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Deliverable D10.1
Standardisation base line

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Abstract
This document constitutes deliverable D1.10 Standardisation base line of the Arrowhead Tools project.

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1. Executive Summary

The standardisation as a key element for the digital inclusion in response to the industrial production globally, plays a crucial role in the Arrowhead Tools project within the WP10 – Standardisation. The main objectives of the Arrohead Tools project is to contribute to the interoperability for IoT and SoS engineering tools, and contribute as well to the interoperability and integration of data between all the systems of the automatisation pyramid.

The present document reports major considerations related to the preliminary standardisation activities associated to WP10. The main objective of the deliverable is to extract standards, the interest and involvement of the consortium, contributing to further activities within the project lifetime associated to the interoperability and integration of IoT and SoS engineering tools.

Arrowhead Tools project does not intend to create and drive new standards but intends to try and influence standards and frameworks that are of particular interest to the project and its members.

The document is divided into two main parts:

1. ***State of the art of the standardisation landscape, as well as the main standards and reference architectures and models for the industrial sector***

   On the one hand, the contextualisation of standardisation in current manufacturing processes and its relevance in digital transformation exploring the main challenges industrial companies must approach while implementing structured standards. The interconnected industries should consider three kinds of integrations; End-to-end integration, Horizontal integration, and Vertical integration with enough flexibility to maximise efficiency. The main standards identified to the industry 4.0 by the principles standardisation stakeholders are the ones of communication protocols, interface and data exchange, semantic, interoperability, management and software frameworks.

   On the other hand, the smart manufacturing reference architectures and models that support a company in setting up its entire production based on a jointly agreed standard solution, such as RAMI 4.0, Smart Manufacturing ecosystem developed by NIST and IIRA. Furthermore, the document describes the most relevant Standards Setting Organisations (SDOs) and alliances.

2. ***Partner standardisation survey.***

   Each Arrowhead Tools partner received a standardisation survey receiving a response of 37 of them, as a significant sample of the consortium. The partner survey main objective was to identify the standardisation involvement and interest in a particular standard or standards group, and how each organization relate to the specific standard or group. The roles were: Charing/co-chairing, actively contributing, member (rather monitoring or observing), member on national level, user, or interested.

A major target point for Arrowhead Tools partners is to automate more – on the factory floor, throughout the supply chain and during the maintenance during the lifespan of the products.

The results obtained from the partners´ inputs reflect the existing need in industrial environments in terms of interoperability in the transmission of data as well as its format and suitable representation between the different OT-IT layers. Interoperability for the use of IoT / SoS Engineering solutions to favour the digital transformation that allows meeting the global objectives of the Arrowhead Tools project and standardisation. With the partners´ inputs receiving a response of 37 institutions´ interests related to standardisation, seven major groups of standardisation areas have been identified:

- ***System and Software***
  The current requirements of industrial environments that compel the management of industrial control systems as an asset within the upper layers of the automation pyramid through IT software solutions, such as *ISO / IEC 42010 Systems and software engineering*, *ISO 15288 Systems and software engineering - System life cycle processes* or *IEC 62890 Life Cycle Management.*

- ***Information and Representation***
  The standard format with which data is transmitted and the representation of the properties of heterogeneous industrial devices and systems, becoming a real need to agilely comply not only with the much-desired interoperability, but also for the representation of digital twins and management of their life cycle. One example could be the *ISO 10303 (STEP) Industrial automation systems and integration - Product data representation and Exchange*.

- ***Semantics and Language***
  The representation and knowledge associated with specific applications and domains require the use of languages prepared for it. The principal standards are related to W3C and OMG.

- ***Communication***
  Partners are users or are interested in interoperable protocols and which can be used in different layers of an industrial environment such as OPC-UA (IEC 62541), the recent UMATI standard for machine tools or the well-known OneM2M, MQTT.

- ***Reference Model***
  The need to standardize industrial processes and their representation throughout their life cycle and in the automation pyramid through one of the standards previously seen in the areas of Communication, Semantics, etc, as seen in RAMI 4.0 and IIRA reference architecture and models.

- ***Cybersecurity and Safety***
  The partners are aware of Cybersecurity, not only at the IT level with the *ISO / IEC 27001* standard, but also at the OT level with the *IEC 62443*. Nor can´t ignore the

interest in Safety in industrial environments as equally or more important than at the software level.
Finally highlight the awareness of authentication and trust for contactless devices, web applications, or for AI.

- ***Domain-Specific Standard***
  It should be noted the active participation of partners in standards associated with Industry 4.0 technologies and therefore facilitators for the introduction of solutions and engineering tools in the working committees of Robotics (*ISO / TC 299)*, Artificial intelligence (*ISO / IEC JTC 1 / SC 42)*, Internet of Things, Blockchain and Digital Twin. Nor can´t forget specific regulations for the Oil & Gas sector, semiconductors or standards associated with Energy and environmental management.

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Table 1. Standardisation Contacts and Involvement

2. Introduction

2.1 Objectives and Scope

The deliverable "10.1 Standardisation base line" is fully related to the activities under the Arrowhead Tools "WP 10 Standardisation" in response to Phase I. The deliverable shows a whole view of the standards which Arrowhead Tools members are interested or part in Standardisation Development Organizations (SDOs), Working Groups or Task Forces. The work carried out represent pre-information to develop in next steps along the project in "Task 10.1 Language standards", "Task 10.2 Reference model and methodology standards" and "Task 10.3 Interface and industrial communication standards".

Once having the whole view of standards from the consortium, the next steps are fully related to specific areas of standardisation such as Language standards, Smart Manufacturing Reference Models or Interface and industrial communication standards together with use cases.

Arrowhead Tools project does not intend to create and drive new standards but intends to try and influence standards and frameworks that are of particular interest to the project and its members. For this reason, there will be contributions associated with the outstanding gaps in Phase II and Phase III.

To complete Phase III, the purpose is to tackle a Guide to implement standardisation strategies in Industrial companies. That outcome would be part of Phase III as added value for all work done before.

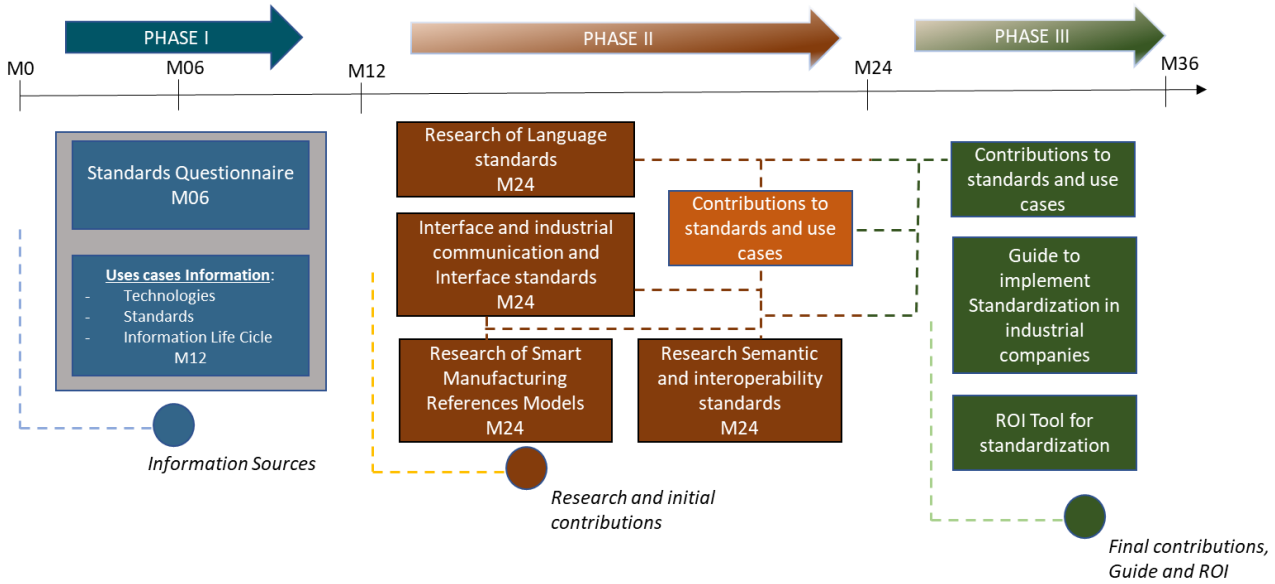

Figure 1. WP10 Workplan

The goal of the deliverable is to **extract the standards**, from the consortium, which are part of smart manufacturing and the technology associated with the objective of a significant reduction in development cost and time-based on more effective engineering tools and toolchains as well as useful instruments to achieve interoperability and prevent vendor lock-in.

To achieve the main objective above, the following specific objectives will be addressed:

- Describe the contextualization of Standardisation in current manufacturing processes and its relevance in digital transformation.
- Extract the principal standards, working groups and reference models for smart manufacturing and engineering tools and toolchains.
- In order to carry out a comprehensive standards' screening across the Arrowhead Tools members, a questionnaire was set up. It aims for retrieving the information on what standards are planned to be followed.
- Categorize the information received associated with a type of standards and relevance areas in smart manufacturing and engineering tools and toolchains.

2.2 Contextualization of Standardisation in current manufacturing processes and its relevance in digital transformation

Markets and new Service Business Models have imposed strong requirements for industrial companies running their businesses, namely demanding highly customized products exhibiting high quality and reduced prices [1]. The approach of the current and future automation systems is incorporating new methodologies and technologies allowing to be more adaptable to react to these changing requirements, as well as to new models of products based on smartization approach. As a consequence, common practices related to developing solutions so far represent vendor-specific or isolated production system should be gradually relegated.

In order to make the new industry paradigm (Industry 4.0) a success, challenges are basically related to implementing more complex systems, able to collaborate with other systems, exhibiting reconfigurability and responsiveness in a quite natural manner.

These systems named Cyber-Physical Systems (CPS) should be able to be self-adaptation, self-configuration and self-diagnosis as well as covering inter/intra-enterprise integration and running in ubiquitous environments. Particularly in manufacturing, from the existing hierarchical control structures based on the ISA 95 automation pyramid to more decentralized and reconfigurable systems based on the CPS principles.

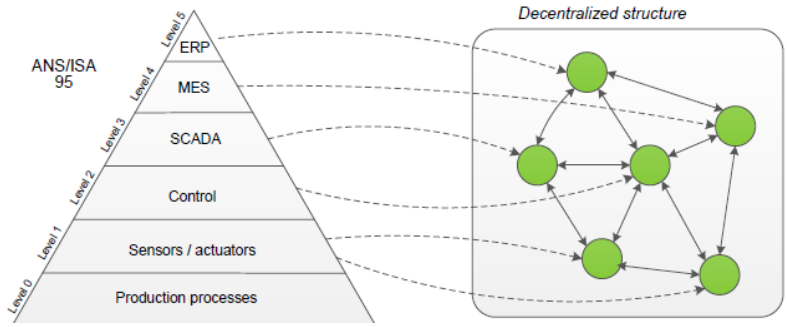

Figure 2: Moving from ISA 95 towards Cyber-Physical Production Systems [1]

On the other hand, with the development of Information & Communication Technology (ICT), industrial technology and management technology, manufacturing pattern and technologies such as Big Data, IoT, Cybersecurity, Additive Manufacturing etc are improving quickly to provide an environment to cover the needs of current industries and consequently the new CPS for the generation of value through a virtual representation of the physical world (Digital Twin) allows the coexistence between the Operation Technology (OT) and the Information Technologies (IT). All of them are related to the intelligent factory and to the interconnected world between customers and suppliers

All these approaches, conceptualizations and technologies which result in Industry 4.0 approach should consider three key characteristics to cover manufacturing life-cycle. They are Horizontal, Vertical and Digital integration [2].

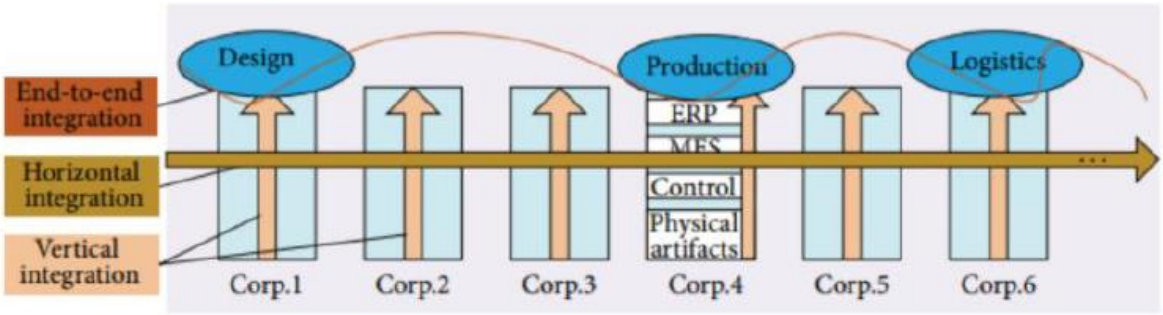

Figure 3: Illustration of three kinds of integration and their relationship [3]

- **Vertical Integration** allows CPS to set up flexible and reconfigurable Systems which manage manufacturing processes. The setting for vertical integration is the Factory. It refers to the **integration** of heterogeneous IT systems at different hierarchical levels during the manufacturing process.

- **End-to-end digital integration** refers to a holistic digital engineering view and proposes to close the gap between product design and manufacturing and the customer (Product Lifecycle Management), from the product design and development, through production planning, production engineering, production and associated services.

- **Horizontal Integration** refers to the use of technologies which are part of Industry 4.0 for exchanging and managing information across different manufacturing process such

as resources management system, logistics, marketing, or the most relevant part as intercompany value chains.

As part of the difficulties in implementing the Industry 4.0 clearly increase owing to the insufficient level of automation technology flexibility. Industrial equipment at the lowest level is highly specialized for a particular function and maximum efficiency. Their deployment results in poor variability and a low degree of compatibility between heterogeneous systems.

Therefore, standardisation is strongly required for all processes and entities that occur throughout the enterprise model, implemented associated with the requirements of the Standard Industry 4.0. It means [4]:

- standardisation of communication protocols.
- standardisation of connectors and interfaces.
- standardisation of data exchange, semantic and interoperability.
- standardisation of management and software frameworks.

Finally, the complete technical description and implementation of these provisions are referred to as the **reference architecture**. Architecture is defined as a description or model of the basic arrangement and connectivity of parts of a system either a physical or a conceptual object or entity [5]. Architectures are widely used to describe top structures and internal relationships of complex systems. In order to develop a smart manufacturing solution and push a systematic standardisation, architectures are developed by different industrial organizations and SDOs such as Smart Manufacturing ecosystem (SME), developed by NIST, Reference Architecture Model Industrie 4.0 (RAMI4.0), developed by Industrie 4.0 or Industrial Internet Reference Architecture (IIRA), developed by industrial internet consortium (IIC).

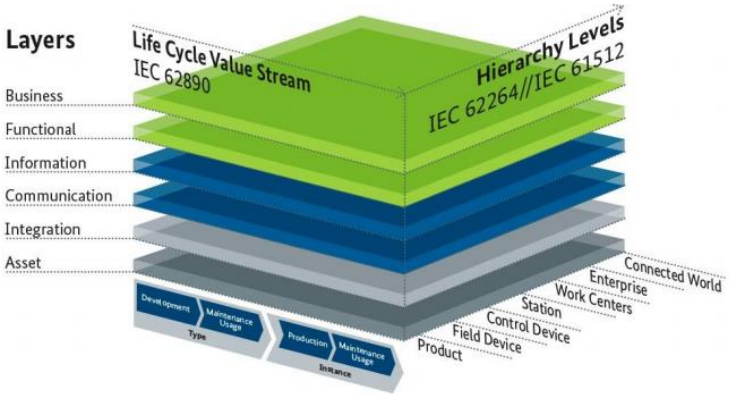

Figure 4: RAMI 4.0 [6]

2.3 Smart Manufacturing Reference Architectures and Models

This section defines the most relevant smart manufacturing reference models although in Phase II will be defined more in deeply. **Reference architectures and models** offer simple and generally proven solutions that support a company in setting up its entire production on the basis of a jointly agreed standard solution and thus quickly migrate to an advanced level.

