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TECHNICAL REPORT

Internet of things (IoT) – Industrial IoT

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FOREWORD

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ISO/IEC TR 30166, which is a Technical Report, has been prepared by subcommittee 41: Internet of Things and related technologies, of ISO/IEC joint technical committee 1: Information technology.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
JTC1-SC41/95/DTR	JTC1-SC41/113/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The IIoT (Industrial Internet of Things) is an identified vertical of the IoT, as seen throughout this document in general.

It consists of Industrial (electronic) communication-capable electronic systems and devices, which can be recognized as the integration base, to allow seamless communication, data processing, data access and data exchange in regard to sensors (sensing), auto-ID (automatic (global, unique) identification), and actors (acting, steering).

This is connected based upon a homogeneous as well as heterogeneous – mostly, but not exclusively, IP based – networking structure, capable of being able to interact seamlessly, in a flat, mesh or hierarchical architecture.

This document is intended for those users who want to get a large-scale informative overview of the current standardization activities and standardization landscape of SDOs, consortia and open-source communities in the field of IIoT.

Therefore, it is primarily intended for standardization managers, system architects, OT and IT specialists with a substantial understanding of technical language in the context of discrete manufacturing and/or process industries and with a focus on future global advanced smart industries.

It lists also national and cooperative initiatives in regard to IIoT and the partly touching field of Smart Manufacturing – with at least distinct working activities on IIoT in terms of their capabilities and individual working scope. It also lists the identified ones in Annex A.

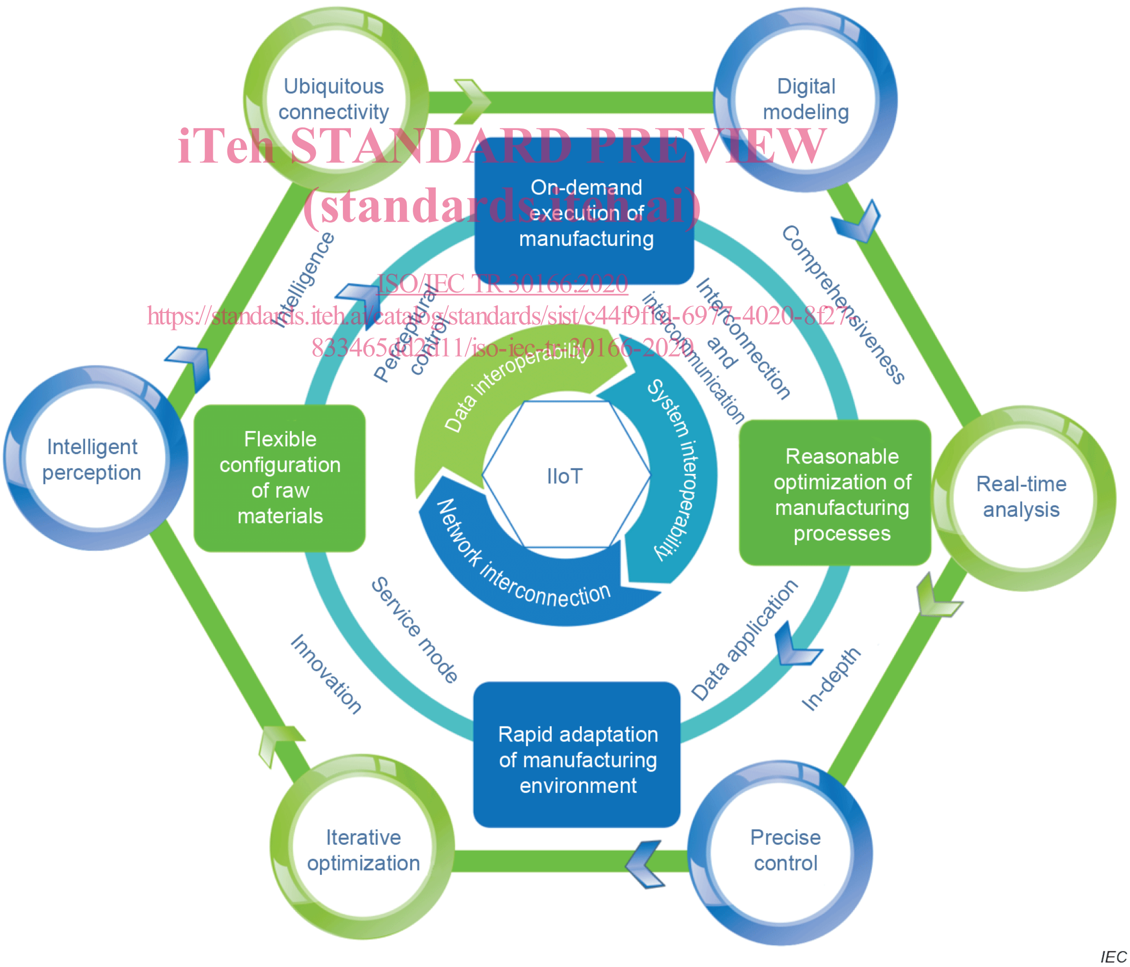
First of all, a definition is used based upon work by CESI in the whitepaper on IIoT from the China NC in 2017:

