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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

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1 Scope

The present document specifies the requirements for an initial semantic model for industry and manufacturing domains based on a limited set of use cases and from available existing data model. It includes deployment and related services aspects. The present document is developed in close collaboration with AIOTI, the H2020 Large Scale Pilots and with ETSI activities in this domain. Further extensions are envisaged in the future to cover entirely the industry and manufacturing domains. The associated ETSI TS 103 410-5 [i.9] will define the extension (i.e. the semantic model) for the industry and manufacturing domains based on the requirements and use cases specified in the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] European Commission and TNO: "Smart Appliances REFerence ontology (SAREF)", April 2015.

NOTE: Available at http://ontology.tno.nl/saref.

[i.2] European Commission and TNO: "D-S4 Final Report - SMART 2013-0077 - Study on Semantic Assets for Smart Appliances Interoperability", March 2015.

NOTE: Available at https://sites.google.com/site/smartappliancesproject/documents.

[i.3] ETSI TS 103 264 (V2.1.1) (03-2017): "SmartM2M; Smart Appliances; Reference Ontology and oneM2M Mapping".

[i.4] ETSI TR 103 411 (V1.1.1) (02-2017): "SmartM2M; Smart Appliances; SAREF extension investigation".

[i.5] ETSI TS 103 410-1: "SmartM2M; Smart Appliances Extension to SAREF; Part 1: Energy Domain".

[i.6] ETSI TS 103 410-2: "SmartM2M; Smart Appliances Extension to SAREF; Part 2: Environment Domain".

[i.7] ETSI TS 103 410-3: "SmartM2M; Smart Appliances Extension to SAREF; Part 3: Building Domain".

[i.8] Adolphs P., Epple U., et al.: "Status Report Reference Architecture Model Industrie 4.0 (RAMI4.0)". Düsseldorf, Frankfurt 2015. VDI - The Association of German Engineers, ZVEI - German Electrical and Electronic Manufacturers' Association.

[i.9] ETSI TS 103 410-5: "SmartM2M; Extension to SAREF; Part 5: extension to Industry and Manufacturing Domains".

[i.10] ETSI TS 103 410 series: "SmartM2M; Extension to SAREF".

[i.11] IEC 62794:2012: "Industrial-process measurement, control and automation - Reference model for representation of production facilities (digital factory)".

[i.12] IEC 62832: "Industrial-process measurement, control and automation - Digital factory framework".

[i.13] VDMA 24582: "Fieldbus Neutral Reference Architecture for Condition Monitoring in Factory Automation".

NOTE: Available at https://www.vdma.org/.

[i.14] ISO/IEC 20140: "Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment".

[i.15] IEC 61804: "Function blocks (FB) for process control and electronic device description language (EDDL)".

[i.16] IEC 62453: "Field device tool (FDT) interface specification".

[i.17] ISO/IEC 27000:2018: "Information technology -- Security techniques -- Information security management systems -- Overview and vocabulary".

[i.18] IEC 62443: "Security for industrial automation and control systems".

[i.19] eCl@ss specification.

NOTE: Available at https://www.eclass.eu/.

[i.20] GTIN Management standard, 1.0. June 2016.

[i.21] IEC 62264: "Enterprise-control system integration".

[i.22] IEC 61512: "Batch control".

[i.23] IEC 62541: "OPC Unified Architecture".

[i.24] DIN SPEC 16592: "Combining OPC Unified Architecture and Automation Markup Language".

NOTE: Available at https://www.din.de/en/wdc-beuth:din21:265597431.

[i.25] IEC 61784: "Industrial communication networks - Profiles".

[i.26] Industrial Data Space: "Reference Architecture Model 2017".

NOTE: Available at https://www.internationaldataspaces.org/.

[i.27] IEC 62890: "Life cycle status".

[i.28] ISO 13849: "Safety of machinery -- Safety-related parts of control systems".

[i.29] IEC 62061:2005: "Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems".

[i.30] IEC 61511: "Functional safety - Safety instrumented systems for the process industry sector".

[i.31] IEC 61508: "Functional safety of electrical/electronic/programmable electronic safety-related systems".

[i.32] IEC 61360: "Standard data element types with associated classification scheme".

[i.33] ISO 13584: " Industrial automation systems and integration -- Parts library".

