ISO/IEC JTC 1 "Information technology"
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Updated SC 41 Business Plan 2025

Document type	Related content	Document date	Expected action
Project / Other	Meeting: Chengdu (China) 10 Nov 2025	2025-10-16	**COMMENT/REPLY** by 2025-11-10

Replaces: N 17600 SC 41 Business Plan 2025

Description

This document is circulated for review and consideration at the November 2025 JTC 1 Plenary.

BUSINESS PLAN FOR JTC 1/SC 41
Internet of Things and Digital Twin

September 2025

1 Executive Summary

The Internet of Things (IoT) is a system concept that uses many technologies that are standardized by other JTC 1 entities and SDOs. These technologies include sensors, actuators, networking and communications, database and big data, distributed and cloud computing, analytics, digital twins and AI technologies.

IoT systems and systems of systems are software and data intensive and can be quite complex, ranging from simple architecture to multi-tier distributed computing cyberphysical systems.

IoT systems are key enablers of 'Smart Everything' such as Smart Agriculture, Smart Health, Smart Manufacturing, Smart Energy, the Smart Grid, Smart Transportation and Smart Cities.

According to Gartner and Deloitte, a digital twin as a digital representation of a real-world entity or system. It is an evolving digital profile of the historical and current behaviour of a physical object or process. The implementation of a digital twin is an encapsulated software object or model that mirrors a unique physical object, process, organization, person or other abstraction. The digital twin is thus based on massive, cumulative, real time, real-world data measurements across an array of dimensions.

Data from multiple digital twins can be aggregated for a composite view across a number of real-world entities, such as a ship, a bridge, a building, a factory, a supply chain or a city. Mirroring is done through synchronization using data streams. The data streams are generated by sensors, but also transactions and other sources (virtual sensors).

Digital Twins (DTw) are also an enabler Smart Everything, being based on measurements that creates an evolving profile of the entity or system in the digital world, it provides important insights on system performance, leading to actions in the real world such as a change in system and process design, or optimizing business performance.

JTC 1 created SC41 with a systems committee mandate at its November 2016 plenary. SC41 inherited standards and projects from JTC 1 WG7 (sensors networks) and JTC1/WG10 (IoT). The Work Program of JTC 1/WG7 and WG10 was transferred to SC41 at the beginning of its May 2017 Plenary. SC41 has had eleven successful plenaries since then. In November 2020, JTC 1 added the mandate of the development of standards for digital twin to SC41 mandate.

SC41 has to deal with a complex and evolving ecosystem of technologies and markets, and SDOs. A system approach is thus used for standard development, with a strategic focus. Capitalizing on the excellent work done by its predecessors, SC41 has already a substantial portfolio of standards and projects, with 47 published standards as of 2024-09-10 and 30 PWI and projects.

Nineteen Exploratory Ad Hocs and Advisory groups (formerly known as 'Study Groups') have concluded since the creation of SC41many proposing New Work. SC 41 has, for the last few years, used the Preliminary Work Item (PWI) process to explore new work.

2 Chairman's Remarks

In its eight years of existence, SC41 is continuing to develop its program of work through the exploratory work of its experts and contributions from its P Members.

From a governance perspective, SC41 has put in place an operational infrastructure that is performing. It has two plenary per years to ensure proper agility in its decision-making. Its governance AG, which meets for at all its plenary and between them, is fully functional. Rapporteurs position have been created and staffed for respectively vocabulary and use-cases.

The industrial IoT (IIoT), which is driven by the convergence between operating technology (OT) and information technology (IT), is a key area for the subcommittee. SC41 has a successful joint working group with IEC TC 65, which prepares standards for industrial-process measurement, control and automation, and has also a joint Advisory Group to explore cooperative work.

Another priority is smart energy. SC41 has formed a joint working group with the IEC Systems Committee for Smart Energy and one with IEC TC 57, which standardizes power system management systems.

In the area of Digital Twin, SC41 has created a WG, WG 6 to manage its projects in this area. There are currently 3 active projects and one PWI in this area. There was strong participation to a 4-day Workshop on Digital Twin organized in partnership with the IEC Academy in September 2021.