> "IIoT is a new industrial ecosystem of service driven built based on the network interconnection, data interoperability and system interoperability of industrial resources, to realize the flexible configuration of the manufacturing materials, the on-demand execution of the manufacturing process, the rational optimization of the manufacturing process and the rapid adaptation of the manufacturing environment, and to achieve the efficient utilization of the resources.
>
> IIoT shows six typical features: intelligent perception, ubiquitous connectivity, precise control, digital modelling, real-time analysis and iterative optimization. (See Figure 1.)
>
> Intelligent perception. It is the base of IIoT. The massive data generated from industrial production, logistics, sales and other industrial chain links are the information data of different dimensions in the industrial life cycle obtained by IIoT in such perceptual means as the sensor and RFID, including: State information about industrial resources, such as personnel, machines, raw materials, processes and environment.
>
> Ubiquitous connectivity. It is the precondition of IIoT. Industrial resources are connected or linked to the Internet through wired or wireless ways, forming a convenient and efficient information channel for IIoT and realizing interconnection and intercommunication of industrial resource data, and the breadth and depth of the connection between machines and machines, machines and people, machines and the environment are expanded.
>
> Digital modelling. It is the method of IIoT. Digital modelling maps industrial resources into digital space, and simulates industrial production processes in a virtual world, which can realize the abstract modelling of all elements in industrial production process by virtue of the powerful information processing ability in digital space and provide effective decision-making for the operation of industrial chain of IIoT entities.

Real-time analysis. It is the means of IIoT. The perceived industrial resource data can be processed in real time in in digital space by means of technical analysis, to obtain the internal relationship between the state of industrial resources in the virtual and the real space; in addition, the abstract data can be further visualized to complete the real-time response of external physical entities.

Precise control. It is the purpose of IIoT. Through the processes of state perception, information interconnection, digital modelling, real-time analysis, etc. of industrial resources, the precise control can be converted into the control commands that the industrial resource entities can understand based on the decision formed in virtual space, and then practical operation shall be conducted to achieve precise information interaction and seamless collaboration of industrial resources.

Iterative optimization. It is the effect of IIoT. IIoT system can learn and upgrade itself continuously. It can form effective and inheritable knowledge base, model base and resource base by processing, analyzing and storing industrial resource data. It can iterate and optimize till the optimal goal facing industrial resource manufacturing raw materials, manufacturing processes, manufacturing processes and manufacturing environment."