According to [7], a reference architecture in information technology is a reference model for a class of architectures. These include the establishment of concepts and a methodology containing rules for the description of the physical world for the purpose of reflection within the information world:

- The reflection of relevant parameters and information from the physical world
- Representation/format of the physical world in the information world.
- Identification, Orchestration and Choreography of components.
- Network structure and data format for the exchange of information between components.
- Minimum requirements for implementation.

On top of that, reference architectures or models are specification documents that often offer common guidelines on e.g. how to apply a manufacturing process in an optimum way considering legacy and future cyber-physical and IoT systems, its interoperability and requirements to apply.

Reference architectures and models are therefore essential for integration IT/OT systems and Engineering tools and tools chains in order to ensure seamless integration of technical systems and related processes over the main industrial production life cycles in industry, health, smart home and building and mobility or energy sector.

In order to develop a smart manufacturing solution and push a systematic standardisation architectures are developed by different industrial organizations and SDOs over the last years. Because of a large heterogeneity of the architectures and models, SDOs and respective organizations start liaisons and undergo cooperation in order to achieve interoperability between the standards and contribute to harmonization. The most representative are:

- **RAMI 4.0 (Reference Architecture Model Industrie 4.0)** is a Reference Architecture Model for Industry 4.0 as well as an adaptation and expansion from the Smart Grid Architecture Model (SGAM) to meet the requirements of Industry 4.0 [8]. The RAMI 4.0 consists of a three-dimensional model to represent the I4.0. The corresponding axes of the model are listed below [9]:

    - **Hierarchy Levels**: a horizontal axis that is based on the IEC 62264 Enterprise-control system integration, that presents four layers called ‘Enterprise’, ‘Work Centers’, ‘Station’, and ‘Control Device’. In the RAMI 4.0 has been added three layers to support the smart factory ‘Field Device’, ‘Product or Workpieces’ and ‘Connected World’

- **Life Cycle and Value Stream:** this axis represents the life cycle of entities, such as workpieces, products and facilities; which is based on IEC 62890 Life Cycle Management.
- **Layers:** a vertical axis to describe the decomposition of machines and physical entities in a way to enable its virtual mapping ('Business', 'Functional', 'Information', 'Communication', 'Integration', and 'Asset')

- **Smart Manufacturing ecosystem developed by NIST** based on the collaboration manufacturing management model of ARC Advisory Group and the hierarchical model of ISO/IEC 62264, NIST describes the SME that encompasses manufacturing pyramid with three dimensions – product, production, and enterprise (business). NIST describes the SME that encompasses manufacturing pyramid with three dimensions – product, production, and enterprise (business) [10].

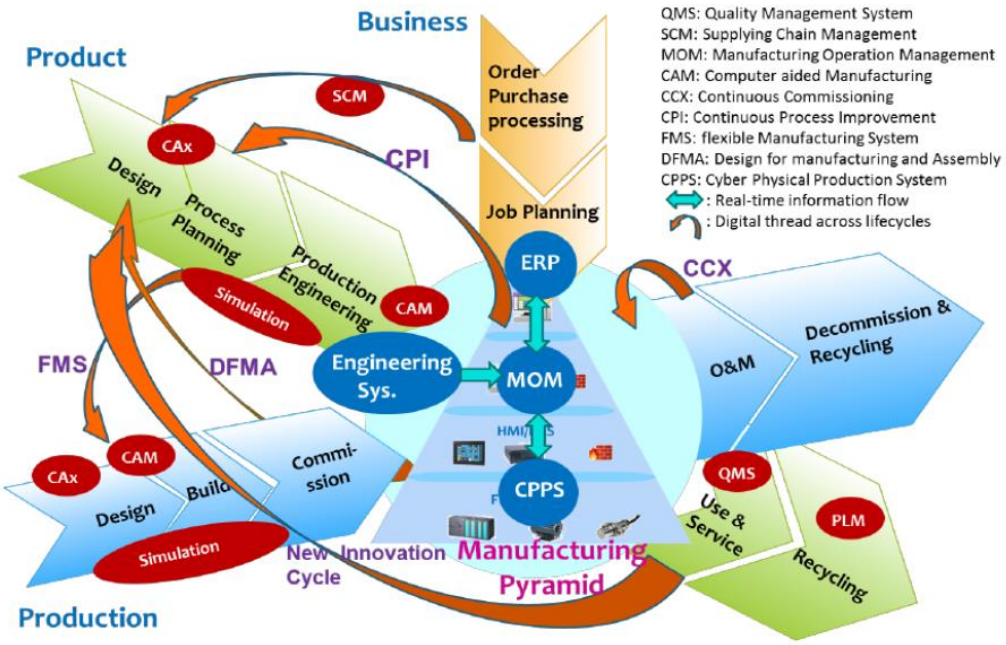

Figure 5: Smart Manufacturing Ecosystem – NIST [11]

The product lifecycle is concerned with the information flows and controls beginning at the early product design stage and continuing through to the end-of-life of the product. The production system lifecycle focuses on the design, deployment, operation and decommissioning of an entire production facility including its systems. Finally, the business cycle addresses the functions of supplier and customer interactions. Each of these dimensions comes into play in the vertical integration of machines, plants, and enterprise systems in what we call the Manufacturing Pyramid [11].

- **The Industrial Internet Reference Architecture (IIRA)** [12] is a standardized open architecture based on industrial production systems. The main scope of IIRA is to maximize its value of industry applicability to boost interoperability as well as mapping

suitable technologies, technological guidelines and standard development. The IIRA abstracts the common characteristics, features and patterns from diverse uses cases associated with the domain of communication, energy, healthcare, manufacturing, security, transporting and logistics [13]. These domains have been defined by the Industrial Internet Consortium (IIC) [1]. The previous concerns identified by the IIC are classified and grouped into four viewpoints (Business, Usage, Functional, Implementation).

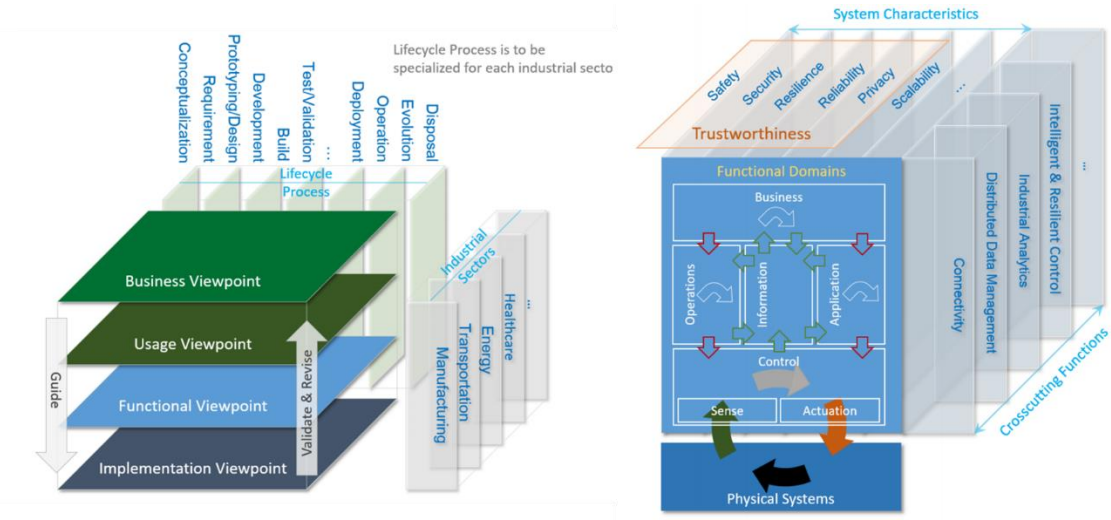

Figure 6: Relationship among IIRA Viewpoints, Application Scope and System Lifecycle Process as well as Functional Domains, Crosscutting Functions and System Characteristics [14]

2.4 Standardisation landscape

Several standardisation organizations associated with industry and research are currently involved in the development of the technological requirements for Industry 4.0 and the Industrial Internet of Things (IIoT). On the international level, the standardisation activities result in a very heterogeneous landscape. As a consequence, there exist a large number of standardisation initiatives that are working in parallel either in individual Standardisation Development Organizations (SDOs) such as Organization for Standardisation (ISO), International Electrotechnical Commission (IEC), International Telecommunication Union (ITU), Worldwide Web Consortium (W3C) and Internet Engineering Task Force (IETF) for Internet Standards or partnerships such as ISO and IEC joint technical committee (ISO/IEC JTC 1), ISA (International Society of Automation), IEEE (Institute of Electrical and Electronics Engineers), OneM2M (standards initiative for machine to machine communications and the Internet of things), IEC/SEG7 (smart manufacturing), ISO SMCC (smart manufacturing coordinating committee), and so forth.

Apart from that, there are other industry initiatives and open platforms which contribute to standardisation ecosystem such as Industrial Internet Consortium (IIC), Platform Industrie

[1] https://www.iiconsortium.org/

4.0, Standardisation Council Industrie 4.0 (SCI 4.0), Labs Network Industrie 4.0 (LNI 4.0), Alliance for IoT Innovation (AIOTI), etc.

Next figure shows the complex current landscape of Standards Setting Organisations (SSOs), identified by the Alliance for the Internet of Things Innovation (AIoTI). It also shows the distribution of SSO activities across different application domains and the underlying communication infrastructure.

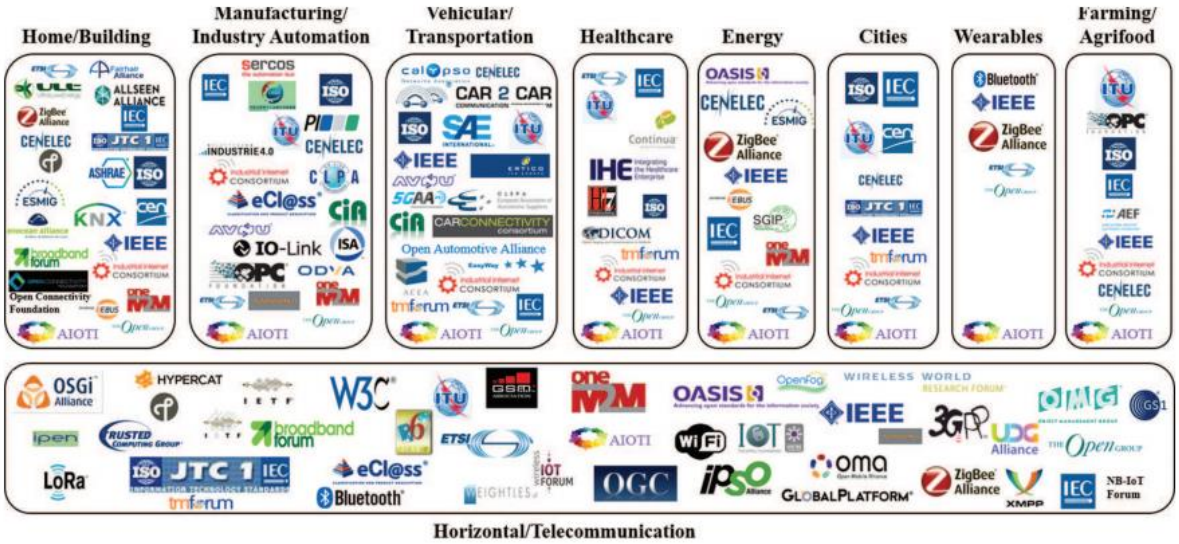

Figure 7: IoT SDOs and Alleances Landscape [15]

The most representative SDOs among others are:

- **ISO/TC184 automation systems and integration**. ISO/TC184 develops standards in the field of automation systems and their integration for design, sourcing, manufacturing, production and delivery, support, maintenance and disposal of products and their associated services. Areas of standardisation include information systems, automation and control systems and integration technologies. Its System Committee 1 is physical device control, System Committee 4 is industrial data and System Committee 5 is interoperability, integration and architectures for enterprise systems and automation applications.

  There is active collaboration with the relevant technical committees responsible for areas such as machines, manufacturing resources and facilities, robotics, electrical and electronic equipment, PLC for general application, quality management, industrial safety, information technologies, multi-media capabilities, and multi-modal communication networks.

- **IEC/TC65 industrial-process measurement, control and automation**. IEC/TC65 develops international standards for systems and elements used for industrial process measurement and control concerning continuous and batch processes. Working Group 10 is security for industrial process measurement and control - network and system security. Working Group 16 is digital factory. Working Group 19 is life-cycle

management for systems and products used in industrial-process measurement, control and automation. AHG3 is smart manufacturing framework and System architecture. Joint Working Group 21 is smart manufacturing reference model(s) which is linked to ISO/TC184 and where the new Task Force 8 is associated with Digital Twin and Asset Administration Shell.

- **ISO/IEC/JTC1 information technology**. ISO/IEC JTC1 develops international standardisation in the field of information technology, which includes the specification, design and development of systems and tools dealing with the capture, representation, processing, security, transfer, interchange, presentation, management, organization, storage and retrieval of information. JTC1 is the standards development environment where experts come together to develop worldwide ICT standards for business and consumer applications. Its WG7 is sensor networks, WG9 is big data, WG10 is Internet of things, SC25 is interconnection of information technology equipment, SC27 is IT security techniques, SC31 is automatic identification and data capture techniques, SC32 is data management and interchange, SC38 is cloud computing and distributed platforms, SC41 is Internet of things and related technologies.

In order to categorize and enumerate the principal and relevant standards for Industrial Internet of Things and provide a landscape, we have based the chapter on published reports from diverse countries, standards associated with smart manufacturing references models and taking into account the different developing stages as can been seen in figure below.

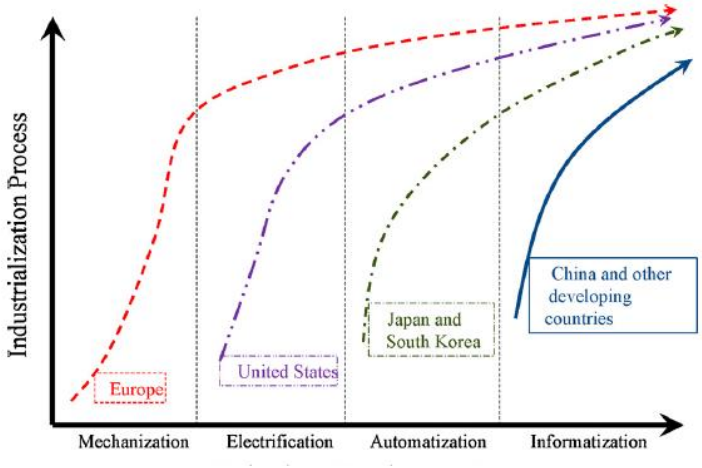

Figure 8: Industrialization process with technology development processes.[16]

Therefore, the principal reports are:

- National Institute of Standards and Technology (NIST) of the United States published Current Standards Landscape for Smart Manufacturing Systems[11].

- DIN, DKE VDE of Germany published German Standardization Roadmap Industry 4.0. [17] as well as Structure of the administration shell, the continuation of the development of the reference model for the industrie 4.0 component [18]

- Ministry of Industry and Information technology of China (MIIT) and Standardization Administration of China (SAC) published a joint report National Intelligent Manufacturing Standards Architecture Construction Guidance.[19]

- UNE / AENOR, Spanish standardization bodies published a report called ”Standardization for Industry 4.0” [20]

- Smart Manufacturing Standardization Reference Model (SMSRM) describing the relationship between process and technologies as can be seen in Figure 9.