[i.34] IEC 62424:2016: "Representation of process control engineering - Requests in P&I diagrams and data exchange between P&ID tools and PCE-CAE tools".

[i.35] IEC 62714: "Engineering data exchange format for use in industrial automation systems engineering - Automation markup language".

[i.36] ISO/PAS 17506:2012: "Industrial automation systems and integration -- COLLADA digital asset schema specification for 3D visualization of industrial data".

[i.37] IEC 61131: "Programmable controllers".

[i.38] IEC 61987: "Industrial-process measurement and control - Data structures and elements in process equipment catalogues".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

ontology: formal specification of a conceptualization, used to explicit capture the semantics of a certain reality

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AIOTI	Alliance for the Internet of Things Innovation
AML	Automation ML
DIN	Deutsches Institut für Normung
EDD	Electronic Device Description
EDDL	Electronic Device Description Language
FDT	Field Device Tool
GTIN	Global Trade Item Number
HTTP	HyperText Transfer Protocol
INMA	Industry and Manufacturing
IoT	Internet of Things
ISMS	Information Security Management System
IT	Information Technology
OPC	Object linking and embedding for Process Control
RAMI 4.0	Reference Architectural Model Industrie 4.0
SAREF	Smart Appliances REFerence ontology
SAREF4INMA	SAREF extension for the Industry & Manufacturing domain
STF	Specialists Task Force
TNO	Netherlands Organization for Applied Scientific Research
TR	Technical Report
TS	Technical Specification
UA	Unified Architecture
URI	Uniform Resource Identifier
VDMA	Verband Deutscher Maschinen- und Anlagenbau
XML	Extensible Markup Language

4 SAREF extension for the Industry and Manufacturing domain

SAREF [i.1] is a reference ontology for IoT created in close interaction with the industry during a study requested by the European Commission in 2015 [i.2] and subsequently transferred into an ETSI TS 103 264 [i.3]. SAREF contains core concepts that are common to several IoT domains and, to be able to handle specific data elements for a certain domain, dedicated extensions of SAREF can be created. Each domain can have one or more extensions, depending on the complexity of the domain. As a reference ontology, SAREF serves as the means to connect the extensions in different domains. The earlier document ETSI TR 103 411 [i.4] specifies the rationale and methodology used to create, publish and maintain the SAREF extensions.

The present document specifies the requirements for an initial SAREF extension for the industry and manufacturing domain based on a limited set of use cases and from available existing data models. The present document has been developed in the context of the STF 534 (https://portal.etsi.org/STF/STFs/STFHomePages/STF534.aspx), which was established with the goal to create SAREF extensions for the domains of Smart Cities, Smart Industry & Manufacturing, and Smart AgriFood. The STF 534 follows the outcomes of the earlier STF 513, which developed an updated SAREF specification [i.3], and the first extensions of SAREF in the energy [i.5], environment [i.6] and building [i.7] domains.

The STF 534 consists of the following two main tasks:

1) gather requirements, collect use cases and identify existing sources (e.g. standards, data models, ontologies, etc.) from the domains of interest (i.e. Smart Cities, Smart Industry & Manufacturing, and Smart AgriFood); and

2) produce extensions of SAREF for each domain based on these requirements.

The present document focuses on the extension of SAREF for the Smart Industry and Manufacturing domain, which will result in a new ontology, called SAREF4INMA, to be published in the companion ETSI TS 103 410-5 [i.9] as part of the SAREF extensions series ETSI TS 103 410 [i.10].

5 Related initiatives

5.1 Introduction

In this clause, some of the main related initiatives in terms of modelling and standardization in the smart industry and manufacturing domain are reviewed. Existing efforts range from national or international standardization initiatives, to specific European projects related to these initiatives and standards/data models used in the domain.

5.2 Standardization initiatives and associations

5.2.1 Industry 4.0 initiatives

There are various national initiatives to support digitalization in manufacturing. These include for instance:

- The platform Industry 4.0 in Germany.
- The Smart Industry initiative in the Netherlands.
- Industria 4.0 in Italy.
- Industrie du future initiative in France.