SOURCE: CESI

Figure 1 – Six typical features of IIoT

IoT is causing dramatic technological changes to the classical manufacturing and process world: New technological and methodological manufacturing concepts like predictive maintenance, adaptive MES/ERP management, big data analysis, augmented reality, Twin-models (Digital), 3D printing, smart grid, intelligent maintenance systems, Artificial Intelligence, CPS (cyber physical systems), CPPS [cyber physical production systems (the 5C's: connection, conversion, cyber, cognition and configuration)] and many more are the drivers of this technological shift. This highlights the urgent need for standardization to enable coexistence, interoperability, in seamless functionality across all these aspects to the IIoT, often also called the "fourth industrial revolution".

However, there is a strong "crossover" in public recognition between "IIoT" and "Smart Manufacturing" (SM) recognized by all in global advanced manufacturing and Smart Manufacturing and in IoT engaged SDOs, organizations and other interested groups.

It is truly difficult to set or identify a hard border-line between both these topics of interest and ongoing development because the overlap shows that often three out of four named topics are handled on both the SM side and the IIoT side, which leads to about 75 % overlapping space being identified.

As this is still an ongoing process of development, it will be considered for review in all future revisions to this document.

IIoT can be defined upon the IoT reference architecture (ISO/IEC 30141), as described later on.

This document has three main focused outcomes:

a) IIoT definition (domains, as well as IIoT systems and landscapes: This provides a structural analysis of all the materials collected and analysed, restructured by subclauses in Clause 5 and outlining different characteristics, technical aspects and functional as well as non-functional elements of the IIoT structure surrounded by appropriate analytic views and comments on standardization to it.

b) Considerations about future standardization in IIoT: This document takes a look at the future of standardization regarding IIoT in Clause 6. Therein it describes the standardization perspective and the necessary risk analysis to be undertaken. It analyses identified problems, challenges and lists potential work items for standardization as well.

c) An overview of identified relevant standards and industrial initiative in relation to IIoT: Listing all the identified SDOs, non-SDOs, and former smart manufacturing and global advanced manufacturing initiatives as input for further development on standardization in the IIoT field in collaboration with Smart Manufacturing, which is the field having the nearest scope to IIoT. Even knowing that these standards are huge in number and mostly related to smart manufacturing as well as global advanced manufacturing, they establish a baseline in relation to each other as well as with regard to new upcoming IIoT related standards.

Clause 6 covers the main conclusions, considerations and outlook to normative roadmapping.

INTERNET OF THINGS (IoT) – INDUSTRIAL IoT

1 Scope

This document describes the following:

- general Industrial IoT (IIoT) systems and landscapes which outline characteristics, technical aspects and functional as well as non-functional elements of the IIoT structure and a listing of standardizing organisations, consortia and open-source communities with work on all aspects on IIoT;
- considerations for the future standardization perspective of IIoT including risk analysis, new technologies and identified collaborations.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Abbreviated terms

3D	Three Dimensional (mostly in CAD/CAE)
5G-ACIA	5G Alliance for Connected Industries and Automation
AAS	Asset Administration Shell (often shortened to Administration Shell)
AI	Artificial Intelligence
AIOTI	The Alliance for the Internet of Things Innovation
ASMT	American Society for Testing and Materials
AutomationML	Automation (Domain Language) Markup Language (like XML)
CCSA	China Communications Standards Association
CESI	China Electronics Standardization Institute
CIM	Computer Integrated Manufacturing
CPPS	Cyber Physical Production System
CPS	Cyber Physical System
CT	Communication Technology
DDS	Data Distribution Service
DIN	Deutsches Institut für Normung (German MB to ISO)
DKE	Deutsche Kommission für Elektrotechnik (German NC to IEC)
e@Class	(electronic) @ Classification and Product description
EC	Edge Computing