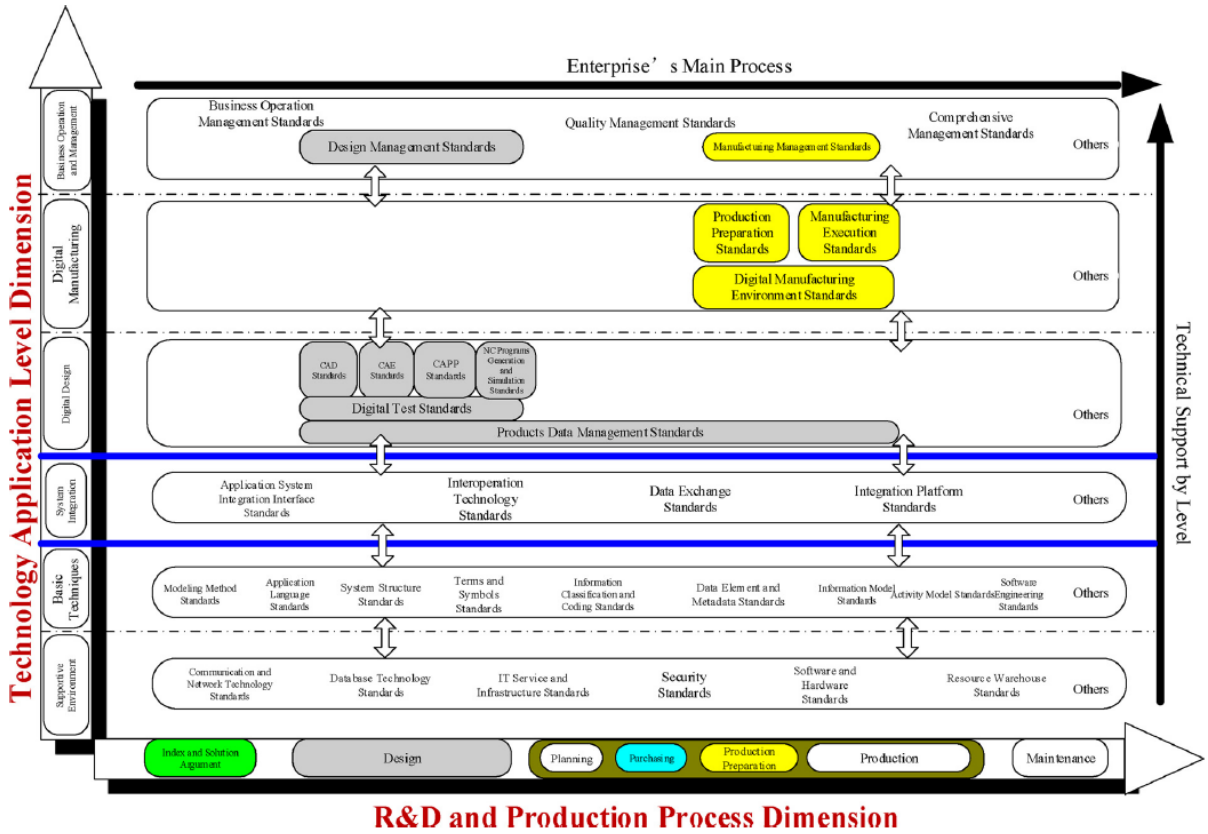

Figure 9: Smart manufacturing standardisation reference model [10]

- A valuable overview of relevant standards provided by Fraunhofer IAIS in http://i40.semantic-interoperability.org/

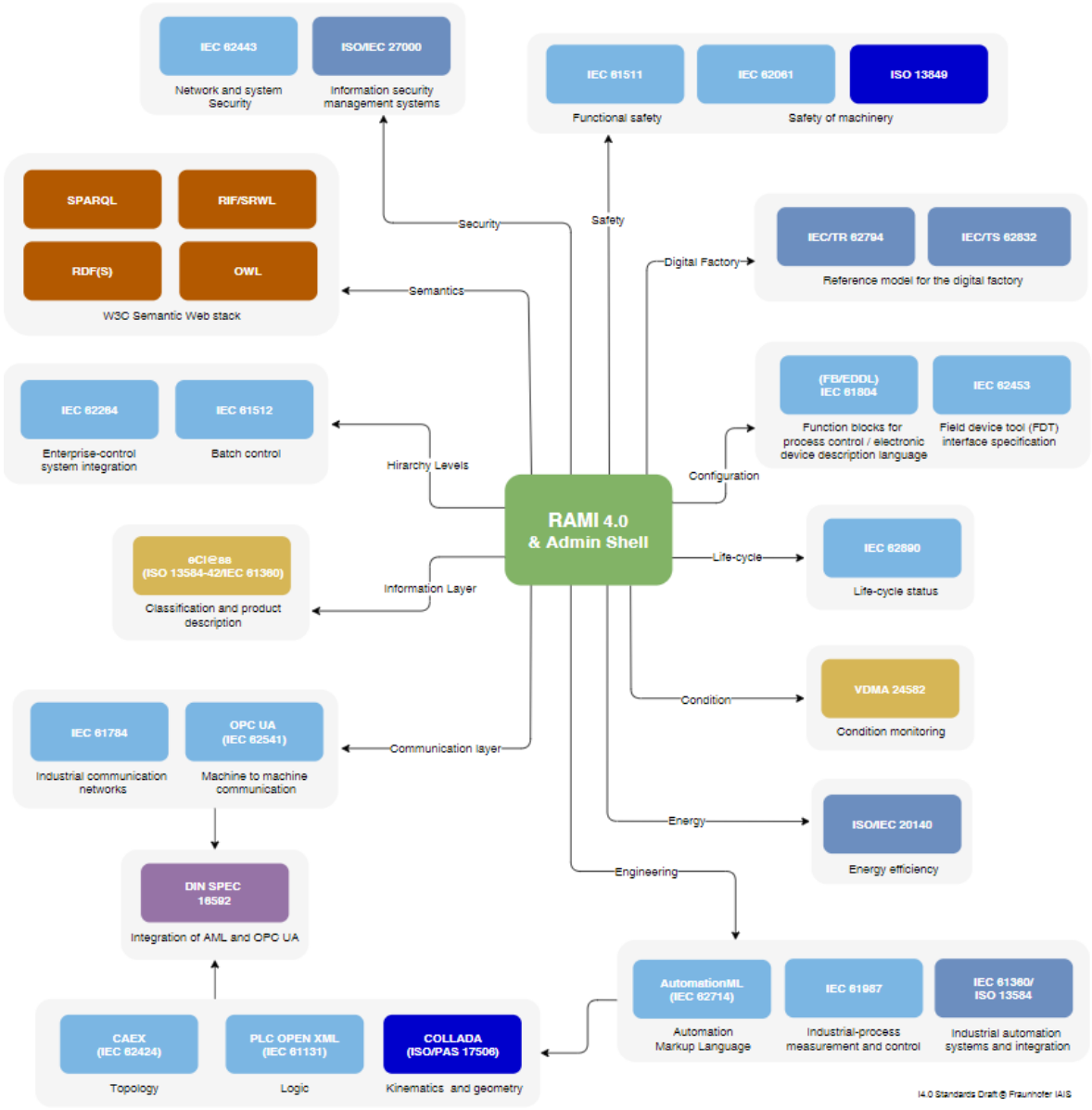

Figure 10: Industry4.0 Standardisation Landscape (Fraunhofer IAIS)

Some extract of the standards that are:

For communication

- IEC 61158: Industrial Communications Networks Fieldbus specifications;
- IEC 61784: Industrial Communications Networks Profiles. Fieldbus profiles;
- IEC 62657-1:2017: Industrial Communications Networks Wireless communication networks.

For interoperability:

- IEC 61804: Electronic Device Description Language;
- IEC 62264: Manufacturing Execution System;
- IEC 62541: UAS OPC UA;

- IEC 62714: Data exchange format;
- ISO 18828: Data Format; ISO/CD 8000; Data Exchange, among others.

For cybersecurity, as a transversal and fundamental area.

- ICT information protection standards are considered:
  - ISOO / IEC 27000 family: Information Security Management;
  - ISO / IEC 27032: Guidelines for the cybersecurity;
  - ISO / IEC 27033: Network security;
  - ISO / IEC 27034: Application security;
  - ISO / IEC 27035: IT security incident management;
  - ISO / IEC 27050: Management of research processes;
  - ISO / IEC 27037: Digital evidence management;
  - ISO / IEC 27036: Information security management in relations with third parties.
- Related to Industrial Networks
  - IEC / SC 65C / W13: industrial networks with the family of standards:
  - IEC TS 62443 for industrial communication networks,
  - ISO TC 292 / WG, Continuity and resilience of organizations with the standard.
  - UNE-EN ISO 22313: Protection and safety of citizens, and Management System for Business Continuity.

For Advanced robotics, robots interacting with people and above all guaranteeing the safety of people who interact with robots. This field highlights the basic safety standards for industrial robots,

- ISO 10218: Robots and robotic devices;
- ISO/AWI 22166: Service Robots;
- IEC TS 63069: Industrial Process. Safety requirements for industrial robots
- ISO TS 15066: Robots and robotic devices

For Additive manufacturing

- ISO/ASTM 52901
- ISO/ASTM AWI 52907
- ISO/ASTM CD 52911
- ISO/ASTM DIS 52903
- ISO/ASTM NP 52905
- ISO/ASTM PWI 52913
- ISO/AWI 14649-17

For Product Development Lifecycle to enhance modelling accuracy, as well as reduce product innovation cycles, and hence contribute directly to manufacturing system agility and product quality.

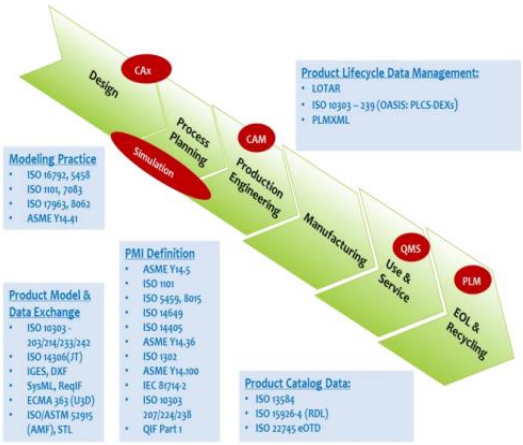

Figure 11: Standards Digitally Threading the Product [11]

For Production System Lifecycle which includes Design, Build, Commission, O&M and Decommission. Similarly, the categories of standards supporting production-system lifecycle activities include Production System Model Data and Practice, Production System Engineering, O&M, and Production System Lifecycle Data Management.

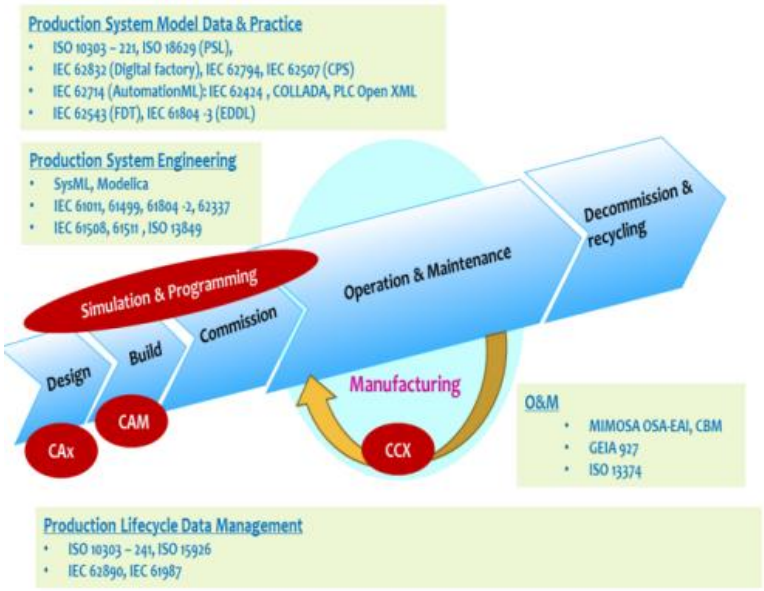

Figure 12: Standards for Production System Lifecycle [11]

For supply chain management to enhance supply chain efficiency and manufacturing agility. There are two sets of critical standards for Business2Business (B2B) and Application2Application (A2A) integration: APICS Supply Chain Operations Reference (SCOR) and Open Applications Group Integration Specification (OAGIS).

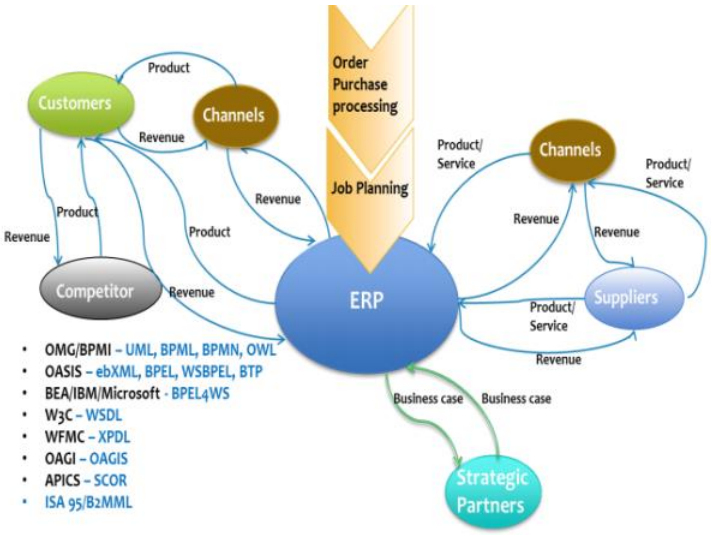

Figure 13: Standards for supply chain management[11]

2.5 Overview and Analysis of Partner Surveys

The present sub-chapter identifies and differentiate the standardisation interests and involvement of each of the participant partners. The main objective is to create a standardisation network to share the committees' outcomes and take the project's results to those national or European organizations. Some partners that are interested in a standard can relate and ask the actively involved partners developing relations according to insights and project results.

The main groups identified are:

- System and Software Standards
- Information and Representation Standards
- Semantic and Language Standards
- Communication Standards
- Reference Model Standards
- Cybersecurity and Safety Standards
- Domain-Specific Standards
- Other interests

2.5.1 System and Software

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested /user	Comments
JOTNE, CEA, POLITO, REUSE, UC3M	ISO/IEC	WG_LCP - Working Group for Life Cycle Processes	15288	Systems and software engineering — System life cycle processes		CEA, JOTNE, POLITO, REUSE, UC3M	

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested /user	Comments
REUSE, UC3M	RTCA	RTCA SC-205, EUROCAE WG-12	DO-178C	Software Considerations in Airborne Systems and Equipment Certification		UC3M, REUSE	
CEA, POLITO, REUSE, UC3M	ISO/IEC	ISO/IEC JTC 1/SC 7	12207:2017	Systems and software engineering -- Software life cycle processes		REUSE, UC3M, CEA, POLITO	
REUSE, UC3M	ISO/IEC	ISO/IEC JTC 1/SC 7	25010:2011	Systems and software engineering -- Systems and software Quality Requirements and Evaluation (SQuaRE)		REUSE, UC3M	
CEA, POLITO	ISO/IEC/ IEEE	ISO/IEC JTC 1/SC 7	42010	Systems and software engineering		CEA, POLITO	
AIT	ISO TC 22	SC 32 WG 12	ISO 24089	Road vehicles - Software update engineering - OTA	AIT		Envolving standards, ASI K038
CEA, POLITO	OMG		MARTE	Modelling and Analysis of Real-time and Embedded systems	CEA	POLITO	
CEA, REUSE, UC3M	INCOSE		NA	Requirements Working Group	REUSE, UC3M	CEA	INCOSE is not directly a standardisation body.
AIT, BEIA	ETSI	ITS		Intelligent Transport Systems	AIT	AIT, BEIA	AIT is ETSI member
VTT, ABB	OSA-EAI		OSA-EAI	OSA-EAI Open System Architecture for Enterprise Application Integration V3.2.3 Production Specification, MIMOSA, 2012		VTT, ABB	
VTT, ABB	OSA-EAI		OSA-EAI	OSA-CBM Open System Architecture for Condition-Based Maintenance V3.3.1 Production Specification, MIMOSA, 2010		VTT, ABB	
UC3M	SWAGGER	n/a	OAS	Open API Specification		UC3M	https://swagger.io/specification/ It is not actually a standardisation body.

