its strengths for the greater good. The Open Industry 4.0 Alliance is the answer to this demand,"

said Dr. Christian Liedtke, KUKA AG

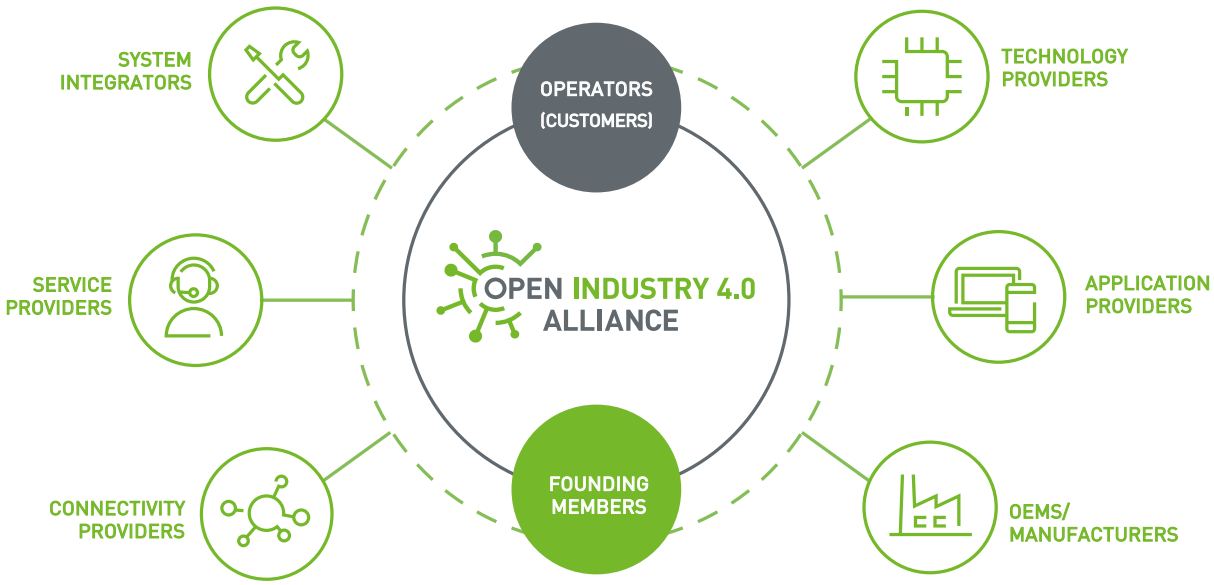

Figure 4: Roles in the Open Industry 4.0 Alliance ecosystem.

2.2 HOW IS THE ALLIANCE DIFFERENT?

Compared with other initiatives on the market, the Open Industry 4.0 Alliance highlights the openness of the proposed approach. The Open Industry 4.0 Alliance design principles for approved solutions are aimed to deliver Industry 4.0/IIoT interoperability amongst solutions from members and enable faster adoption of customers' digitization goals. The Alliance brings together actors from collaborating and even competing companies to align on common architectural concepts to integrate very differing Industry 4.0/IIoT solutions based on existing standards.

The market reality is that most industrial facilities consist of legacy assets. These assets could have different degrees of sophistication (e.g. analog with or without connectivity capability, digital with or without connectivity capability) to allow them to be connected to the Industry 4.0/IIoT hybrid solutions. The existing lack of **interoperability for greenfield and brownfield assets** amongst different vendors usually hinders the customer from deriving value out of seamlessly interoperating solutions and leaves the integration task to the customer. With the open, vendor lock-in free solutions integrating multiple standards, the Alliance offers a low risk option for the operators. The Alliance aims to connect most of the assets in the **brownfield** to ease the grown complexity in the field and secure the existing investments.