These initiatives typically focus on the following different aspects:

- Cyberphysical systems: the usage of robots and advanced T-capabilities (sensors, data analytics) in a production environment.
- Digital manufacturing technologies: new manufacturing technologies such as 3D printing, requiring a high level of digital input (e.g. digital designs/digital twins).
- New business models and propositions: lot size one-manufacturing, servitization of manufacturing, maintenance and other new business propositions leading to changes in the way businesses and their networks are structured.

The Industry 4.0 initiatives focus on aspects such as standardization (which standards to use or to extend), the development of new digital technologies (e.g. 5G wireless connectivity for manufacturing) and 'soft' aspects such as business model innovation and skills. Through so-called 'digital innovation hubs' collaborations between manufacturing companies, their service provides (including IT-companies), (potential) customers and research organizations have been established. The Industry 4.0 initiatives can provide input to the SAREF extension for smart industry and manufacturing in terms of key use cases and the standards used in this domain.

5.2.2 Reference Architecture Model for Industry 4.0 (RAMI)

Figure 1 shows an overview of the Reference Architecture Model for Industry 4.0 (RAMI) [i.7] and [i.8]. This model is used for the alignment of several standards used in the aforementioned Industry 4.0 initiatives. These standards are grouped according to the topics they deal with that, in turn, are related to three key elements in the industry environment, i.e. factory, product and process.

The standards related to the factory describe the organization, communication, structure and involvement in the development process of the machinery. The standards related to the product explain the hierarchy of the different products in the factory and both the communication between the different products and their relation with the machinery. Finally, the standards related to the process show the life-cycle of the products and the machinery. It is worth highlighting that there are topics related to two or more elements in the industry environment.

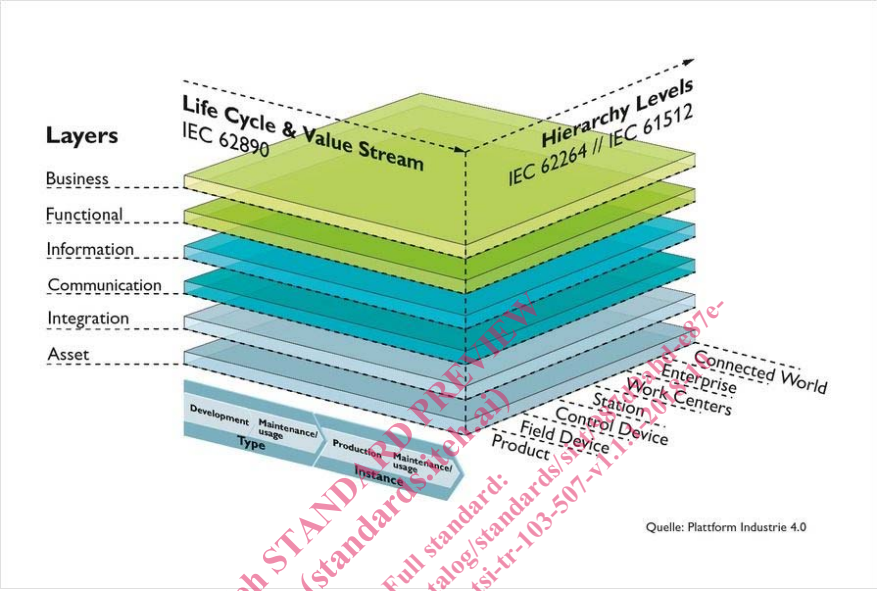

Figure 1: Reference Architecture Model for Industry 4.0

5.2.3 AIOTI

The Alliance for Internet of Things Innovation (https://aioti.eu/), founded by the European Commission in 2015, consists on thirteen working groups. The WG03 on IoT standardization is a horizontal working group that addresses, amongst other, the issue of semantic interoperability in the IoT that is especially relevant to SAREF. The WG11 on Smart Manufacturing is a vertical working group dedicated to IoT solutions that can bring together information, technology and human ingenuity to achieve a rapid revolution in the development and application of manufacturing intelligence to every aspect of business.

5.3 Standards

Figure 2 shows an (initial) overview of existing standards in the industry and manufacturing domain. These standards are grouped based on their scope (e.g. digitalization, communication, engineering, life-cycle, etc.) and the topic they cover (i.e. factory, product, process).