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested /user	Comments
ECL	OGC		OGC SensorThings API	OGC SensorThings API		ECL	Eclipse Whiskers
IQL	AUTOSAR	WP4	AUTOSAR	AUTOSAR		IQL	Open software architecture for automation
ECL, FAUT	IEC	TC 65/SC 65B	IEC 61499	IEC 61499 Function Blocks for Embedded and Distributed Control System Design		ECL, FAUT	EClipse Whiskers
AIT	IEC	IEC TC 56	IEC 62741	Reliability of systems, equipment and components. Guide to the demonstration of dependability requirements. The dependability case		AIT	EWICS TC7, ÖVE EG 56
AIT	IEC	IEC TC 56	IEC 62853	Open systems dependability		AIT	EWICS TC7, ÖVE EG 56
BEIA, MGEP, MON, POLITO, REUSE, ROPARDO, UC3M	IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management		BEIA, MGEP, MON, POLITO, REUSE, ROPARDO, UC3M	
MON, VTC	IEC	ISO/TC 10	IEC 81346	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations		MON, VTC	
AIT, BEIA	IEC TC 65	WG 22	IEC TS 63164	Reliability of Industrial Automation Devices and Systems	AIT	BEIA	ÖVE MR65
CEA, REUSE, UC3M, FARR	OASIS	CORE	OSLC CORE	OASIS OSLC Lifecycle Integration Core, REST APIs to connect data		CEA, REUSE, UC3M, FARR	See also: https://open-services.net / The interest and application are in the OSLC ecosystem.
FARR	IETF	RESTful Environments	RFC 6690	RESTful Environments (CoRE) Link Format		FARR	

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested /user	Comments
UC3M	RTCA	SC-205	DO-331	Model-Based Development and Verification Supplement to DO-178C and DO-278A		UC3M	
FAUT	ISO	ISO/IEC JTC 1/SC 22 Programming languages, their environments and system software interfaces	ISO 16262	ISO 16262 Information technology — Programming languages, their environments and system software interfaces — ECMAScript language specification		FAUT	(ES6 published 2015)
IFAK	VDI/VDE-GMA	FA6.23	VDI/VDE 2651	Plant Asset Management (PAM) in the process industry	IFAK		
IFAK	ZVEI	MES	Position paper	MES - Industry specific Requirements and Solutions	IFAK		

Table 2. Systems and softwares standardisation partners interest

2.5.2 Information and Representation

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
INDUSTRIAL DATA REPRESENTATION	JOTNE, REUSE, U3CM, VTT, FAUT	ISO	• TC 184/SC 4/WG 12 "STEP Product Modeling and Resource" • TC 184/SC 4/WG 21 "SMRL Validation Team"	ISO 10303 (STEP) ISO 10303-1000 ISO 14649 (Extend ISO 10303 - FAUT)	• Industrial automation systems and integration — Product data representation and exchange • STEP Module and Resource Library (SMRL)	JOTNE	REUSE, UC3M, VTT	**Most important:** • 10303-11: EXPRESS language • ISO 10303-21: ASCII data exchange file format • 10303-209: Multidisciplinary analysis and design

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
INDUSTRIAL DATA REPRESENTATION	JOTNE, REUSE, U3CM, VTT, FAUT	ISO	• TC 184/SC 4/WG 12 "STEP Product Modeling and Resource" • TC 184/SC 4/WG 21 "SMRL Validation Team"	ISO 10303 (STEP) ISO 10303-1000 ISO 14649 (Extend ISO 10303 - FAUT)	• Industrial automation systems and integration — Product data representation and exchange • STEP Module and Resource Library (SMRL)	JOTNE	REUSE, UC3M, VTT	• 10303-239: Product Life-Cycle Support • 10303-242: Managed model-based 3D engineering • The baseline data models for building the above application protocols, i.e., 10303-209/239/242 etc...
INDUSTRIAL DATA REPRESENTATION	JOTNE	ISO	•TC 59/SC 13/WG 6 "Framework for object-oriented information exchange" •TC 59/SC 13/WG 6 "Framework for object-oriented information exchange"	ISO 12006-2 ISO 12006-3	• Framework for classification • Framework for object-oriented information exchange	JOTNE		
	JOTNE	ISO	TC 29 "Small tools"	ISO 13399	Cutting tool data representation and exchange	JOTNE		
	JOTNE	ISO	TC 184/SC 4 "Industrial data"	ISO 18876	Integration of industrial data for exchange, access and sharing	JOTNE		
	MON	ISO, IEC	TC 65	eCl@ss (ISO 13584-42/IEC 61360)	ISO 13584-42, Methodology for structuring part families EC 61360 series, IEC Common Data Dictionary		MON	
	VTT	IGES		NBSIR 80-1978	Initial Graphics Exchange Specification IGES. Digital Representation for Communication of Product Definition Data		VTT	

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
INDUSTRIAL DATA REPRESENTATION	JOTNE	ASD/AIA	LOTAR "Longterm Archival and Retrieval"	NAS/EN 9300	Long Term Archiving and Retrieval of digital technical product documentation such as 3D, CAD and PDM data		JOTNE	
	ACCIONA	ISO	TC 127/SC 3	ISO-15143-3/AEMP 2.0	Earth-moving machinery and mobile road construction machinery — Worksite data exchange — Part 1: System architecture		ACCIONA	
	FAUT	ISO	ISO/TC 184	ISO 6983 (G-CODE)	Automation systems and integration — Numerical control of machines — Program format and definitions of address words — Part 1: Data format for positioning, line motion and contouring control systems		FAUT	
BUILDING CONSTRUCTION DATA INFORMATION	dotGIS	ISO	TC 211	• ISO 19114 • ISO 19115 • ISO 19115:2013 • ISO / TS 19103: 2005 • ISO / TS 19104: 2008 • ISO 19139 • ISO 6709: 2008 ISO/CD 19166 • ISO 19101	• Data quality elements • Geographical standard information • Geographical metadata standard • Geographic information - conceptual scheme language • Geographical information - Terminology • Geographical metadata standard • Standard representation of the location of geographical points by coordinates • Geographic information — BIM to GIS conceptual mapping GEOGRAPHICAL / GEOMATIC INFORMATION		dotGIS	

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
BUILDING CONSTRUCTION DATA INFORMATION	JOTNE	ISO	TC 59/SC 13 "Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)"	16739	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries	JOTNE	JOTNE	
	MGEP	OMG		BPMN	Business Process Model and Notation		MGEP	https://www.omg.org/spec/BPMN/2.0/
	HIOF	OMG	ManTIS	different	SENSR Product Knowledge Framework		HIOF	ongoing OMG processes in ManTIS group

Table 3. Information and Representation standardisation partners interest

2.5.3 Semantics and Language

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/user	Comments
MGEP, REUSE, UC3M, IFAG	W3C	OWL WG	OWL2	OWL Web Ontology Language Overview		IFAG, REUSE, UC3M, MGEP	The W3C Web Ontology Language (OWL) is a Semantic Web language designed to represent rich and complex knowledge about things, groups of things, and relations between things https://www.w3.org/OWL/

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/user	Comments
IFAG, MGEP IFAG. REUSE, UC3M	W3C	RDB2 RDFWG RDF WG	• R2RML • RDF • RDF 1.1 • RDF Data Cube • RDFS	• RDB to RDF Mapping Language • Resource Description Framework • RDF 1.1 Concepts and Abstract Syntax • The RDF Data Cube Vocabulary • RDF Schema 1.1		IFAG, REUSE, UC3M, MGEP	RDF is a standard model for data interchange on the Web https://w3id.org/i40/sto#W3C_RDF
IFAG, UC3M	W3C	Data Shapes WG	SHACL	Shapes Constraint Language (SHACL)		UC3M, IFAG	Shape Expressions
IFAG, REUSE, UC3M	W3C	SKOS WG	SKOS	SKOS Simple Knowledge Organization System Reference		UC3M, IFAG, REUSE	
IFAG, MGEP	W3C	SPARQL WG	SPARQL	SPARQL Query Language		IFAG, MGEP	The SPARQL Protocol and RDF Query Language (SPARQL) is a query language and protocol for RDF. https://w3id.org/i40/sto#W3C_SPARQL
CEA, ICTG, MON, POLITO, VTC, HIOF, IQL, REUSE, UC3M, BME, TUE	OMG		SysML	System Modeling Language	IQL, CEA, HIOF	MON, POLITO, REUSE, UC3M, VTC, ICTG, TUE, BME	
CEA, POLITO, TUE	OMG		UML	Unified modeling language	CEA	POLITO, TUE	
TUE	OMG		MOF	Meta Object Facility		TUE	Foundational standard for model and language design, storage, transmission
FAUT	W3C		HTML	Hypertext Markup Language		FAUT	
FAUT	CSS	CSS WG	CSS 3	Cascading Style Sheets 3		FAUT	

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/user	Comments
MGEP	OASIS		BPEL	Business process Execution Language		MGEP	http://download.boulder.ibm.com/ibmdl/pub/software/dw/specs/ws-bpel/ws-bpel.pdf
UC3M	W3C	LDP WG	LDP 1.0	Linked Data Platform 1.0		UC3M	
CEA, REUSE, U3CM	INCOSE		NA	Ontologies and Knowledge Management Group	UC3M, REUSE	CEA	INCOSE is not directly a standardisation body.
IFD	W3C		XML	Extensible Markup Language (XML) 1.0 (Fifth Edition)		IFD	
TUE	OMG FMI		XMI FMI	XML Metadata Interchange Functional Mock-up Interface		TUE	• Standard format for model transmission and storage. •A tool independent standard to support both model exchange and co-simulation of dynamic models using a combination of xml-files and compiled C-code
FARR, IFD	IETF	JSON WG	RFC 5741.	JavaScript Object Notation (JSON) Data Interchange Format		FARR, IFD	
UC3M	OMG	n/a	SACM 2.1	Structured Assurance Case Metamodel		UC3M	

Table 4. Semantics and Language standardisation partners interest

2.5.4 Communication

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
OPC-UA	BEIA, IFD, MON, VTC, VTT, ICTG, IKELAN, ECL, FARR, ABB, FAUT, MSI	OPC Foundation/IEC	TC 65	IEC 62541	OPC-UA		VTC, VTT, BEIA, ECL, FARR, ICTG, IFD, IKERLAN, MON, ABB, FAUT	Eclipse Milo

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
UMATI	FARR, FAUT	VDW, OPC Fundation	umati JWG	UMATI	umati – universal machine tool interface OPC UA Companion Specification for machine tools and manufacturing systems to external communication partners		FARR, FAUT	
MQTT	FARR, EUROTECH, ECL, IKERLAN	ISO/IEC	ISO/IEC JTC 1 Information technology	ISO IEC 20922	ISO/IEC 20922:2016 Information technology — Message Queuing Telemetry Transport (MQTT)	EUROTECH,	EUROTECH, IKERLAN, FARR, ECL	Eclipse Paho
MQTT	IKERLAN	OASIS	OASIS MQTT TC	MQTT	Message Queuing Telemetry Transport		IKERLAN	machine-to-machine (M2M)/"Internet of Things" connectivity protocol
M2M	AIT, BEIA	ETSI	SmartM2M	cooperation with AIOTI WG03	Smart machine-to-machine communication (IoT)	AIT	AIT, BEIA	AIT is ETSI and AIOTI member
M2M	ECL	oneM2M		oneM2M	oneM2M		ECL	Eclipse OM2M
M2M	ECL	OMA		OMA LWM2M	OMA LightweightM2M		ECL	Eclipse Wakaama

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
RFID	CISC	ISO/IEC	• JTC1/SC31 /WG4 • JTC1/SC31 /WG4	• ISO/IEC 18000-3 • ISO/IEC 18000-63	• Information technology — Radio frequency identification for item management — Part 3: Parameters for air interface communications at 13,56 MHz • Information technology -- Radio frequency identification for item management -- Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C	CISC		
NFID	CISC	ISO/IEC	JTC1/SC6/ WG1	ISO/IEC 21481	Information technology — Telecommunications and information exchange between systems — Near Field Communication — Interface and Protocol (NFCIP-1, NFCIP-2)	CISC		
	FAUT	AMT IEC IEC CIA IEC IEC	TC65 TC65 TC65 TC65 TC65	MTConnect IEC 61784-5-12 IEC 61784-5-13 IEC 61800 CANOpen IEC 61784-5-13 IEC-61131	MTConnect ETHERCAT SERCOS III Adjustable speed electrical power drive systems CAN Open SERCOS III PLC Open		FAUT	
	EUROTECH	IEEE	1815-2012	DNP3	Distributed Network Protocol		EUROTECH	

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
FARR	IETF	RFC 3748	EAP	Extensible Authentication Protocol (EAP) framework		FARR	
AIT	ISO TC 22	SC31	all	Road vehicles - Data communication	AIT	AIT	ASI K038
ECL	IETF	RFC 7252	CoAP	Constrained Application Protocol		ECL	Eclipse Californium
CISC	ETSI	ERM TG 28	EN 302 208,EN 300 330	Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU	CISC		
EUROTECH	EN	13757-2&3	M-BUS	Meter-Bus		EUROTECH	
ECL	Eclipse	Eclipse Unide / IoT Working Group	PPMP	Production Performance Management Protocol		ECL	Eclipse Project
IFD	SEMI	SECS/GEM	SECS/GEM	equipment communication standars semiconductors		IFD	
EUROTECH	EN	13757-4	Wireless M-BUS	Wireless Meter-Bus		EUROTECH	
EUROTECH	ISO	16484-5	BACnet	Building Automation and Control (BAC) networks		EUROTECH	

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
IFAK	DKE	AK STD	1941.0.1	Normungsroadmap I4.0	IFAK		
IFAK	DKE	AK STD	1941.0.2	Funk I4.0	IFAK		
IFAK	DKE	K 956	IEC61158	Digital data communication for measurement and control - Fieldbus for use in industrial control systems	IFAK		

Table 5. Communication standardisation partners interest

2.5.5 Reference Model

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
BEIA, FB, MGEP, MON, POLITO, ROPARDO, VTC, FAUT, MSI	DKE	Industrie4.0	RAMI40	Reference Architectural Model		FB, MGEP, MON, POLITO, ROPARDO, VTC, BEIA, FAUT	
EDI, FB, MON, POLITO, ROPARDO, VTC, MSI	IIConsortium		IIRA	Industrial Internet Reference Architecture		EDI, FB, MON, POLITO, ROPARDO, VTC	
AIT, BEIA	IEC TC 65	WG23	SM	Smart Manufacturing Framework and System Architecture	AIT	BEIA	ÖVE MR65
ARC, MON, VTC, AIT, BEIA	IEC	TC 65/JWG 21	SMRM	Smart Manufacturing Reference Model(s)	AIT, MON	BEIA, VTC, ARC	ÖVE MR65

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
AIT	IEC TC 65	SC65E	AHG1	Smart manufacturing information models	AIT		ÖVE MR65
AIT	IEC TC 65	SyC SM System Committee Smart Manufact.	SM2TF	Smart Manufacturing Standards Map Task Force	AIT		ÖVE MR65
IKERLAN, MGEP, MON, VTC, ECL	ZVEI, DKE	Plattform Industrie 4.0	AAS	Asset administration Shell		IKERLAN, MGEP, MON, VTC,	Eclipse Basys
ARC, MON, ROPARDO, VTC, MSI	IEC	TC 65	IEC 62832 and IEC TR62794	Digital Factory		MON, ROPARDO, VTC, ARC	
IFAG	ECSEL	Productive 4.0	key in the URI	Digital Reference	IFAG		in discussion
STM	NIST		NIST	Standards Landscape for Smart Manufacturing Systems		STM	National Institute of Standards and Technology
IFAK	VDI/VDE-GMA	FA7.21	N/A	Infrastructure for Industry 4.0 Asset Administration Shells	IFAK		