At its May 2021 Plenary, SC41 decided to consolidate its work in underwater and maritime IoT in a new WG, WG7.

A two-day webinar, organized in cooperation with the IEC academy, was given in April 2022 to mark the 5th anniversary of SC41. More than a thousand people registered, and peak attendance was over 300. Recording and presentations of the webinar are available at https://www.iec.ch/academy/webinars/iot-and-digital-twin-standardization-isoiec-jtc1sc41-webinar.

In June 2024, another two-day webinar was given on SC 41 work on Digital Twin standardization as well as some sectorial applications. Up to 319 unique viewers were present. Recording and presentations of the webinar are available at https://www.iec.ch/academy/webinars/digital-twin-webinar.

During the SC 41 Plenary in Montréal, Québec, Canada in June 2025, a hybrid webinar was given on SC 41 work on IoT standardization, with both in-person and online participation. Recording and presentations of the webinar are available at https://www.iec.ch/academy/webinars/isoiec-jtc1sc41-hybrid-webinar-iot-standardization .

The level of interest in these webinars demonstrates the pertinence of SC 41 standards development work.

2.1 Market Requirements, Innovation

The Internet of Things (IoT) is defined in ISO/IEC 20924 as:

> *an infrastructure of interconnected entities, people systems and information resources together with services which processes and reacts to information from the physical and virtual world.*

The IoT brings value as part of a system or a system of systems. IoT systems have the following main characteristics:

- Network centric
- Distributed, and Machine to Machine (M2) driven, with various distributed computing architectures using two or more tiers (e.g. 'mist', 'swarm', 'fog', edge and cloud computing)
- Data intensive

The IoT 'objects', which range from sensors and actuators to integrated systems such as a connected vehicle or an industrial robot, can also be 'Smart'.

Some of these systems, or more precisely system of systems, are also socio-technical. An example of this is a smart city. Others, such as smart factories or autonomous vehicles, are cyber-physical in nature.

As we can see in Figure 1, the IoT is a horizontal technology that is impacting, and disrupting, many application domains in our global society. This also means that there is a wide range of requirements, both functional and non-functional (i.e. availability, resiliency...) for IoT systems. A wide range of IoT architectural patterns are thus needed to meet these diverse requirements.

Another characteristic of many IoT systems is heterogeneity. This is because of the large number of technologies that are in use and because of the large number of suppliers of IoT products and services. This characteristic is there to stay not only because of the large scope of requirements for IoT systems but also because of the continuous evolution of these technologies.