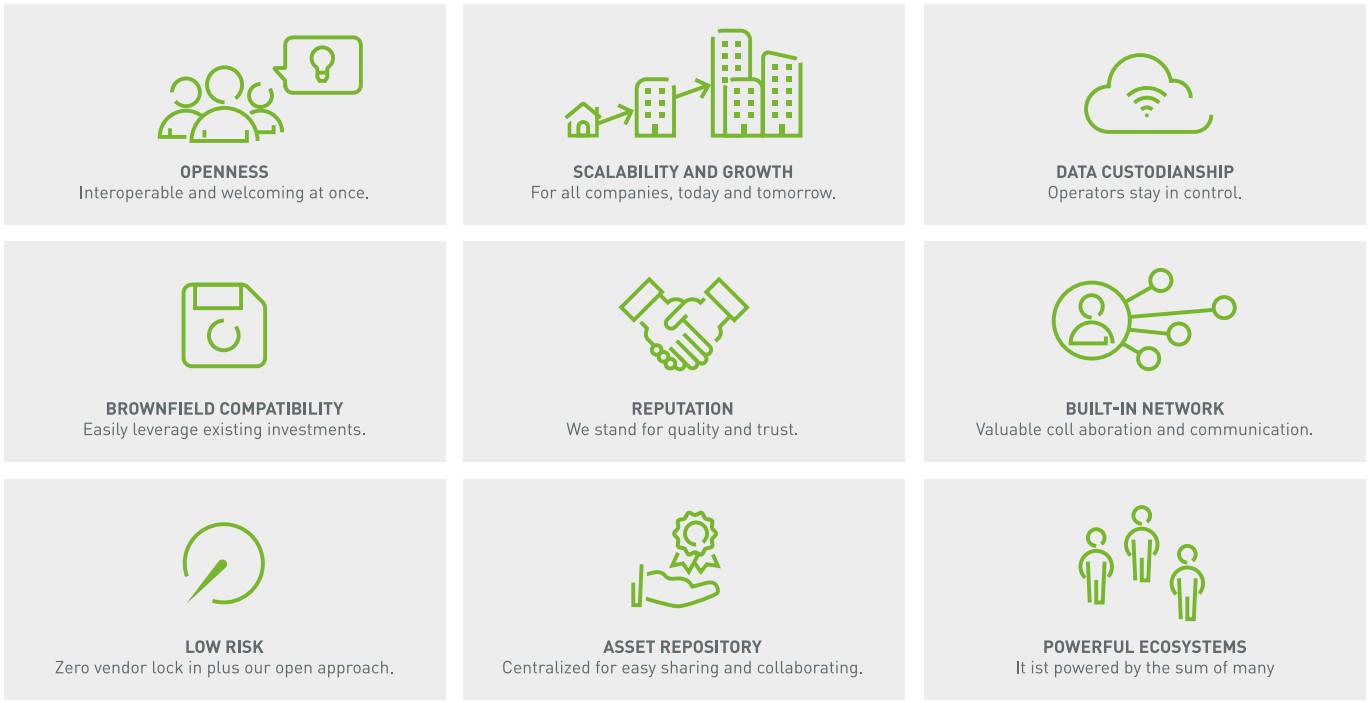

Figure 5: Differentiating elements for operators (= end customers).

The solutions offered are aimed to address **enterprises of any size** and support operators to start with a selective scope and grow the scope with time. The solutions and services can be **sourced from the operators' trusted and established business partners** or suppliers who are members of this Alliance. Members provide semantics of their products through a common asset repository with the aim to offer standards-based high-quality master data to the operators along with it. For an operator to integrate solutions from different vendors, connectivity alone is not enough. Hence these semantics in a common asset repository can be leveraged in building interoperable solution components.

The solution architecture blue print consists at the start of the collaboration effort of the Alliance of a **central common asset repository** and management system and semantic ontology, namely the Central Asset Repository in the common cloud central providing the **built-in network for collaboration** between business partners- operators, OEMs and service providers. The partners target to enhance access and interoperability of assets, applications and services including available ecosystem offerings in the market by leveraging the open, multi-protocol and multi-data semantic approach described above to grow the broadness, multi-ethnicity and collaboration capabilities of the approach.

Open Industry 4.0 Alliance aims at bringing several micro-ecosystems relevant for operators and leverage the individual and joint strengths in technical, commercial and subject matter expertise. Instrumenting industrial production processes demands for **high security standards** of the measured, processed and stored data. As such, the Alliance understands and supports the desire of customers and asset operators to determine the geography, location and legislation of Industry 4.0/IIoT data and indicators, either locally stored, on premise, or in local or central cloud systems of their choice.

The Alliance acts as a **data custodian**: A critical hindering factor for broader success of Industry 4.0/IIoT solutions is the exposure of customers to the B2C business approach of “the customer is the product” established by hyperscaler cloud providers. What is evitable in the consumer markets cannot be the basis for implementation by businesses, as own know-how protection interest and liabilities towards clients’ IP assets build obligations for decision makers in due diligence of their operations.