Table 6. Reference Models standardisation partners interest

2.5.6 Cybersecurity and Safety

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
INDUSTRIAL SYSTEMS SECURITY & SAFETY	ARC, EDI, FB, IKERLAN, MON, VTC, AIT, BEIA, FAUT, FARR, MSI	IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	AIT, FB, MON	VTC, ARC, BEIA, EDI, FARR, IKERLAN, FAUT	EWICS TC7 SEC Subgroup, ÖVE MR65.1 Security
	BEIA, ROPARDO	ISO	ISO/IEC JTC 1/SC 27	ISO/CEI 27001	information security management system		BEIA, ROPARDO	
	EDI	NIST/NICE		SP 800-181	Cybersecurity Workforce Framework		EDI	
	FB	NIST		NIST SP 800-82	Guide to Industrial Control Systems Security		FB	
	AIT, BEIA	IEC TC 65	WG 20	IEC TR 63069	Industrial-process measurement, control and automation - Framework for functional safety and security	AIT	BEIA	EWICS TC7 OOSS subgroup, ÖVE MR65
	AIT	IEC TC 65	• SC65A • SC65A WG 17 • SC65A • WG18 • SC65A • WG23	MT 61511 IEC 62879 IEC 63187 IEC TS 63177 SM Cybersecurity Task Force	• Functional safety - Safety instrumented systems for the process industry • Human factors - functional safety • Functional safety - Framework for safety critical E/E/PE systems for defence industry applications • Requirements	AIT		• Evolving new standard, ÖVE MR65 • EWICS TC7 MDS, SEC Subgroup, ÖVE MR65 (1) • ÖVE MR65

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
					for object-oriented software in safety-related systems • Smart Manufacturing recommendations for Cybersecurity			
INDUSTRIAL SYSTEMS SECURITY & SAFETY	IKERLAN	TCG	TNC Work Group	TNC	Trusted Computing Group		IKERLAN	TNC: Trusted Network Connect Technology Standards: https://www.nist.gov/sites/default/files/documents/standardsgov/TCG.pdf
	REUSE, UC3M,AIT, FAUT	IEC	TC 65/SC 65A - System aspects	IEC 61508-2:2010 IEC 61508/3 plus other related parts IEC 61508-1/2 plus other parts outside Part 3	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems	AIT	REUSE, UC3M, FAUT	ÖVE TK44

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
ROAD VEHICLES SECURITY & SAFETY	EDI	ISO/PAS	ISO/TC 22/SC 32	21448	Road Vehicles — Safety of the Intended Functionality		EDI	Mainly in the process and management: Road vehicles -- Functional safety -- Part 2: Management of functional safety (2)
ROAD VEHICLES SECURITY & SAFETY	CEA,REUSE, UC3M	ISO	WG2	26262	Road vehicles -- Functional safety		CEA, REUSE, UC3M	ASI K038
	AIT	ISO TC 22	SC 32	WG 08	Road vehicles - Funcional safety	AIT		evolving standard, ASI K038
	AIT	ISO TC 22	SC 32 WG 11	ISO/SAE 21434	Road vehicles - Cybersecurity engineering	AIT		EWICS TC7 member, ÖVE MR65 (1)
	AIT	IEC	IEC TC 44	IEC 62601	Safety of machinery - electrotechnical aspects	AIT	AIT	ÖVE MR65
	CISC, EDI	ISO/IEC	JTC1/SC17 /WG8	ISO/IEC 14443	Cards and security devices for personal identification -- Contactless proximity objects	CISC	EDI	
	CISC, EDI	ISO/IEC	JTC1/SC17 /WG8	ISO/IEC 15693	Cards and security devices for personal identification - Contactless vicinity objects	CISC	EDI	
	JOTNE	ISO	TC 20/SC 13 "Space data and informatio	16363	Audit and certification of trustworthy digital repositories		JOTNE	

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
		n transfer systems"					
ECL	IETF		DTLS	Datagram Transport Layer Security		ECL	Implementation: Eclipse tinydtls
IKERLAN	OWASP Foundation	OWASP WP	OWASP	Open Web Application Security Project		IKERLAN	https://www.owasp.org/index.php/Main_Page
IKERLAN	NIST	SCAP WG	SCAP	Security Content Automation Protocol		IKERLAN	https://csrc.nist.gov/projects/security-content-automation-protocol/
AIT	ISO/IEC JTC1	SC42	WG 03	Artificial Intelligence - Trustworthiness	AIT		ASI K001.42
IKERLAN	W3C	WHATWG HTML WG	WebAuthn	Web Authentication		IKERLAN	https://www.w3.org/TR/webauthn/
IFAK	DKE	UK 914.1	IEC61784-3	Industrial communication networks - Profiles - Part 3: Functional safety fieldbuses - General rules and profile definitions	IFAK		

Table 7. Cybersecurity and Safety standardisation partners interest

2.5.7 Domain Specific Standard

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
ROBOTICS	AIT	IEC TC 62	SC 65D	JWG 35/JWG 36	Medical robots for surgery	AIT	AIT	ÖVE TK 62 MP
	AIT	ISO TC 299			Robotics	AIT	AIT	ASI K028
ARTIFICIAL INTELLIGENCE	AIT, BEIA	ISO/IEC JTC1	SC42		Artificial Intelligence	AIT, BEIA		ASI K001.42
	CEA,REUSE, UC3M	INCOSE		NA	Future of Systems Engineering and AI	UC3M, REUSE	CEA	INCOSE is not directly a standardisation body.
	AIT	ISO/IEC JTC1	SC41 AHG 19	Report drafted - group was disbanded	Study group on Swarm intelligence	AIT		Joint ÖVE/ASI K001.41 (Austrian Standards International)
IOT	AIT, BEIA	ISO/IEC JTC1	SC41	all	Internet of things and related applications	AIT, BEIA		Joint ÖVE/ASI K001.41 (Austrian Standards International)
	AIT	ISO/IEC JTC1	SC41 AHG 17		Study Group on Societal and human factors in IoT based services	AIT		Joint ÖVE/ASI K001.41 (Austrian Standards International)

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
DIGITAL TWIN	AIT, JOTNE	ISO TC 184	TC 184/SC 4 "Industrial data"	ISO 23247	Digital Twin manufacturing framework	AIT, JOTNE		ASI K028
ENERGY/ ENVIRONMENTAL MANAGEMENT	STM	ISO	ISO/TC 301	ISO 50001	Energy management		STM	International Organization for Standardisation
	STM	ISO	ISO/TC 207/SC 2 ISO/TC 207/SC 1	ISO14015 ISO 14001 ECOPACK® 1	• Environmental management - Environmental assessment of sites and organizations. • Environmental management systems • Environmental Compatibility Standards		STM	
OIL & GAS	JOTNE	ISO	TC 184/SC 4 "Industrial data"	15926	Integration of life-cycle data for process plants including oil and gas production facilities		JOTNE	
SEMICONDUCTORS	STM	SEMI		SEMI MS1-0812 SEMI MS2-1113 SEMI MS3-0915 SEMI MS4-0416 SEMI MS5-0813 SEMI MS6-0308 SEMI MS7-0708	• Wafer-Wafer Bonding Alignment Targets • Test Method for Step Height Measurements of Thin Films • Terminology for MEMS Technology • Test Method for Young's Modulus Measurements		STM	Semiconductor Equipment and Materials International

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
SEMICONDUCTORS				SEMI MS8-0309 SEMI MS9-0611	of Thin, Reflecting Films Based on the Frequency of Beams in Resonance • Test Method for Wafer Bond Strength Measurements Using Micro-Chevron Test Structures • Guide for Design and Materials for Interfacing Microfluidic Systems • Specification for Microfluidic Interfaces to Electronic Device Packages • Guide to Evaluating Hermeticity of Microelectromechanical Systems (MEMS) Packages • Specification for High Density Permanent Connections between Microfluidic Devices			
	IFD	SEMI	SEMI300	SEMI300	many different standards for AMHS in semiconductor industry		IFD	

	PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
BLOCKCHAIN	BME	ISO	TC 307	ISO/TC 307	Blockchain and distributed ledger technologies		BME	national delegate
	EUROTECH	IEC	61850		Family of standards in industry automation		EUROTECH	

Table 8. Domain Specific Standards standardisation partners interest

2.5.8 Other interests

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
JOTNE	ISO	TC 20/SC 13 "Space data and information transfer systems"	14721	Open archival information system (OAIS) — Reference model		JOTNE	
EDI, STM	IEC	TC 47/SC 47F	IEC 62047 series	MEMS (Micro-Electromechanical Devices) standards		EDI, STM	
STM	SEMI		SEMI MS10-0912	Test Method to Measure Fluid Permeation through MEMS Packaging Materials		STM	
VTT, ABB	ISO	ISO/TC 108/SC 2 ISO/TC 108/SC 5	ISO10816 ISO13374 ISO13379 ISO13381	ISO10816 Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts ISO13374:Conditi		VTT, ABB	

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
				on monitoring and diagnostics of machine systems. Data processing, communication and presentation ISO13379 Condition monitoring and diagnostics of machines - general guidelines on data interpretation and diagnostics techniques ISO13381 Condition monitoring and diagnostics of machines — Prognostics			
STM	JEDEC	JC-14.1	JESD22 JESD22-A114E JESD22-C101E	Reliability Tests ElectroStaticDischarge Human Body Mode ESD ChargedDeviced Model		STM	
AIT	ETSI	MTS	MBT	Model-based testing	AIT	AIT	AIT is ETSI member
STM	IECQ		QC 080000	Hazardous Substances Process Management System Requirements (HSPM) standard		STM	International Electro-technical Commission Quality Assessmen

PARTNER	SDO	TC/ WG	Standard	Name of Standard	Partners actively involved	Partners interested/ user	Comments
							t System for Electronic Components
TU DRESDEN	VDI	VDI-Fachbereich Schwingungstechnik	VDI3832 VDI3836 VDI3839	Measurement of structure-borne sound of rolling element bearings in machines and plants for evaluation of condition		TU DRESDEN	
AIT	ISO TC 22	SC31	WG 10	Extended vehicle time critical applications	AIT		ASI K038
IFAG	ZVEI	AK SCM	Whitebook	ZVEI Guideline Supply Chain Management in Electronics Manufacturing	IFAG		
EUROTECH	IEC	69870-5		Standard for power system monitoring, control & associated communications for telecontrol, teleprotection, and associated telecommunications for electric power systems		EUROTECH	
AIT	ISO TC 22	AG1	ADAG	Automated Driving Ad-hoc Group	AIT		ASI K038
AIT	IEC TC 62	SC 62A	IEC 60601	Common aspects of electrical equipment used in medical practice	AIT		ÖVE TK 62 MP

Table 9. Other standardisation partners interest

3. Appendixes

1. Appendix 1 - Partner Questionnaires

4. References

[1] P. Leitão, J. Barbosa, M.-E. C. Papadopoulou, y I. S. Venieris, «Standardization in cyber-physical systems: The ARUM case», en *2015 IEEE International Conference on Industrial Technology (ICIT)*, 2015, pp. 2988–2993.
[2] U. Ro\s sgoderer y G. Piepenbrock, «Simulationsgestütztes Value Stream Mapping-Symbiose zwischen IE und Industrie 4.0. 5», *Ind. Eng.*, 2014.
[3] S. Wang, J. Wan, D. Li, y C. Zhang, «Implementing smart factory of industrie 4.0: an outlook», *Int. J. Distrib. Sens. Netw.*, vol. 12, n.º 1, p. 3159805, 2016.
[4] H. Igor, J. Bohuslava, y J. Martin, «Proposal of communication standardization of industrial networks in Industry 4.0», en *2016 IEEE 20th Jubilee International Conference on Intelligent Engineering Systems (INES)*, 2016, pp. 119–124.
[5] ISO/TC184/SC5/WG1, «ISO 15704», *ISO*. [En línea]. Disponible en: http://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/02/87/28777.html. [Accedido: 19-sep-2019].
[6] ISO/TC184/SC5/, «Requirements for enterprise-reference architectures and methodologies.»
[7] R. Heidel, M. Hankel, U. Döbrich, y M. Hoffmeister, *Basiswissen RAMI 4.0: Referenzarchitekturmodell und Industrie 4.0-Komponente Industrie 4.0*. Beuth Verlag, 2017.
[8] L. Adolph, «German Standardization Roadmap: Industry 4.0», en *Version 2. Berlin: DIN eV*, 2016.
[9] M. A. Pisching, M. A. Pessoa, F. Junqueira, D. J. dos Santos Filho, y P. E. Miyagi, «An architecture based on RAMI 4.0 to discover equipment to process operations required by products», *Comput. Ind. Eng.*, vol. 125, pp. 574–591, 2018.
[10] Q. Li *et al.*, «Smart manufacturing standardization: Architectures, reference models and standards framework», *Comput. Ind.*, vol. 101, pp. 91–106, 2018.
[11] Y. Lu, K. C. Morris, y S. Frechette, «Standards landscape and directions for smart manufacturing systems», en *2015 IEEE International Conference on Automation Science and Engineering (CASE)*, 2015, pp. 998–1005.
[12] S.-W. Lin *et al.*, «Industrial internet reference architecture», *Ind. Internet Consort. IIC Tech Rep*, 2015.
[13] Z. Ma, A. Hudic, A. Shaaban, y S. Plosz, «Security viewpoint in a reference architecture model for cyber-physical production systems», en *2017 IEEE European Symposium on Security and Privacy Workshops (EuroS&PW)*, 2017, pp. 153–159.
[14] M. Buchheit, «Industrial Internet Reference Architecture», p. 58.

[15] E. Darmois, L. Daniele, P. Guillemin, J. Heiles, P. Moretto, y A. Van der Wees, *IoT Standards Landscape–State of the Art Analysis and Evolution*. Online at: https://www. riverpublishers. com/pdf/ebook/chapter ….

[16] E. Markl y M. Lackner, «Industrial Engineering Management – THE key skill for the Digital Age», *Int. J. Eng. Sci. IJES*, vol. 8, p. 22, 2019.

[17] DIN, DKE, VDE, «German Standardization Roadmap Industrie 4.0 – Version 3», p. 146, 2018.

[18] P. Adolphs *et al.*, «Structure of the administration shell. continuation of the development of the reference model for the industrie 4.0 component», *ZVEI VDI Status Rep.*, 2016.

[19] MIIT, SAC, «National Intelligent Manufacturing Standard System Construction Guidelines», 2015. [En línea]. Disponible en: https://www.dke.de/resource/blob/929020/7080b1667308545c088901b39a111756/manufacturing-guidelines-data.pdf. [Accedido: 25-sep-2019].

[20] UNE - AENOR, «Estandarizacion-para-la-industria-4_0.pdf». [En línea]. Disponible en: https://www.une.org/normalizacion_documentos/Estandarizacion-para-la-industria-4_0.pdf. [Accedido: 25-sep-2019].

5. Conclusions

Arrowhead Tools standardization mapping is directly related to the general project objectives defined, as a major pillar of the project, and the use-cases. A major target point for Arrowhead Tools is digitalisation and automation solutions for the European industry, which will close the gaps that hinder the IT/OT integration.

The results obtained from the partners´ inputs reflect the existing need in industrial environments in terms of interoperability in the transmission of data as well as its format and suitable representation between the different OT-IT layers. Interoperability for the use of IoT / SoS Engineering solutions to favour the digital transformation.