ECC	Edge Computing Committee (China)
ETSI	European Telecommunications Standards Institute
FOAF	(Friend of a Friend) [ontology]
FOSS	Free Open Source Systems
GD	Gateway Devices
GIoT	Green IoT (A LPWAN IoT total solution provider)
GSMA	GSM Association
GUI	Graphic user interface
H2020	Horizon 2020 (EC/EU Founding Research program)
HMI	Human–Machine Interface
I4.0	Industrie 4.0
ICT	Information and Communication Technology
IDSA	International Data Spaces Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IIC	Industrial Internet Consortium
IIoT	Industrial Internet of Things
IIRA	Industrial Internet Reference Architecture
Industrial CPS	Industrial Cyber-Physical-System
IoT	Internet of Things
IP	Internet Protocol
IRTF	Internet Research Task Force
ISA	International Society of Automation
ISG	ETSI Industry Specification Group – for cross-cutting Context Information Management
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunications Union
ITU-T	ITU Telecommunication Standardization Sector
IVI	Industrial Value-Chain Initiative (Japan)
JWG	Joint working group
LNI	Labs Network Industrie 4.0 (Standardization Council I4.0 DIN/DKE/VDE)
MB	Member Body (ISO)
M2M	Machine-to-machine
NC	National Committee (IEC)
NIST	National Institute of Standards and Technology
NRM	Normative Roadmap Rev. 3.0 (defined by SCI, see below)
OMG	Object Management Group
OneM2M	One Machine to Machine collaboration – by different NBs (USA, EU/EC, JP, China, Korea)
OPC	OLE (object linking and embedding) for Process Control
OSI	Open Systems Interconnection Model
OT	Operational Technology

PLC	Programmable Logic Controller
QoS	Quality of Service
RA	Reference Architecture
RAMI 4.0	Reference Architecture Model Industrie 4.0 (IEC PAS 63088:2017)
R&D	Research and Development
RDF	Resource Description Framework
RTLS	Real-Time-Locating-System
SAG	Strategic Advisory Group
SCI	SCI 4.0 (Standardization Council Industrie 4.0)
SDN	Software Defined Network
SDN	Software Defined Networking
SDO	Standards Developing Organization
SEG	Strategy Evaluation Group
Semanz4.0	Semantics for I4.0
SG	Study Group
SM	Smart Manufacturing
SM/IIoT	Smart Manufacturing/IIoT (Common View)
SmartM2M	Smart Machine to Machine (Focus: Communication)
SOA	Service Oriented Architecture
TC	Technical Committee
TCP	Transmission Control Protocol
TDIA	Telecommunication Development Industry Alliance
TMBG	Technical Management Board Group
ToR	Terms of reference
TSN	Time Sensitive Networking
UA	Unified Architecture
UdF	Usine de Future (France NB)
VDE	Verband der Elektrotechnik, Elektronik und Informationstechnik (Germany NC in IEC)
W3C	World Wide Web Consortium
WSDL	Web Services Description Language

5 IIoT systems and landscape, see [1]

5.1 Overview

5.1.1 General

Figure 2 depicts a structural view of IIoT as the big picture, showing how IIoT is constructed.

Figure 2 should give a base impression of the complexity and structural setup of IIoT, intended as a common view; all technical details and aspects shown therein are explained in the following clauses and subclauses.

It shows up a static as well as dynamic layered view consistently built up from the bottom (the OT Operation Technology World) to the top (the IT-World).

In this way, analog values are converted into digital information, streamed upwards and downwards through the IP centric medial structures (Middleware, Fog-, Edge-) up towards the Business layers, in which this information is analysed, processed, streamed back down to the OT side again, resulting in business outcome with the highest flexibility and lot-size-zero profitable capable results.

All of this is accompanied by vertical organized intersectional elements of checks and balanced control like: Security, Safety, Trustworthiness, Life cycle, as well as vertical management functionalities across all of these.

"Dynamic" in this regard means that all of these structural elements can be seen layered, recursive and paralleled in their being and instantiation like Hardware and software development systems to generate exactly this entire infrastructure are explained in the CESI whitepaper cited in the Introduction.