



TECHNICAL REPORT



Internet of things (IoT) – Industrial IoT





Copyright © 2020 ISO/IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about ISO/IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.



TECHNICAL REPORT



Internet of things (IoT) – Industrial IoT

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 25-040-40; 35.020; 35.240.50

ISBN 978-2-8322-8251-9

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	7
1 Scope.....	10
2 Normative references	10
3 Terms and definitions	10
4 Abbreviated terms	10
5 IIoT systems and landscape, see [1].....	12
5.1 Overview.....	12
5.1.1 General	12
5.1.2 Architecture.....	15
5.1.3 Implementation of IIoT systems	15
5.1.4 IIoT use case implementations	16
5.1.5 Edge (fog) computing in IIoT, see [2].....	16
5.1.6 Interoperability and conformance.....	16
5.1.7 IIoT characteristics trustworthiness.....	17
5.1.8 Wearables in IIoT	18
5.1.9 Cross-cutting activities on IIoT.....	18
5.2 Analysis consideration on IIoT landscape of systems	19
5.2.1 General	19
5.2.2 IIoT systems and architecture.....	19
5.2.3 IIoT application (virtual/physical use case)	22
5.2.4 IIoT connectivity	23
5.2.5 IIoT interoperability focus	23
5.2.6 The IIoT user, see [20]	23
5.2.7 IIoT migration strategies, see [29].....	24
5.3 General definition of IIoT and smart manufacturing (SM).....	25
5.3.1 Definition of IIoT	25
5.3.2 Cyber physical systems differentiation in the IIoT	26
5.3.3 Industrial Internet to CPPS and CPS definition	26
5.3.4 Smart Manufacturing differentiation vs. IIoT.....	26
5.3.5 Verticals of IoT market.....	26
5.4 Smart Manufacturing and IIoT	28
5.4.1 General	28
5.4.2 The IIoT high-level view.....	28
5.4.3 Industrial products/services life cycle – in IIoT/Smart Manufacturing.....	30
5.4.4 Industrial manufacturing/automation through (IT/OT) standardization – CPPS	30
5.5 Collaboration considerations on an IIoT reference architecture for standardization (use case driven)	31
5.5.1 General	31
5.5.2 General comparison of RAs and models on IIoT, see [37].....	31
5.5.3 IIoT systems characteristics: connectivity and communication aspects	31
5.5.4 IIoT semantic aspects: IIoT characteristics	32
5.5.5 Data scale in IIoT	37
5.5.6 Runtime integration of IIoT	37
5.5.7 Edge computing in IIoT	37
5.5.8 The endpoint – considerations on IIoT	37

5.5.9	“Dependability” for IIoT systems (IEC TC 56).....	38
6	Considerations for future standardization of IIoT.....	38
6.1	Main findings by this document on IIoT standardization	38
6.2	Risk for standards development on IIoT	39
6.2.1	General	39
6.2.2	Avoiding work duplication on IIoT standards development – across SDOs.....	39
6.2.3	Important to IIoT: “semantics above syntax”, see [55].....	39
6.2.4	Standards for handling the “ownership of data” in IIoT, see [56]	39
6.2.5	Vocabulary definitions – issues to IIoT.....	40
6.3	Perspective to development of standards for IIoT.....	40
6.3.1	“Digital twins” – as a generic concept in IIoT	40
6.3.2	(AI) Artificial Intelligence to be used by IIoT (ISO/IEC JTC 1/SC 42).....	41
6.3.3	Federation of cloud in/between IIoT systems (DIN SPEC 92222)	42
6.3.4	Future standardization on: “microservices and micro-applications in IIoT” see [40]	42
6.3.5	“Blockchain technology” – future standardization in IIoT	42
6.3.6	“Wearables” (in IIoT).....	43
6.3.7	Compatibility requirements and model – for devices – within IIoT systems	43
6.4	Roadmap perspective analysis for future standardization work for IIoT	45
6.4.1	Future standardization work for IIoT as a vertical domain of the IoT	45
6.4.2	ISO/IEC collaboration in relation to IIoT.....	47
Annex A (informative)	Listing of all SDOs, non-SDOs, consortia, FOSS (free open source systems) in context of the IIoT mentioned in this document.....	50
A.1	SDOs recognized/identified as of interest to IIoT and also in relation to Clause 5 on standardization landscape in IIoT	50
A.1.1	General	50
A.1.2	3GPP 3 rd Generation Partnership Project.....	50
A.1.3	ETSI (European Telecommunication Standards Institute)	51
A.1.4	IEEE (Institute of Electrical and Electronics Engineers)	51
A.1.5	ISO/IEC	52
A.2	IIoT related initiatives/engagements by national standardization bodies	61
A.2.1	General	61
A.2.2	Sweden – LISA.....	61
A.2.3	France – “Usine du Futur”, see [67]	62
A.2.4	Germany – Industrie 4.0, see [68].....	63
A.2.5	Korea – “Korea – Manufacturing Industry Innovation 3.0 strategy”,	63
A.2.6	China – Industrial Initiatives (Standards Development).....	64
A.2.7	Japan (RRI and IVI).....	65
A.2.8	USA – CPS/CPPS/IIoT Standards Initiatives.....	67
A.2.9	IIoT activities by EC EU	69
A.3	Industrial consortia recognized/identified as being of interest on working about the IIoT	69
A.3.1	General	69
A.3.2	Alliance of Industrial Internet: “Chinese Model of Smart Manufacturing in context of program China Manufacturing 2025” [70]	70
A.3.3	5G-ACIA in IIoT, and Smart Manufacturing	70
A.3.4	China Edge Computing Consortium ECC	71
A.3.5	DMG (Data Mining Group)	71