With the partners´ inputs receiving a response of 37 institutions´ interests related to standardization, seven major groups of standardization areas have been identified as seen in Figure 14:

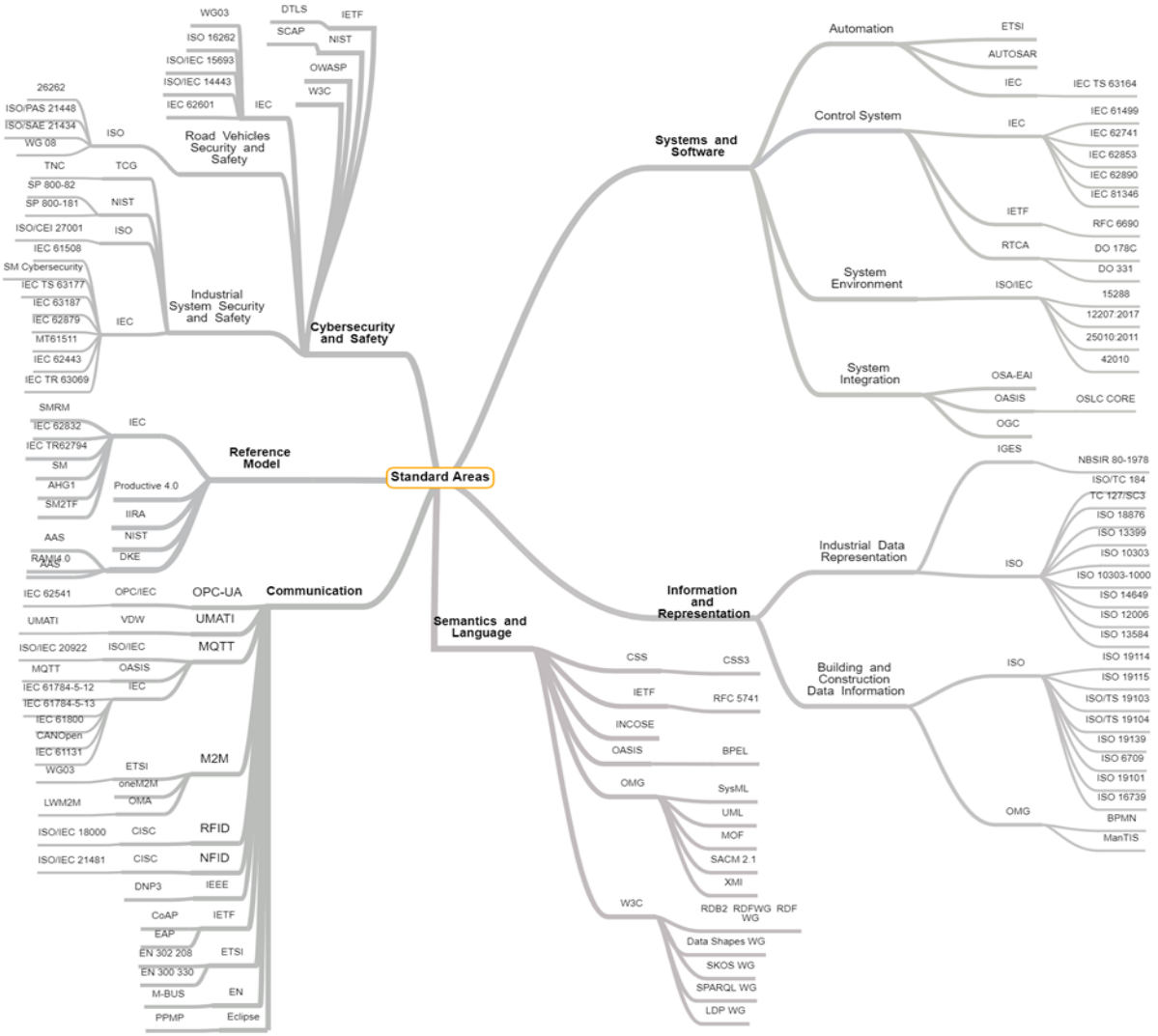

Figure 14. Standard Area of interest to the Arrowhead Tools partner

- ***System and Software***

  The current requirements of industrial environments that compel the management of industrial control systems as an asset within the upper layers of the automation pyramid through IT software solutions. A significative sample of 44,4 % the partners are JOTNE, CEA, POLITO, REUSE, AIT, MGEP, BEIA, UC3M among others that show interest in those standards. In that sense, standards such as *ISO / IEC 42010 Systems and software engineering*, *ISO 15288 Systems and software engineering - System life cycle processes* or *IEC 62890 Life Cycle Management* become relevant for the industrial environments. Likewise, MON and VTC in the standard *IEC 81346 Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations*, are the most representative partners.

  On the other hand, frameworks and/or APIs such as *ASIS OSLC Lifecycle Integration Core, REST APIs to connect data* or *OSA-EAI Open System Architecture for Enterprise Application Integration V3.2.3 Production Specification, MIMOSA, 2012* or *ISO 16262 Information technology - Programming languages, their environments and system software interfaces - ECMAScript language specification* are representative for VTT, ABB, FARR or FAUT among others.

- ***Information and Representation***

  The standard format with which data is transmitted and the representation of the properties of heterogeneous industrial devices and systems, becoming a real need to agilely comply not only with the much-desired interoperability, but also for the representation of digital twins and management of their life cycle.

  Thus we find the interest and use of standards such as *ISO 10303 (STEP) Industrial automation systems and integration - Product data representation and Exchange* by a selected group of partners such us JOTNE, REUSE, UC3M, VTT and FAUT, *ISO 12006-3 Framework for object-oriented information exchange* by JOTNE, *IEC 61360 associated to the Common Data Dictionary* by MON, *ISO 6983 Automation systems and integration - Numerical control of machines - Program format and definitions of address words - Part 1: Data format for positioning, line motion and contouring control systems* by FAUT or *SO-15143-3 / AEMP 2.0 Earth-moving machinery and mobile road construction machinery - Worksite data exchange* by ACCIONA.

  We cannot forget the real interest of representation and standardization associated to buildings by DotGis and JOTNE with standards such as *ISO 19114:2003 Geographic information — Quality evaluation procedures, ISO 19115 Geographic information – Metadata*, or *ISO/TS 19103 Geographic information — Conceptual schema language*, among others.

- ***Semantics and Language***

  The representation and knowledge associated with specific applications and domains require the use of languages prepared for it.

  Thus it is worth noting that parties such as CEA, ICTG, MON, POLITO, VTC, HIOF, IQL, REUSE, UC3M, BME, TUE are not only interested but also actively participating in languages such as *SysML for Systems modelling, RDF for model design it gives data for metadata, OWL as a language for ontologies, SPARQL to perform queries*, among others, associated usually with the *W3C World Wide Web Consortium or the Object Management Group OMG* (standards for "common portable and interoperable object model"). This group is represented by 41,6 % of the participant partners.

- ***Communication***

  A large group of partners, 41,6 % that include MON, VTC, VTT, FAUT among others, coincide in being users of interoperable protocols that can be used in different layers of an industrial environment such as *OPC-UA*, the recent *UMATI* standard for machine tools or the well-known *OneM2M*, *MQTT*. Also, noteworthy the interest in short wireless protocols such as *RFID, NFCID* or *Wireless Meter bus*.

  An isolated partner, FAUT, sees the need to keep using typical protocols of Industrial environments such as Ethercat, Sercos or CanOpen.

- ***Cybersecurity and Safety***

  The partners are highly aware of the importance of the Cybersecurity, being the most relevant standardisation area (52,7%), not only at the IT level with the *ISO / IEC 27001* standard in which BEIA and ROPARDO stand out as users or interested parties, but also at the OT level with the *IEC 62443 Security for industrial process measurement and control - Network and system security* with the involvement of representative companies such as MON, VTC or FAUT, FB, IKRELAN, BEIA or the *NIST SP 800-82 guide*.

  Nor can we ignore the interest in Safety in industrial environments as important or more than at the software level. Standards used or interesting for partners are *IEC 63187 Functional safety - Framework for safety-critical E/E/PE systems for defence industry applications, IEC 61508: Functional Safety*, among others.

  Finally highlight the awareness of authentication and trust for contactless devices with standards such as the *ISO/IEC 14443: Cards and security devices for personal identification -- Contactless proximity objects*, in web applications with standards such as *OWASP* or for AI with *WG03: Artificial intelligence – Trustworthiness*.

- ***Reference Model***

  The need to standardize industrial processes and their representation throughout their life cycle and in the automation pyramid through one of the standards previously seen in the areas of Communication, Semantics, etc. is based on the current Industry 4.0 reference models such as *RAMI 4.0*, the N*IST Standards Landscape for Smart Manufacturing Systems model* or the Industrial Internet Consortium - *Industrial Internet Reference Architecture* in which parties such as BEIA, FB, MGEP, MON, POLITO, ROPARDO, VTC, AIT and FAUT are interested and/or actively participating.

- ***Domain-Specific Standard***

  It should be noted the active participation of partners in standards associated with Industry 4.0 technologies and therefore facilitators for the introduction of solutions and engineering tools such as the working committees *ISO / TC 299 Robotics, ISO / IEC JTC 1 / SC 42 - Artificial intelligence, ISO / IEC JTC1 SC41 for Internet of Things, ISO / TC 307 Blockchain* and distributed ledger technologies or the *ISO 23247 framework* for Digital Twin.

  Nor can forget specific regulations for the Oil & Gas sector *ISO 15926: Integration of life-cycle data for process plants including oil and gas production facilities*, semiconductors *SEMI300*, or standards associated with Energy and Environmental Management *ISO 5000: Energy management*, among others.

In the end, the actual document shows the standards which approach the actual needs of standardisation for European industry in response to digitalisation and automation solutions which will close the gaps that hinder the IT/OT integration. Furthermore, this deliverable approaches the next WP10 tasks and steps to follow supporting the identification and influence of gaps related to cybersecurity, safety, reference models, systems and software standards for national or industrial SDOs (Standardization Organizations).

6. Revision history

6.1 Contributing and reviewing partners

Contributions	Reviews	Participants	Representing partner
Deliverable Template	0.1	Michel Iñigo	MON
Survey Template	0.2	Michel Iñigo	MON
Partner contributions, two reminders	0.3	Partners, see Table 1. Standardisation Contacts and Involvement	Partners, see Table 1. Standardisation Contacts and Involvement
Review of Contributions	0.4	Carolina Mejia, Michel Iñigo	MON
Final Draft	0.5	Carolina Mejia, Michel Iñigo	MON
Review	0.51	Jerker Delsing	LTU
Final Version	1.0	Michel Iñigo, Carolina Mejía	MON

6.2 Amendments

No.	Date	Version	Subject of Amendments	Author

6.3 Quality assurance

No	Date	Version	Approved by
1	2019 – 10 - 22	0.51	Jerker Delsing

7. Appendix 1 – Partner Questionnaires

Partners´ standardization involvement can be identified in certain roles described below and listed in column "Role":

C - Chairing/co-chairing a standardization WG (convenor, co-ordinator in project, etc.)
A - Active in this standardization (working) group (contributor, nominated delegate/expert)
M - Member of a standardization (working) group (rather monitoring, but entitled to access the working documents) active on higher than national level, nominated expert
N - Member of a national standardization (working) group; please indicate to which standardization group on higher than national level it is a mirror group (e.g. VDE to IEC, ÖVE MR65 to IEC TC65 + SC65A + SC65B + SC65C + SC65E + CENELEC TC65X)
U - User applying standards of this WG or particular standard
I - Interested in standards of this WG or this particular standard
P - Member of a pre-standardization WG (e.g. EWICS TC7 on Safety, Reliability and Security)
O - Other role (please specify)

For other acronyms related to the first two columns:

SDO – Standardization Organization
TC – Technical Committee
SC – Subcommitee
WG – Working Group
TF – Task Force

PARTNERS´STANDARIZATION INVOLVEMENT

Partner:	**ABB**
Contact:	Jan Westerlund
Email:	Jan.westerlund@fi.abb.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	ISO/TC 108/SC 2	ISO13374	ISO13374:Condition monitoring and diagnostics of machine systems. Data processing, communication and presentation	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	ISO/TC 108/SC 5	ISO13379	ISO13379 Condition monitoring and diagnostics of machines - general guidelines on data interpretation and diagnostics techniques	I	
ISO	ISO/TC 108/SC 5	ISO13381	ISO13381 Condition monitoring and diagnostics of machines — Prognostics	I	
ISO	ISO/TC 108/SC 2	ISO10816	ISO10816 Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts	I	
OSA-EAI		OSA-EAI	OSA-EAI Open System Architecture for Enterprise Application Integration V3.2.3 Production Specification, MIMOSA, 2012	I	
OSA-EAI		OSA-EAI	OSA-CBM Open System Architecture for Condition-Based Maintenance V3.3.1 Production Specification, MIMOSA, 2010	I	
IEC	TC 65	IEC 62541	OPC-UA	I	

Table 10. Partner ABB Standardization Involvement

Partner:	**ACCIONA**
Contact:	José Luis Burón
Email:	joseluis.buron.martinez@acciona.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	TC 127/SC 3	ISO-15143-3/AEMP 2.0	Earth-moving machinery and mobile road construction machinery — Worksite data exchange — Part 1: System architecture	I	

Table 11. Partner ACCIONA Standardization Involvement

Partner:	**AIT**
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC TC 65	SC65A MT61508-1/2	IEC 61508-1/2 plus other parts outside Part 3	Functional safety for E/E/PE systems	A, N, U, P	EWICS TC7 member, ÖVE MR65
IEC TC 65	SC65A MT61508/3	IEC 61508/3 plus other related parts	Functional safety for E/E/PE systems	A, N, U, P	EWICS TC7 member, ÖVE MR65
IEC TC 65	SC65A WG18	IEC 63187	Functional safety - Framework for safety critical E/E/PE systems for defence industry applications	A, N	evolving new standard, ÖVE MR65
IEC TC 65	SC65A WG 17	IEC 62879	Human factors - functional safety	A, N	ÖVE MR65
IEC TC 65	SC65A	IEC TS 63177	Requirements for object-oriented software in safety-related systems	A, N	EWICS TC7 OOSS subgroup, ÖVE MR65
IEC TC 65	WG 10	IEC 62443	Security for industrial automation and control systems	A, N	EWICS TC7 SEC Subgroup, ÖVE MR65.1 Security
IEC TC 65	WG 20	IEC TR 63069	Framework for functional safety and security	A, N, U, P	EWICS TC7 MDS, SEC Subgroup, ÖVE MR65
IEC TC 65	JWG 21	SMRM	Smart Manufacturing Reference Model(s)	A, N	ÖVE MR65
IEC TC 65	WG 22	IEC TS 63164	Reliability of Industrial Automation Devices and Systems	M, N	ÖVE MR65
IEC TC 65	WG23	SM	Smart Manufacturing Framework and System Architecture	A, M, N	ÖVE MR65

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC TC 65	WG23	SM Cybersecurity Task Force	Smart Manufacturing recommendations for Cybersecurity	A, M, N	ÖVE MR65
IEC TC 65	SyC SM System Committee Smart Manufact.	SM2TF	Smart Manufacturing Standards Map Task Force	M, N	ÖVE MR65
IEC TC 65	SC65A	MT 61511	Functional safety - Safety instrumented systems for the process industry	A, M, N	ÖVE MR65
IEC TC 65	SC65E	AHG1	Smart manufacturing information models	M, N	ÖVE MR65
IEC TC 56	TC 56	all	Dependability	M, N, I	ÖVE EG 56
IEC TC 56	TC 56	IEC 62853	Open systems dependability	N, I, U, P	EWICS TC7, ÖVE EG 56
IEC TC 56	TC 56	IEC 62741	Reliability of systems, equipment and components. Guide to the demonstration of dependability requirements. The dependability case	N, I, U, P	EWICS TC7, ÖVE EG 56
IEC TC 44	TC 44	IEC 62601	Safety of machinery - electrotechnical aspects	M, N, I	ÖVE TK44
ISO TC 299	TC 299		Robotics	M, N, I	ASI K028
ISO TC 184	SC 4	ISO 23247	Digital Twin	M, N, I	ASI K028
ETSI	SmartM2M	cooperation with AIOTI WG03	Smart machine-to-machine communication (IoT)	M, I	AIT is ETSI and AIOTI member
ETSI	MTS	MBT	Model-based testing	M, I	AIT is ETSI member
ISO/IEC JTC1	SC41	all	Internet of things and related applications	A, M, N	Joint ÖVE/ASI K001.41 (Austrian Standards International)
ISO/IEC JTC1	SC41 AHG 17		Study Group on Societal and human factors in IoT based services	M, N	Joint ÖVE/ASI K001.41 (Austrian Standards International)