The only available solution for that problem is to establish services which guarantee single-sided and clear business models and strictly prohibit hidden agendas with customers and their data for back door exploitation. As a result, a non-negotiable principle of the Alliance is to demand by implementers and service providers to act in this regard as a **trustworthy custodian for customer data and IP assets**.

3 BENEFITS AND VALUES

The Alliance aims at accelerating the digitization in factories, processing plants and warehouses of the operators. The Alliance creates mutual benefits and values for both the customers, operators, users, OEM and vendors of Open Industry 4.0 approved components, systems and solutions.

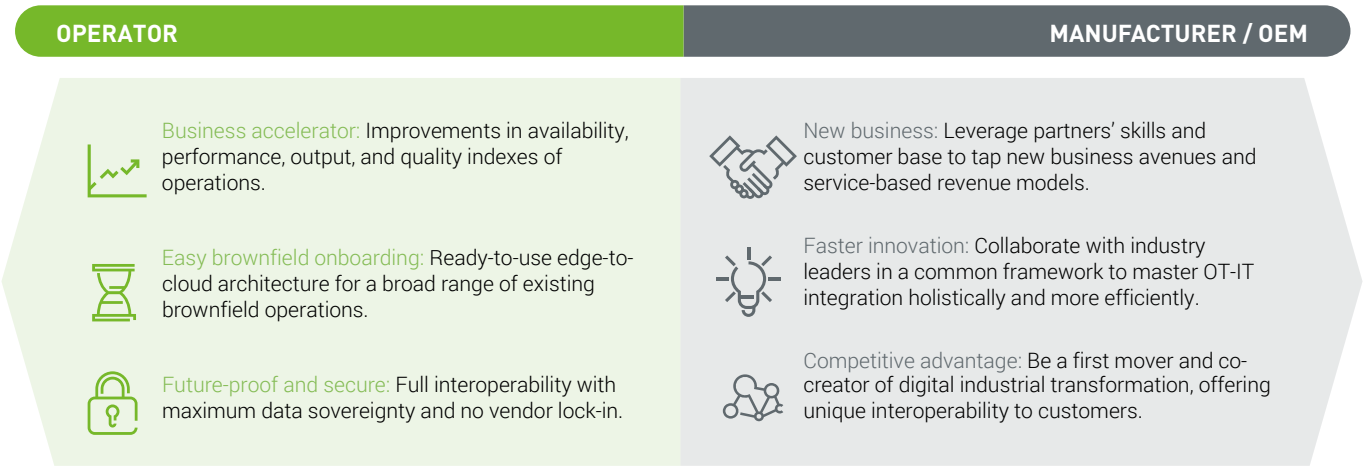

Figure 6: Summary of benefits for operators and manufacturers/OEMs.

3.1 VALUE FOR OPERATORS AND OPEN INDUSTRY ALLIANCE ECOSYSTEM

Operators, owners of the industrial facilities in discrete and process industries, are keen on constantly improving production/logistics efficiency and optimization. Today's data collection analysis capabilities offer to optimize existing greenfield and brownfield operations and enable manufacturers to deliver the digital twin together with the physical product as expected by many clients. Operators benefit from:

End-to-End Solutions – From Shop Floor to Top Floor. The Alliance strives for Industry 4.0 /IIoT solution sets targeting the needs of the operator. The members compose solution sets out of the complimentary interoperable components and suitable professional services covering the path from thing to business processes in a unified solution.

Enhancing Interoperability. Operators typically run a diverse multi-vendor set of machinery on the shop floor. To unleash the Industry4.0/IIoT benefits across the complete production process, the operators integrate partial solutions from different vendors into a system of systems. To enable interoperability between multi-vendor solutions, the Alliance members commit to provide solution components adopting a broad range of industry standards and protocols for common semantics and an open API. The Alliance solution design principles explicitly address hybrid (Edge-Cloud computing) approaches by highlighting the importance of edge computing.

The Principles of the Open Industry Alliance Ecosystem are:

- **Trust Relationship Management.** Trust is the principle of cooperation for every member of the ecosystem on every level of the Industry 4.0/IIoT solution, from device to edge to local to public cloud. As one cornerstone of the federated **Identity Management**, role-based access to data and algorithms and execution by subsidiarity principle means public and private data and algorithms on every layer for every participant. This hybrid architecture enables the customer and the vendor of sensitive applications to distribute production process data on the edge computing and the cloud platform level to avert the reverse engineering of existential production processes through information fragmentation.