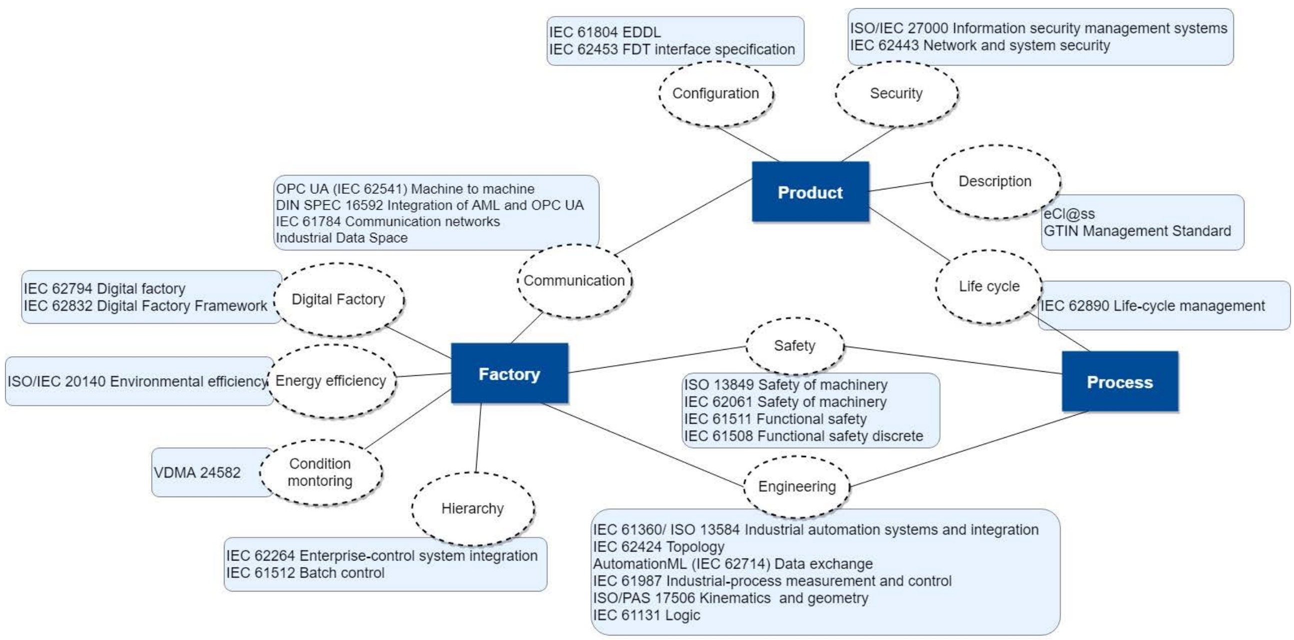

Figure 2: Relevant standards in Industry and Manufacturing

The next paragraphs describe in more detail each of the standards included in Figure 2 grouped according to the scope and the topic each one deals with.

The standards related to the *factory* are:

- Concerning digital factory:
  - **IEC 62794 [i.11] Digital Factory:** This specification describes a reference model which comprises the abstract description for automation assets and structural and operational relationships. This reference model supports the electronic representation of certain aspects of a plant. It covers the systems used to make products, although it does not cover raw production material, work pieces in process nor end products.
  - **IEC 62832 [i.12] Digital Factory Framework:** This specification defines the general principles of the Digital Factory framework, which is a set of model elements and rules for modelling production systems. This standard is built upon the IEC 62794 **[**i.11**]** standard.
- Concerning condition monitoring:
  - **VDMA 24582 [i.13]:** This specification presents the reference architecture of condition monitoring systems in production automation. It is the basis for the creation of communication profiles for condition monitoring and the integration of condition monitoring into engineering tools within automation systems.
- Concerning energy efficiency:
  - **ISO/IEC 20140 [i.14] Environment efficiency:** This specification specifies a method for evaluating the energy efficiency of a manufacturing system and other factors such as energy consumption, waste and release that influence the environment. The evaluation method provides guidelines to analyse the usage of energy by the manufacturing system and its effects on the environment.

The standards related to the *product* are:

- Concerning configuration:
  - **IEC 61804 [i.15] EDDL:** This standard specifies electronic device description (EDD) interpretation for EDD applications and EDDs to support EDD interoperability. It is intended to ensure that field device developers use the EDD language constructs consistently and that EDD applications interpret in the same way the EDD.