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO/IEC JTC1	SC41 AHG 19	Report drafted - group was disbanded	Study group on Swarm intelligence	A, N	Joint ÖVE/ASI K001.41 (Austrian Standards International)
ISO/IEC JTC1	SC42		Artificial Intelligence	M, N	ASI K001.42
ISO/IEC JTC1	SC42	WG 03	Artificial Intelligence - Trustworthiness	A, M, N	ASI K001.42
ISO TC 22	SC 32	WG 08	Road vehicles - Funcional safety	A, N	ASI K038
ISO TC 22	SC 32 WG 11	ISO/SAE 21434	Road vehicles - Cybersecurity engineering	A, N	evolving standard, ASI K038
ISO TC 22	SC 32 WG 12	ISO 24089	Road vehicles - Software update engineering - OTA	A, N	evolving standards, ASI K038
ISO TC 22	SC31	all	Road vehicles - Data communication	M, N, I	ASI K038
ISO TC 22	SC31	WG 10	Extended vehicle time critical applications	A, M,N	ASI K038
ISO TC 22	AG1	ADAG	Automated Driving Ad-hoc Group	M, N	ASI K038
ETSI	ITS		Intelligent Transport Systems	M, I	AIT is ETSI member
IEC TC 62	SC 62A	IEC 60601	Common aspects of electrical equipment used in medical practice	M, N, I	ÖVE TK 62 MP
IEC TC 62	SC 65D	JWG 35	Medical robots for surgery	M, N, I	ÖVE TK 62 MP
IEC TC 62	SC 65D	JWG 36	Medical robots for rehabilitation	M, N, I	ÖVE TK 62 MP

Table 12. Partner ACCIONA Standardization Involvement

Partner:	**ARC**
Contact:	Alper Özel
Email:	alper.ozel@arcelik.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65/JWG 21	SMRM	Smart Manufacturing Reference Model(s)	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	U,I	
IEC	TC 65	IEC 62832 and IEC TR62794	Digital Factory	U,I	

Table 13. Partner ARC Standardization Involvement

Partner:	**BEIA**
Contact:	George Suciu
Email:	george@beia.ro

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
ETSI	SmartM2M	cooperation with AIOTI WG03	Smart machine-to-machine communication (IoT)	I	
ETSI	ITS		Intelligent Transport Systems	I	
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	
IEC	TC 65	IEC 62541	OPC-UA	I	
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	
IEC TC 65	WG 22	IEC TS 63164	Reliability of Industrial Automation Devices and Systems	I	
IEC TC 65	WG 10	IEC 62443	Security for industrial automation and control systems	I	
IEC TC 65	WG 20	IEC TR 63069	Framework for functional safety and security	I	
IEC TC 65	JWG 21	SMRM	Smart Manufacturing Reference Model(s)	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC TC 65	WG23	SM	Smart Manufacturing Framework and System Architecture	I	
ISO/IEC JTC1	SC41	all	Internet of things and related applications	M,N	
ISO/IEC JTC1	SC42		Artificial Intelligence	M,N	
ISO		ISO/CEI 27001	Information security management system	I	

Table 14. Partner BEIA Standardization Involvement

Partner:	**BME**
Contact:	Pal Varga
Email:	pvarga@alpha.tmit.bme.hu

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	TC 307		Blockchain and distributed ledger technologies	M	national delegate
OMG		SysML	System Modeling Language	I	

Table 15. Partner BME Standardization Involvement

Partner:	**BUT**
Contact:	Tomas Vojnar
Email:	vojnar@fit.vutbr.cz

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
NONE					

Table 16. Partner BUT Standardization Involvement

Partner:	**CEA**
Contact:	Chkri Mraidha
Email:	chokri.mraidha@cea.fr

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OMG		UML	Unified modeling language	A,M	
OMG		SysML	System Modeling Language	A,M	

OMG		MARTE	Modeling and Analysis of Real-time and Embedded systems	A,M	
ISO/IEC/IEEE		42010	*Systems and software engineering*	U	
ISO		26262	Road vehicles -- Functional safety	I, U	
ISO/IEC/IEEE		15288:2015	Systems and software engineering -- System life cycle processes	I	
ISO/IEC		12207:2017	Systems and software engineering -- Software life cycle processes	I	
INCOSE		NA	Future of Systems Engineering and AI	I	INCOSE is not directly a standardization body.
INCOSE		NA	Ontologies and Knowledge Management Group	I	INCOSE is not directly a standardization body.
INCOSE		NA	Requirements Working Groiup	I	INCOSE is not directly a standardization body.
OASIS		OSLC CORE	OASIS OSLC Lifecycle Integration Core	I	
ISO/IEC/IEEE		29148:2011	Systems and software engineering -- Life cycle processes -- Requirements engineering	I	

Table 17. Partner CEA Standardization Involvement

Partner:	**CISC**
Contact:	Markus Pistaeur
Email:	m.pistaeur@cisc.at

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO/IEC	JTC1/SC31/ WG4	ISO/IEC 18000-3	Information technology — Radio frequency identification for item management — Part 3: Parameters for air interface communications at 13,56 MHz	CAN	
ISO/IEC	JTC1/SC31/WG4	ISO/IEC 18000-63	Information technology -- Radio frequency identification for item management -- Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C	CAN	
ISO/IEC	JTC1/SC17/WG8	ISO/IEC 14443	Cards and security devices for personal identification -- Contactless proximity objects	MA	
ISO/IEC	JTC1/SC17/WG8	ISO/IEC 15693	Cards and security devices for personal identification - Contactless vicinity objects	MA	
ISO/IEC	JTC1/SC6/WG1	ISO/IEC 21481	Information technology — Telecommunications and information exchange between systems — Near Field Communication — Interface and Protocol (NFCIP-1)	MA	
ISO/IEC	JTC1/SC6/WG1	ISO/IEC 21481	Information technology — Telecommunications and information exchange between systems — Near Field Communication Interface and Protocol -2 (NFCIP-2)	MA	

ETSI	ERM TG 28	EN 300 330	Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU	AN	
ETSI	ERM TG 28	EN 302 208	Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W and in the band 915 MHz to 921 MHz with power levels up to 4 W; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU	AN	

Table 18. Partner CISC Standardization Involvement

Partner:	**dotGIS**
Contact:	Miguel Fernandez
Email:	mfernandeza@dotgiscorp.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	TC 211	ISO 19115 ISO/TC 211 committee.	Geographical standard information	U, I	
ISO	TC 211	19101	GEOGRAPHICAL / GEOMATIC INFORMATION	U, I	
ISO	TC 211	ISO 6709: 2008	Standard representation of the location of geographical points by coordinates	U, I	
ISO	TC 211	ISO / TS 19103: 2005	Geographic information - conceptual scheme language	U, I	
ISO	TC 211	ISO / TS 19104: 2008	Geographical information - Terminology	U, I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	TC 211	ISO 19115:2013	Geographical metadata standard	U, I	
ISO	TC 211	ISO 19139	Geographical metadata standard	U, I	
ISO	TC 211	ISO/CD 19166	Geographic information — BIM to GIS conceptual mapping	U, I	
ISO		ISO 19114	Data quality elements	U, I	

Table 19. Partner dotGIS Standardization Involvement

Partner:	**ECL**
Contact:	Marco Jahn – Philippe Krief
Email:	marco.jahn@eclipse-foundation.org; philippe.krief@eclipse-foundation.org

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IETF		CoAP	Constrained Application Protocol	I,O	Eclipse Californium
IETF		DTLS	Datagram Transport Layer Security	I,O	Implementation: Eclipse tinydtls
IEC		IEC 61499	IEC 61499	I,O	Eclipse 4DIAC project
OMA		OMA LWM2M	OMA LightweightM2M	I,O	Eclipse Wakaama
ISO/OASIS		MQTT		I,O	Eclipse Paho
OGC		OGC SensorThings API	OGC SensorThings API	I,O	Eclipse Whiskers
oneM2M		oneM2M	oneM2M	I,O	Eclipse OM2M
	Eclipse Unide / IoT Working Group	PPMP	Production Performance Management Protocol	I,O	Eclipse Project
	OPC Foundation	OPC-UA	OPC Unified Architecture	I,O	Eclipse Milo
			Eclipse BaSyx	I,O	Eclipse BaSyx. Not a standard but a middleware for Industrie 4.0

Table 20. Partner ECL Standardization Involvement

Partner:	**EDI**
Contact:	Krisjanis Nesenbergs
Email:	krisjanis.nesenbergs@edi.lv

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC		IEC 62443	Security for industrial process measurement and control - Network and system security	I	
IIConsortium		IIRA	Industrial Internet Reference Architecture	I	
ISO/IEC		ISO/IEC 14443	Cards and security devices for personal identification -- Contactless proximity objects	I	
ISO/IEC		ISO/IEC 15693	Cards and security devices for personal identification - Contactless vicinity objects	I	
IEC		IEC 62047 series	MEMS standards	I	
NIST/NICE		SP 800-181	Cybersecurity Workforce Framework	I	
ISO/PAS		21448	Road Vehicles — Safety of the Intended Functionality	I	

Table 21. Partner EDI Standardization Involvement

Partner:	**EuroTech**
Contact:	Paolo Azzoni
Email:	paolo.azzoni@eurotech.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO, IEC	PRF 20922	MQTT	Message Queuing Telemetry Transport	M, U	
EN	13757-2	M-BUS	Meter-Bus	U	
EN	13757-3	M-BUS	Meter-Bus	U	
EN	13757-4	Wireless M-BUS	Wireless Meter-Bus	U	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEEE	1815-2012	DNP3	Distributed Network Protocol	U	
ISO	16484-5	BACnet	Building Automation and Control (BAC) networks	U	
IEC	61850		Family of standards in industry automation	U	
IEC	69870-5		Standard for power system monitoring, control & associated communications for telecontrol, teleprotection, and associated telecommunications for electric power systems	U	

Table 22. Partner EuroTech Standardization Involvement

Partner:	**FARR**
Contact:	Mikel Viguera
Email:	m.viguera@fagorarrasate.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO/IEC	ISO/IEC JTC 1 Information technology	ISO IEC 20922	ISO/IEC 20922:2016 Information technology — Message Queuing Telemetry Transport (MQTT)	U	
OPC Foundation/IEC	TC 65	IEC 62541	OPC-UA	U	
VDW, OPC Fundation	umati JWG	UMATI	umati – universal machine tool interface OPC UA Companion Specification for machine tools and manufacturing systems to external communication partners	U	
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	I	Trying to meet the requirements to obtain certification

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IETF	RESTful Environments	RFC 6690	RESTful Environments (CoRE) Link Format	U	

Table 23. Partner FARR Standardization Involvement

Partner:	**FAUT**
Contact:	Carlos Yurre – Marcelino Novo
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	ISO/IEC JTC 1/SC 22	ISO16262	ECMAScript	U	(ES6 published 2015)
W3C	W3C		HTML 5	U	
W3C	CSS WG	CSS 3	Cascading Style Sheets 3	U	
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	I	
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
IEC	TC 65	IEC-61499	Functional Blocks	I	
IEC	TC 65	IEC-61131	Programmable Controllers, PLCOPEN	I	
ISO	ISO/TC 184	ISO/TS 14649-x	STEP-NC	I	
ISO	ISO/TC 184	ISO 6983	G-Code	U	
ISO		ISO/IEC PRF 20922	MQTT	U	
CiA			CAN Open	U	
IEC	TC 65	IEC 62541	OPC-UA	U	
IEC	TC 65	IEC 61784-5-12	ETHERCAT	U	
IEC	TC 65	IEC 61784-5-13	SERCOS III	U	
IEC	TC 65	IEC 61800	Adjustable speed electrical power drive systems	U	
VDW		UMATI	Universal Machine Tool Interface	U	
AMT		MTConnect	MTConnect	U	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65	IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems	U	

Table 24. Partner FAUT Standardization Involvement

Partner:	**FB - Forschung Burgenland**
Contact:	Ani Bicaku
Email:	ani.bicaku@forschung-burgenland.at

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	M,N	
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
IIConsortium		IIRA	Industrial Internet Reference Architecture	I	
NIST		NIST SP 800-82	Guide to Industrial Control Systems Security	I	

Table 25. Partner FB Standardization Involvement

Partner:	**HIOF - Østfold University College**
Contact:	Øystein Haugen
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OMG	ManTIS	different	SENSR Product Knowledge Framework	M	ongoing OMG processes in ManTIS group
OMG	ADTF	SysML v2	System Modeling Language	A	participates in submission team SST

Table 26. Partner HIOF Standardization Involvement

Partner:	**ICTG**
Contact:	Oscar Reynhout
Email:	Oscar.Reynhout@ict.nl

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OMG	ADTF	SysML	System Modeling Language	I	
OPC Foundation	TC 65	IEC 62541	OPC Unified Architecture	I	

Table 27. Partner ICTG Standardization Involvement

Partner:	**IFAG - Infineon Technologies AG**
Contact:	Hans Ehm, Nour Ramzy
Email:	hans.ehm@infineon.com; nour.ramzy@infineon.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
W3C	OWL WG	OWL2	OWL Web Ontology Language Overview	I,U	Family of OWL W3C Recommendations
W3C	RDF WG	RDF 1.1	RDF 1.1 Concepts and Abstract Syntax	I,U	Family of RDF W3C Recommendations
W3C	SKOS WG	SKOS	SKOS Simple Knowledge Organization System Reference	I,U	
W3C	Data Shapes WG	SHACL	Shapes Constraint Language (SHACL)	I,U	Shape Expressions
W3C	RDFS WG	RDFS	RDF Schema 1.1	I,U	
W3C	RDB2RDF WG	R2RML	RDB to RDF Mapping Language	I,U	
W3C	SPARQL WG	SPARQL	SPARQL Query Language	I,U	
ZVEI	AK SCM	Whitebook	ZVEI SCM Standrad	A	
ECSEL	Productive4.0	key in the URI	Digital Reference	A	in discussion

Table 28. Partner IFAG Standardization Involvement

Partner:	**IFAK**
Contact:	Mario Thron
Email:	Mario.thron@ifak.eu

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
VDI/VDE-GMA	FA6.23	VDI/VDE 2651	Plant Asset Management (PAM) in the process industry	A	
VDI/VDE-GMA	FA7.21	N/A	Infrastructure for Industry 4.0 Asset Administration Shells	A	
DKE	AK STD	1941.0.1	Normungsroadmap I4.0	A	
DKE	AK STD	1941.0.2	Funk I4.0	A	
DKE	UK 914.1	IEC61784-3	Industrial communication networks - Profiles - Part 3: Functional safety fieldbuses - General rules and profile definitions	A	
DKE	K 956	IEC61158	Digital data communication for measurement and control - Fieldbus for use in industrial control systems	A	
ZVEI	MES	Position paper	MES - Industry specific Requirements and Solutions	A	

Table 29. Partner IFAK Standardization Involvement

Partner:	**IKERLAN**
Contact:	Cristobal Arellano
Email:	carellano@ikerlan.es

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OPC Foundation		OPC-UA	OPC Unified Architecture	U	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	I	
ZVEI, DKE	Plattform Industrie 4.0	AAS	Asset administration Shell	I, U	
OASIS	OASIS MQTT TC	MQTT	Message Queuing Telemetry Transport	I,U	machine-to-machine (M2M)/"Internet of Things" connectivity protocol
OWASP Foundation	OWASP WP	OWASP	Open Web Application Security Project	U, I	https://www.owasp.org/index.php/Main_Page
TCG	TNC Work Group	TNC	Trusted Computing Group	I	TNC: Trusted Network Connect Technology Standards: https://www.nist.gov/sites/default/files/documents/standardsgov/TCG.pdf
W3C	WHATWG HTML WG	WebAuthn	Web Authentication	U, I	https://www.w3.org/TR/webauthn/
NIST	SCAP WG	SCAP	Security Content Automation Protocol	I	https://csrc.nist.gov/projects/security-content-automation-protocol/

Table 30. Partner IKERLAN Standardization Involvement

Partner:	**IQL**
Contact:	Géza Kulcsár
Email:	geza.kulcsar@incquerylabs.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OMG	WP4	SysML v2	Systems Modeling Language, version 2	A	
AUTOSAR	WP4	AUTOSAR	AUTOSAR	I	

Table 31. Partner IQL Standardization Involvement

Partner:	**JOTNE**
Contact:	Jochen Haenisch
Email:	jochen.haenisch@jotne.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	TC 184/SC 4/WG 12 "STEP Product Modeling and Resource"	10303 (STEP)	Industrial automation systems and integration — Product data representation and exchange	C	**Most important:** 10303-11: EXPRESS language ISO 10303-21: ASCII data exchange file format 10303-209: Multidisciplinary analysis and design 10303-239: Product Life-Cycle Support 10303-242: Managed model-based 3D engineering
ISO	TC 184/SC 4/WG 21 "SMRL Validation Team"	10303-1000	STEP Module and Resource Library (SMRL)	C	The baseline data models for building the above application protocols, i.e., 10303-209/239/242 etc. .