- **Cross Platform – Cross Company – Cooperation.** The technical world of Industry 4.0/IIoT assets, devices or cyber physical systems is too big to be embraced by a singular offering in the domain of Industry 4.0/IIoT platforms and solutions. Thus, a truly open "hyper" platform concept must target the "open and interconnectable for everyone" principle. The operators can collaborate directly with the asset OEMs for optimal operation of the assets through their life cycle by the common cloud central layer. Horizontally and vertically, the architecture allows for integration of all market companions and offerings.
- **Data Ownership and Custodian Principle.** The Open Industry 4.0 Alliance delivers trust through comprehensible data custodianship principles. I.e. the Alliance asserts a common understanding of data ownership to enable the operators to determine the rules of data sharing along with appropriate levels of data privacy. Generally, the operator should be considered the owner of use-centric data produced by equipment owned, whilst asset- or device-centric data may be of a private nature to the asset or device vendor in the ecosystem. With fair and balanced data ownership without hidden exploitation by any of the partners, services rendered can become trust-based, and a truly sustainable business model arises from Industry 4.0/IIoT, and data owners can truly determine access and data usage.
- **Choice of Region & Choice of Legislation.** For operators and ecosystem participants alike, it is critical to choose where to store and execute algorithms and data. Therefore, choice of geography, legislation, locale of asset, locale of operator (on premise cloud, e.g.) or central data and service allocation is crucial.
- **Security by Design.** The Alliance asserts a clear and comprehensible security concept. Every chosen technology must meet the state-of-the-art requirements of security for encryption and authentication. The common shared asset semantics and information modelling allows for object-oriented authentication techniques which are significantly harder to compromise. The hybrid edge-cloud architecture introduces fragmentation of edge computing of mass data and cloud-based interactive information processing and consumption. To gain a deeper understanding of the security concept there is a detailed Security White Paper (see www.openindustry4.com).
- **Easy Asset Onboarding.** By embracing standards for the connectivity, asset semantic modelling and integration of Industry 4.0/IIoT solutions, the Alliance accelerates the deployment and onboarding of new or replaced assets at lower costs.
- **Future Proof and Sustainability.** The Alliance members are committed to ensuring stability and backwards compatibility.

Process House Framework with relevant Use Cases and Product Solutions Ecosystem

The principles of the Open Industry 4.0 Alliance reflect the deep understanding of the Alliance members of what matters for the operators at a high level.

Additionally, we have taken this understanding a level deeper and formulated a common **Process House Framework** across discrete and process industries. By populating this Process House with the priority use cases that the Alliance members will work on together, we are creating a common ground for discussions with operators.

While use cases signify the pain points, we wish to address, the creation of a list of product solutions across all the Alliance members underlines our strong commitment and aspiration to deliver on the promise of an interoperable future.

More details about our *Process House Framework, the related use cases and the Product Solutions Ecosystem* can be found on www.openindustry4.com as a white paper with additional graphics and details to the above for download.

3.2 VALUE FOR MEMBERS

The framework of the Alliance enhances the collaboration between operators and OEMs through visibility of asset operations and usage. OEMs/manufacturers benefit from the use of shared data by operators to expand services offering, increase services efficiency, build customer loyalty and improve product designs. Additional revenue through managed applications as value-added services help to differentiate product offerings and expand the market reach with industry 4.0/IIoT applications.

„As a member of the Alliance, we can offer our current customers additional and advanced solutions in our product portfolio",
mentioned Mr. Hans Huber, General Manager, Endress+Hauser Process Solutions GmbH

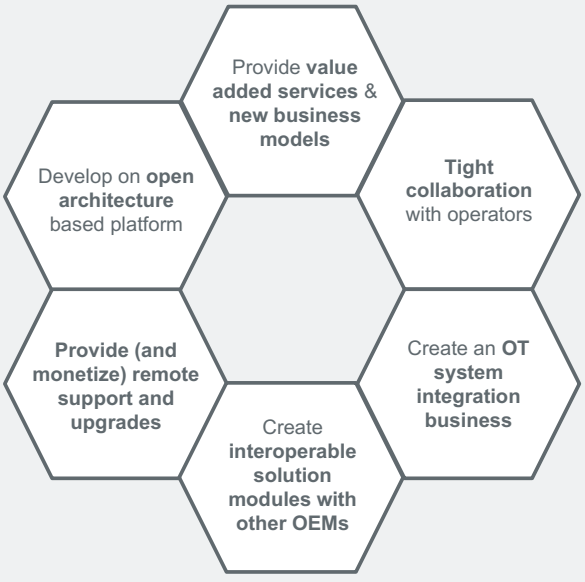

Figure 7: Key benefits for members of the Open Industry 4.0 Alliance.