A.3.6	eCI@ss.....	71
A.3.7	IIC (Industrial Internet Consortium).....	73
A.3.8	International Data Spaces.....	73
A.3.9	Industrial Value Chain Initiative (IVI).....	73
A.3.10	ISA (International Society of Automation)	74
A.3.11	oneM2M – also linked to ETSI above.....	74
A.3.12	OPC Foundation.....	74
A.3.13	Automation ML	75
A.3.14	OMAC (Organization for Machine Automation and Control), see [71]	75
A.3.15	IIoT Semantic: WiSE-IoT (Worldwide interoperability for semantics IoT), see [72]	75
A.4	RFC-based standards development recognized as being of interest to IIoT.....	76
A.4.1	General	76
A.4.2	IETF/IRTF on IT Section related standards development also in IIoT	76
A.4.3	OASIS – Organization for the Advancement of Structured Information Standards.....	77
A.4.4	OCF (Open Connectivity Foundation)	77
A.4.5	ODVA – Open DeviceNet Vendors Association	78
A.4.6	OGC (Open Geospatial Consortium).....	78
A.4.7	OMG (Object Management Group).....	79
A.4.8	OpenFog Consortium – former, now part of IIC	80
A.4.9	The Open Group.....	80
A.4.10	Project Haystack – IIoT Semantic	81
A.4.11	W3C – World Wide Web Consortium.....	81
A.5	Consortial work on standardization by reference	82
A.5.1	General	82
A.5.2	IIRA (by IIC)	82
A.5.3	Bluetooth SIG	83
A.5.4	IO-Link – on Wireless Industrial RealTime Communication	83
	Bibliography.....	85
	Figure 1 – Six typical features of IIoT.....	8
	Figure 2 – IIoT mapping landscape description for SDO and non-SDO, consortia, FOSS.....	14
	Figure 3 – Trustworthiness functional components as identified in ISO/IEC 30141:2018	18
	Figure 4 – Migration approach towards IIoT systems	25
	Figure 5 – IoT SDOs and alliances landscape (vertical and horizontal domains)	27
	Figure 6 – Layout of the overall view on IIoT in the SC 41 context – the IoT bird’s eye view in ISO/IEC JTC 1/SC 41, see [34].	29
	Figure 7 – Diagram showing that the IIoT is part of the IoT applications domain (bird’s eye view), see [35].....	30
	Figure 8 – IIoT connectivity stack from IICF, see [38].....	32
	Figure 9 – The semiotic triangle.....	33
	Figure 10 – Semantics in IIoT meaning context, i.e. sensing.....	36
	Figure A.1 – Structure of IEC TC 65 and ISO/TC 184 JWG 21	58
	Figure A.2 – ISO/IEC Taskforce Standards Map Smart Manufacturing	59
	Figure A.3 – KOSF logo	64
	Figure A.4 – Link reference on Chinese GB/T standards vs. OPC/UA	65

This is a preview of "ISO/IEC TR 30166:202...". [Click here to purchase the full version from the ANSI store.](#)

Figure A.5 – Robot Revolution & Industrial IoT Initiative	66
Figure A.6 – RRI and cooperative relationship	66
Figure A.7 – Industrial Value Chain Initiative (IVI)	67
Figure A.8 – NIST logo	68
Figure A.9 – eCI@ss in Context to other SDO's and institutions	72
Figure A.10 – Activities in the BIM domain:	72
Figure A.11 – Overview of the W3C WoT Building Blocks	82
Table A.1 – List of protocol for IIoT / SM use case by NC China	64

INTERNET OF THINGS (IoT) – INDUSTRIAL IoT

FOREWORD

- 1) ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.
- 2) The formal decisions or agreements of IEC and ISO on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees and ISO member bodies.
- 3) IEC, ISO and ISO/IEC publications have the form of recommendations for international use and are accepted by IEC National Committees and ISO member bodies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC, ISO and ISO/IEC publications is accurate, IEC or ISO cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees and ISO member bodies undertake to apply IEC, ISO and ISO/IEC publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC, ISO or ISO/IEC publication and the corresponding national or regional publication should be clearly indicated in the latter.
- 5) IEC and ISO do not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC or ISO are not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or ISO or its directors, employees, servants or agents including individual experts and members of their technical committees and IEC National Committees or ISO member bodies for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication of, use of, or reliance upon, this ISO/IEC publication or any other IEC, ISO or ISO/IEC publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this ISO/IEC publication may be the subject of patent rights. IEC and ISO shall not be held responsible for identifying any or all such patent rights.

The main task of IEC and ISO technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

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 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."



IEC

SOURCE: CESI

Figure 1 – Six typical features of IIoT

This is a preview of "ISO/IEC TR 30166:202...". [Click here to purchase the full version from the ANSI store.](#)

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.