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	TC 59/SC 13/WG 6 "Framework for object-oriented information exchange"	12006-2	Framework for classication	A	
ISO	TC 59/SC 13/WG 6 "Framework for object-oriented information exchange"	12006-3	Framework for object-oriented information exchange	A	
ISO	TC 59/SC 13 "Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)"	16739	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries	A	
ISO	TC 20/SC 13 "Space data and information transfer systems"	14721	Open archival information system (OAIS) — Reference model	U	
ISO	TC 29 "Small tools"	13399	Cutting tool data representation and exchange	I	
ISO/IEC	JTC 1/SC 7 "Software and systems engineering"	15288	Systems and software engineering — System life cycle processes	U	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	TC 20/SC 13 "Space data and information transfer systems"	16363	Audit and certification of trustworthy digital repositories	I	
ISO	TC 184/SC 4 "Industrial data"	23247	Digital Twin manufacturing framework	A	
ASD/AIA	LOTAR "Longterm Archival and Retrieval""	NAS/EN 9300	Long Term Archiving and Retrieval of digital technical product documentation such as 3D, CAD and PDM data	U	
ISO	TC 184/SC 4 "Industrial data"	18876	Integration of industrial data for exchange, access and sharing	U	
ISO	TC 184/SC 4 "Industrial data"	15926	Integration of life-cycle data for process plants including oil and gas production facilities	U	

Table 32. Partner JOTNE Standardization Involvement

Partner:	**MGEP**
Contact:	Felix Larrinaga
Email:	flarrinaga@mondragon.edu

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
ZVEI, DKE	Plattform Industrie 4.0	AAS	Asset administration Shell	I, U	
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	
OMG		BPMN	Business Process Model and Notation	I	
OASIS		BPEL	Business process Execution Language	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
W3C		RDF	Resource Description Framewor	I	RDF is a standard model for data interchange on the Web
W3C		OWL	Web Ontology Language	I	The W3C Web Ontology Language (OWL) is a Semantic Web language designed to represent rich and complex knowledge about things, groups of things, and relations between things
W3C		SPARQL	SPARQL	I	The SPARQL Protocol and RDF Query Language (SPARQL) is a query language and protocol for RDF.

Table 33. Partner MGEP Standardization Involvement

Partner:	**MON**
Contact:	Michel Iñigo
Email:	minigo@mondragoncorporation.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65/JWG 21	SMRM	Smart Manufacturing Reference Model(s)	A, M, N	
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	M,N	
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
ZVEI, DKE	Plattform Industrie 4.0	AAS	Asset administration Shell	I, U	
ISO, IEC	TC 65	eCl@ss (ISO 13584-42/IEC 61360)	ISO 13584-42, Methodology for structuring part families	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
			EC 61360 series, IEC Common Data Dictionary		
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	
IEC	TC 65	IEC 62832 and IEC TR62794	Digital Factory	I	
IEC	TC 65	IEC 62541	OPC-UA	I	
IEC		IEC 81346	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations	I	
IIConsortium		IIRA	Industrial Internet Reference Architecture	I	
OPC Foundation		OPC-UA	OPC Unified Architecture	U	
OMG	ADTF	SysML	System Modeling Language	I	

Table 34. Partner MON Standardization Involvement

Partner:	**MSI**
Contact:	Peter Craamer
Email:	pcraamer@msigrupo.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	U	
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
IEC	TC 65	IEC 62541	OPC-UA	U	
IEC	TC 65	IEC 62832 and IEC TR62794	Digital Factory	I	
IIConsortium		IIRA	Industrial Internet Reference Architecture	I	
ISA	ISA-95		International Standard for Automation	U	

Table 35. Partner MSI Standardization Involvement

Partner:	**IFD**
Contact:	Germar Schneider
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
SEMI	SECS/GEM	SECS/GEM	equipment communication standars semiconductors	U	
IEC	TC 65	IEC 62541	OPC-UA	U	
SEMI	SEMI300	SEMI300	many different standards for AMHS in semiconductor industry	U	
IETF	JSON WG	RFC 5741.	JavaScript Object Notation (JSON) Data Interchange Format	U	
W3C		XML	Extensible Markup Language (XML) 1.0 (Fifth Edition)	U	

Table 36. Partner IFD Standardization Involvement

Partner:	**POLITO**
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OMG		UML	Unified modeling language	I	
OMG		MARTE	Modeling and Analysis of Real-time and Embedded systems	I	
OMG	ADTF	SysML	System Modeling Language	I	
ISO/IEC/IEEE		42010	Systems and software engineering	I	
ISO/IEC/IEEE		15288:2015	Systems and software engineering -- System life cycle processes	I	
ISO/IEC		12207:2017	Systems and software engineering -- Software life cycle processes	I	
ISO/IEC/IEEE		29148:2011	Systems and software engineering -- Life cycle processes -- Requirements engineering	I	
IIConsortium		IIRA	Industrial Internet Reference Architecture	I	
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	

Table 37. Partner POLITO Standardization Involvement

Partner:	**REUSE**
Contact:	Roy Mendieta
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	
OMG	ADTF	SysML v2	System Modeling Language	I	
ISO/IEC/IEEE	n/a	15288:2015	Systems and software engineering -- System life cycle processes	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO/IEC	n/a	12207:2017	Systems and software engineering -- Software life cycle processes	I	
INCOSE	FUSE	NA	Future of Systems Engineering and AI	M	INCOSE is not directly a standardizatio n body.
INCOSE	ONTOLOG IES	NA	Ontologies and Knowledge Management Group	A	INCOSE is not directly a standardizatio n body.
INCOSE	REQUIRE MENTS	NA	Requirements Working Groiup	A	INCOSE is not directly a standardizatio n body.
RTCA	RTCA SC-205, EUROCAE WG-12	DO-178C	Software Considerations in Airborne Systems and Equipment Certification	I	
IEC	TC 65/SC 65A - System aspects	IEC 61508-2:2010	Functional safety of electrical/electronic/program mable electronic safety-related systems - Part 2: Requirements for electrical/electronic/program mable electronic safety-related systems	I	
ISO	WG2	26262	Road vehicles -- Functional safety	I, U	Mainly in the process and management: Road vehicles -- Functional safety -- Part 2: Management of functional safety
ISO/IEC	n/a	25010:2011	Systems and software engineering -- Systems and software Quality Requirements and Evaluation (SQuaRE)		

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OASIS	CORE	OSLC CORE	OASIS OSLC Lifecycle Integration Core	U	
ISO/IEC/IEEE	ISO/IEC JTC 1/SC 7	29148:2011	Systems and software engineering -- Life cycle processes -- Requirements engineering	I, U	
ISO	n/a	10303	Automation systems and integration — Product data representation and exchange	I,U	
W3C	OWL WG	OWL2	OWL Web Ontology Language Overview	I,U	Family of OWL W3C Recommendations
W3C	RDF WG	RDF 1.1	RDF 1.1 Concepts and Abstract Syntax	I,U	Family of RDF W3C Recommendations
W3C	SKOS WG	SKOS	SKOS Simple Knowledge Organization System Reference	I,U	
W3C	RDFS WG	RDFS	RDF Schema 1.1	I,U	

Table 38. Partner REUSE Standardization Involvement

Partner:	**ROPARDO**
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Email:	gabriela.candea@ropardo.ro

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	
IEC	TC 65	IEC 62832 and IEC TR62794	Digital Factory	I	
IIConsortium		IIRA	Industrial Internet Reference Architecture	I	

ISO		ISO/CEI 27001	information security management system	U	

Table 39. Partner ROPARDO Standardization Involvement

Partner:	**STMicroelectronics**
Contact:	Luca Zanotti
Email:	luca.zanotti@st.com

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
MIG					MEMS Industry Group
NIST					National Institute of Standards and Technology
ETSI					European Telecommunication Standards Institute
IEC		IEC 62047 series	MEMS standards		International Electrotechnical Commission
CEN/CENELEC					European Committee for Standardization
SEMI		SEMI MS1-0812	Wafer-Wafer Bonding Alignment Targets		Semiconductor Equipment and Materials International
		SEMI MS2-1113	Test Method for Step Height Measurements of Thin Films		
		SEMI MS3-0915	Terminology for MEMS Technology		
		SEMI MS4-0416	Test Method for Young's Modulus Measurements of Thin, Reflecting Films Based on the Frequency of Beams in Resonance		
		SEMI MS5-0813	Test Method for Wafer Bond Strength Measurements Using Micro-Chevron Test Structures		
		SEMI MS6-0308	Guide for Design and Materials for Interfacing Microfluidic Systems		

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
		SEMI MS7-0708	Specification for Microfluidic Interfaces to Electronic Device Packages		
		SEMI MS8-0309	Guide to Evaluating Hermeticity of Microelectromechanical Systems (MEMS) Packages		
		SEMI MS9-0611	Specification for High Density Permanent Connections between Microfluidic Devices		
		SEMI MS10-0912	Test Method to Measure Fluid Permeation through MEMS Packaging Materials		
JEDEC		JESD22-A114E	ESD HBM		Joint Electron Device Engineering Council
JEDEC		JESD22-C101E	ESD CDM		
JEDEC		JESD22	Reliability Tests		
ECOPACK®1			Environmental Compatibility Standards		
IECQ		QC 080000	Hazardous Substances Process Management System Requirements (HSPM) standard		International Electro-technical Commission Quality Assessment System for Electronic Components
ISO		ISO 50001	Energy management		International Organization for Standardization
		ISO 14001	Environmental management systems		
		ISO14015	Environmental management - Environmental assessment of sites and organizations.		

Table 40. Partner ST Standardization Involvement

Partner:	**TU Dresden**
Contact:	Burkhard Hensel
Email:	burkhard.hensel@tu-dresden.de

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
VDI	VDI-Fachbereich Schwingungstechnik	VDI3832	Measurement of structure-borne sound of rolling element bearings in machines and plants for evaluation of condition	U	
VDI	VDI-Fachbereich Schwingungstechnik	VDI3839	Instructions on measuring and interpreting the vibrations of machines - General principles	U	
VDI	VDI-Fachbereich Schwingungstechnik	VDI3836	Measurement and evaluation of mechanical vibration of screw-type compressors and Root blowers - Addition to DIN ISO 10816-3	U	

Table 41. Partner TUD Standardization Involvement

Partner:	**TUE**
Contact:	Loek Cleophas
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OMG		SysML	System Modeling Language	U	general-purpose modeling language for systems engineering applications
OMG		UML	Unified modeling language	U	general-purpose modeling language for software design
OMG		MOF	Meta Object Facility	U	Foundational standard for model and language design, storage, transmission
OMG		XMI	XML Metadata Interchange	U	Standard format for model transmission and storage

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
FMI		FMI	Functional Mock-up Interface	I	a tool independent standard to support both model exchange and co-simulation of dynamic models using a combination of xml-files and compiled C-code

Table 42. Partner TUE Standardization Involvement

Partner:	**UC3M**
Contact:	Jose María Alvarez Rodríguez
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65	IEC 62890	IEC 62890 Life Cycle Management	I	
OMG	ADTF	SysML v2	System Modeling Language	I	Letter of intent has been sent.
ISO/IEC/IEEE	n/a	15288:2015	Systems and software engineering -- System life cycle processes	I	
ISO/IEC	n/a	12207:2017	Systems and software engineering -- Software life cycle processes	I	
INCOSE	FUSE	NA	Future of Systems Engineering and AI	A	INCOSE is not directly a standardization body.
INCOSE	ONTOLOGIES	NA	Ontologies and Knowledge Management Group	C	INCOSE is not directly a standardization body.
INCOSE	REQUIREMENTS	NA	Requirements Working Groiup	A	INCOSE is not directly a standardization body.

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
RTCA	RTCA SC-205, EUROCAE WG-12	DO-178C	Software Considerations in Airborne Systems and Equipment Certification	I	
IEC	TC 65/SC 65A - System aspects	IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems	I	
ISO	WG2	26262	Road vehicles -- Functional safety	I, U	Mainly in the process and management: Road vehicles -- Functional safety -- Part 2: Management of functional safety
ISO/IEC	n/a	25010:2011	Systems and software engineering -- Systems and software Quality Requirements and Evaluation (SQuaRE)		
OMG	n/a	SACM 2.1	Structured Assurance Case Metamodel	M, U	
OASIS	CORE	OSLC CORE	OASIS OSLC Lifecycle Integration Core	U	See also: https://open-services.net/ The interest and application is in the OSLC ecosystem.
SWAGGER	n/a	OAS	Open API Specification	U	https://swagger.io/specification/ It is not actually an standardization body.
ISO/IEC/IEEE	ISO/IEC JTC 1/SC 7	29148:2011	Systems and software engineering -- Life cycle processes -- Requirements engineering	I, U	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO	n/a	10303	Automation systems and integration — Product data representation and exchange	I,U	Mainly interest in AP 242, 239, 243
RTCA	SC-205	DO-331	Model-Based Development and Verification Supplement to DO-178C and DO-278A	I	
W3C	OWL WG	OWL2	OWL Web Ontology Language Overview	I,U	Family of OWL W3C Recommendations
W3C	RDF WG	RDF 1.1	RDF 1.1 Concepts and Abstract Syntax	I,U	Family of RDF W3C Recommendations
W3C	SKOS WG	SKOS	SKOS Simple Knowledge Organization System Reference	I,U	
W3C	Data Shapes WG	SHACL	Shapes Constraint Language (SHACL)	I	Shape Expressions
W3C	LDP WG	LDP 1.0	Linked Data Platform 1.0	I,U	
W3C	n/a	RDF Data Cube	The RDF Data Cube Vocabulary	I,U	
W3C	RDFS WG	RDFS	RDF Schema 1.1	I,U	

Table 43. Partner UC3M Standardization Involvement

Partner:	**VTC**
Contact:	Richard Hedman
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65/JWG 21	SMRM	Smart Manufacturing Reference Model(s)	I	
IEC	TC 65/WG 10	IEC 62443	Security for industrial process measurement and control - Network and system security	I	
DKE	Industrie4.0	RAMI40	Reference Architectural Model	I	
ZVEI, DKE	Plattform Industrie 4.0	AAS	Asset administration Shell	I, U	
IEC	TC 65	IEC 62832 and IEC TR62794	Digital Factory	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
IEC	TC 65	IEC 62541	OPC-UA	U	
IEC		IEC 81346	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations	I	
IIConsortium		IIRA	Industrial Internet Reference Architecture	I	
OPC Foundation		OPC-UA	OPC Unified Architecture	U	
OMG	ADTF	SysML	System Modeling Language	I, U	

Table 44. Partner VTC Standardization Involvement

Partner:	**VTT**
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SDO	TC/ WG	Standard	Name of Standard	Role	Comments
ISO		ISO13374	ISO13374:Condition monitoring and diagnostics of machine systems. Data processing, communication and presentation	I	
ISO		ISO13379	ISO13379 Condition monitoring and diagnostics of machines - general guidelines on data interpretation and diagnostics techniques	I	
ISO		ISO13381	ISO13381 Condition monitoring and diagnostics of machines — Prognostics	I	
ISO		ISO10816	ISO10816 Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts	I	

SDO	TC/ WG	Standard	Name of Standard	Role	Comments
OSA-EAI		OSA-EAI	OSA-EAI Open System Architecture for Enterprise Application Integration V3.2.3 Production Specification, MIMOSA, 2012	I	
OSA-EAI		OSA-EAI	OSA-CBM Open System Architecture for Condition-Based Maintenance V3.3.1 Production Specification, MIMOSA, 2010	I	
IEC	TC 65	IEC 62541	OPC-UA	I	
ISO		ISO 10303	ISO 10303 STEP, the Standard for the Exchange of Product Model Data	I	
IGES		NBSIR 80-1978	Initaial Graphics Exchange Specification IGES. Digital Representation for Communication of Product Definition Data	I	

Table 45. Partner VTT Standardization Involvement