4 ALLIANCE FRAMEWORK - ONE AND OPEN

The Alliance framework aligns to a common set of design principles which provide the foundation and guideline for all organizational and technical decisions made by the members. The design principles, **One and Open**, are one of the main differentiators to other Industry 4.0/IIoT initiatives in the market. The design principles are guidelines to align the solutions created and offered by members of the Alliance.

Figure 8: Design principles of the Open Industry 4.0 Alliance – One and Open.

- An Open Industry 4.0 Alliance member will provide **integrated cloud and/or edge platforms** for manufacturing with secure connectivity, device management, edge application management, data ingestion, condition monitoring in a wide variety for targeted industry segments. Such **end-to-end solutions will adopt end-to-end standards-based common semantical data models** developed and supported jointly by the Alliance members across all offered solutions.
- The Open Industry 4.0 Alliance members provide a **central asset repository for operators and OEMs/ manufacturers** to share and update semantic models of the assets, easing asset onboarding, integration and collaboration.
- All Open industry 4.0 Alliance members (OEMs) will pre-populate asset master data models in this central asset repository.
- **All major connectivity protocols** for assets and devices, e.g. OPC UA, Profinet, Ethernet/IP, EtherCAT, IO-Link, Hart etc., will be supported for automatic asset discovery and onboarding into the central asset repository.
- **A library of Open Industry 4.0 Alliance certified applications & solutions** from different members (manufacturers, application providers, partners etc.) is provided on the Alliance marketplace and promoted by the Open Industry 4.0 Alliance members.

5 TECHNICAL ARCHITECTURE

To fulfill the Open Industry 4.0 Alliance's vision, i.e. to provide "A holistic IIoT framework powered by an Alliance of leading industry partners to drive the digitization of the factory, plant and warehouse and ultimately create an ecosystem by linking IT and OT, while bridging the divide between owners/operators and OEMs", members bring their collective expertise to provide high value integrated and interoperable industry 4.0 solutions as per the "Open Industry 4.0 Alliance modular reference solution architecture framework". This solution architecture framework is conceptualized keeping in mind to embrace all the important industry 4.0 standards and protocols and by defining interfaces to be used by a multitude of offerings inside an open ecosystem.

"For the customers and members of the Open Industry 4.0 Alliance, open and fair dealings within the Alliance will be crucial. Customers expect product and capability competition based on open, compatible and standards-based infrastructures,"

said Mr. Gerd Hoppe, Beckhoff Automation GmbH & Co.KG.

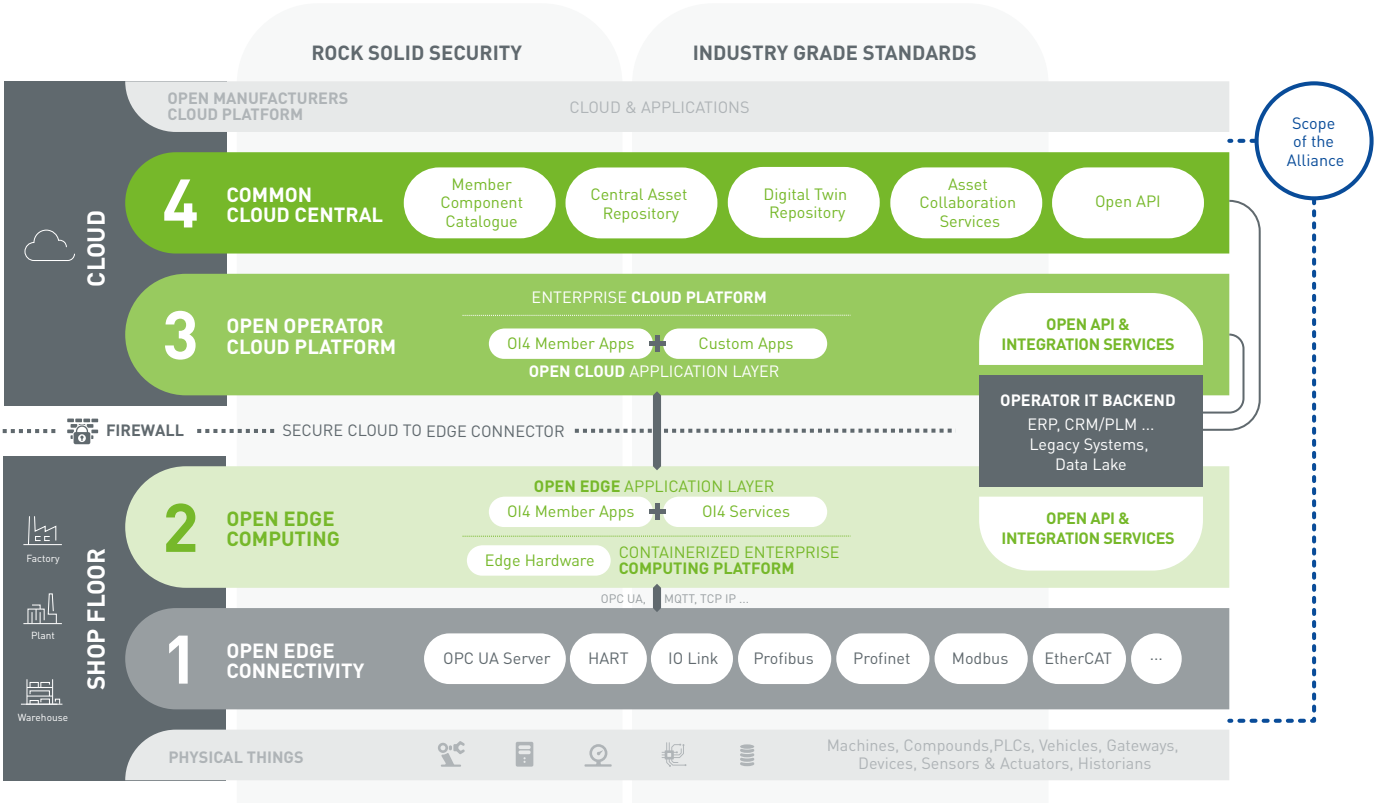

Figure 9: The Open Industry 4.0 Alliance technical architecture – a holistic IIoT framework.

Alliance members collectively provide solutions and services across the building blocks as depicted in the picture above. The key highlights are as below

- The overall solution works with **common data semantics** driven by the **common cloud central**.
- End customers (operators) can also readily access the repository of assets from the vendors directly and enable **collaboration with contents and updates**.
- Alliance members plan to provide a range of **edge connectivity solutions** to serve both **greenfield and brownfield assets** for faster implementations.
- This reference architecture will leverage emerging needs to serve the factory/plant personnel with an **open and containerized edge computing platform.**
- The IIOT cloud platform layer is open to accommodate customers' existing investment with an approved **cloud-to-edge connector**.

As a proof of concept, the members of the Open Industry 4.0 Alliance have already implemented a first demo system combining solutions from different companies in an interoperable onboarding and data acquisition setup. Focusing on the Open Edge Computing layer as the first step into the world of Open Industry 4.0 Alliance, the demo system comprises of several devices, an edge solution with a message bus and a well-defined data exchange based on MQTT with a JSON-encoded OPC UA payload. The demo system will be exhibited, for instance, at the SPS fair in Nuremberg 2019.

All delivered solutions by members are expected to be listed in the marketplace directory which will come soon. For a deeper dive into the technical architecture, please request *Open Industry 4.0 Technical white paper*.

6 ORGANIZATIONAL ASPECTS

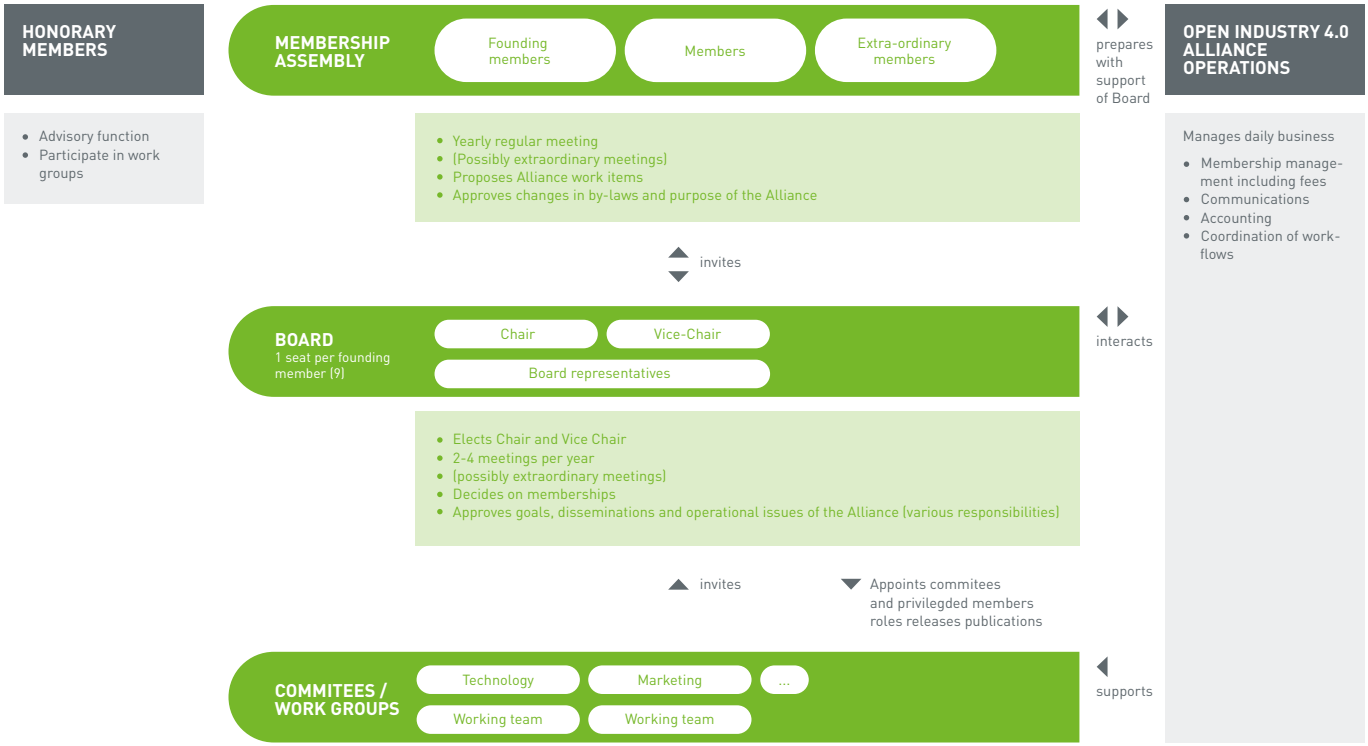

Figure 10: Organizational Structure

The Alliance members comprise of founders, members and (non-voting) honorary members. The founding members elect the board of directors, which appoints an executive body to run the day-to-day operations of the Alliance. The board of directors and the membership assembly can appoint non-voting members as advisors or evangelists for the Alliance and assign special roles in the Alliance to privileged members.

The board of directors also appoints Technical and Go-to-Market Committees, who in turn can set up individual work groups. The regular members nominate their representatives to engage in the workgroups and collaborate in creating the Open Industry 4.0 Alliance ecosystem. Details about membership and structuration can be found in the

- **Bylaws**
- **Intellectual Property Rights Policy**

(see www.openindustry4.com)

7 OUTLOOK FOR 2020

In order to achieve the goal of creating customer value, the outlook of Open Industry 4.0 Alliance future of activities reflect our phased approach to immediately engage with operators in pilot implementations. The key activities are as below:

- Further engage with customers (operators) to initiate pilot projects
- Expand the collaboration with other interest groups and organizations to foster the integrative mission of the Alliance
- Strategically expand the member ecosystem along the customers' (i.e. operators') value chains
- Members to build and package interoperable end-to-end solutions for high-value use cases of the target industries
- Members develop multilateral interoperable solutions and services further and provide them across the building blocks of an ecosystem
- Members (OEMs) of the Alliance continue to pre-populate the central asset repository with asset master data for ready to use by the operators
- Further streamline and scale the organizational processes of the Open Industry 4.0 Alliance operation to match the growing interest in the Alliance.

For more information on The Open Industry 4.0 Alliance, please visit www.openindustry4.com.

8 LIST OF FIGURES

www.openindustry4.com

OPEN INDUSTRY 4.0
ALLIANCE