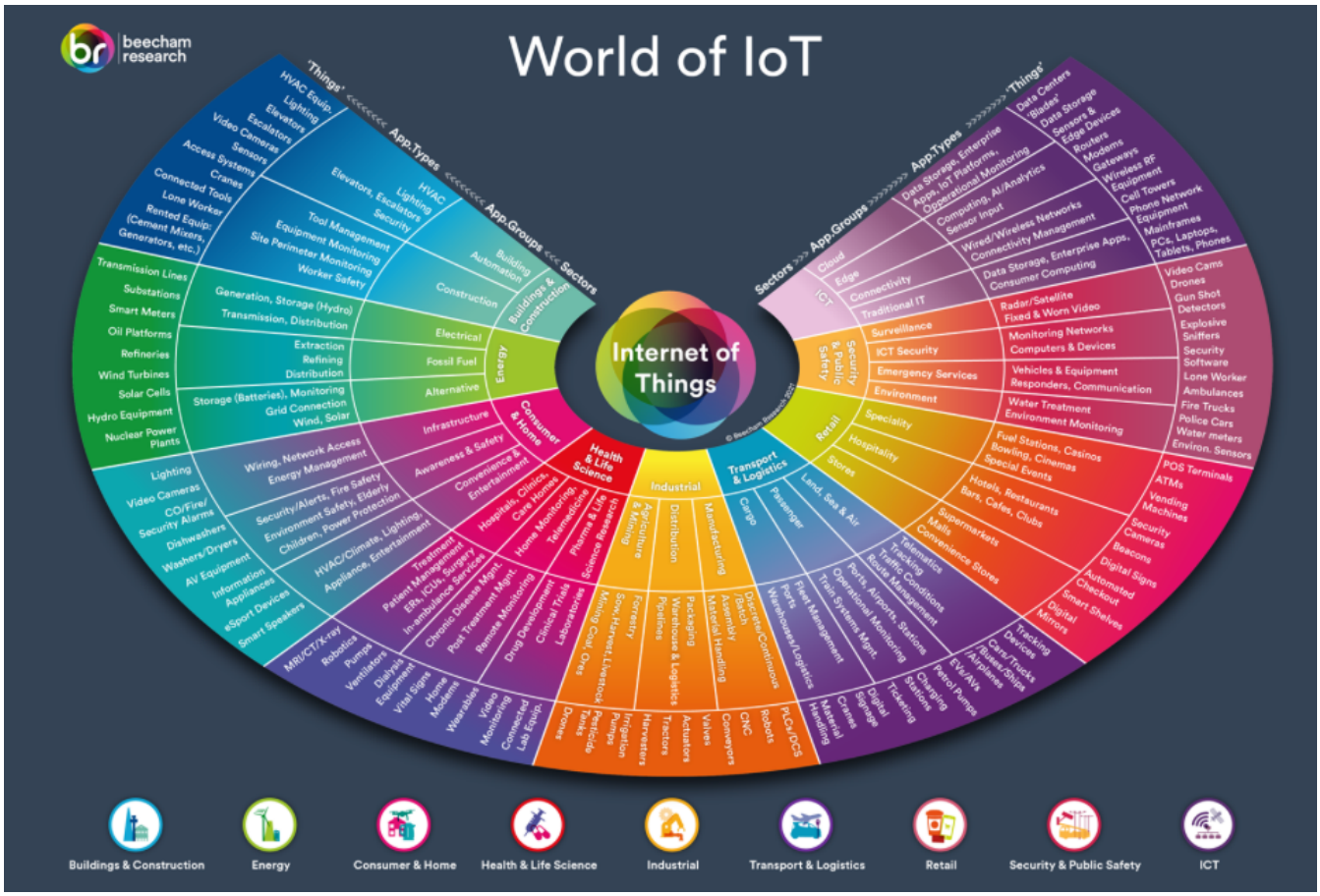

Figure 1 The horizontality of IoT

Finally, IoT systems incorporate other "smart ICT" such as Big Data and Analytics including learning systems and other artificial intelligence (AI) technologies.

This implies, for SC41:

- A strong need for horizontal and flexible foundational standards (Reference Architecture, Vocabulary)
- Challenges to get a consensus on some technical topics given the continuing evolution of the technology and the market.
- Horizontality challenged from both a technical (overlap with topics like cloud computing, security...) and application domain standpoint.
- An emphasis of 'not reinventing the wheel' given the high level of activity in SDOs and consortia.

The following principal strategic approaches are thus followed:

- Use a system approach:
  - Practice strategic planning
  - Embrace an agile approach
  - Work cooperatively with SDO's and leverage their work
  - Work cooperatively with other JTC 1, ISO and IEC entities, considering joint work
- Actively explore new areas and options with exploratory Ad Hocs and Advisory Groups.

This is why SC41 was created as a systems committee: to fulfill its mandate, it will have to work cooperatively with other JTC 1, ISO and IEC entities as well as with many SDO's.

Given the IoT characteristics that have been listed previously, SC41 needs to concentrate on technology agnostic frameworks and standards, and also to publish standards that would help bridge IoT technology with its wide range of application domain.

2.2 Accomplishments

SC41 has held two face to face (F2F) plenaries (and WGs meetings) with support for remote participation in this period on November 11-15, 2024 and June 2- 6, 2025. Attendance to these meetings was respectively 117 and 119 participants.

SC41 has, as of 2025-09, 32 participating members and 11 observing members as well as 10 A liaison. 470 experts are registered at the IEC.

The standards published by SC 41 are categorized in Figure 2.

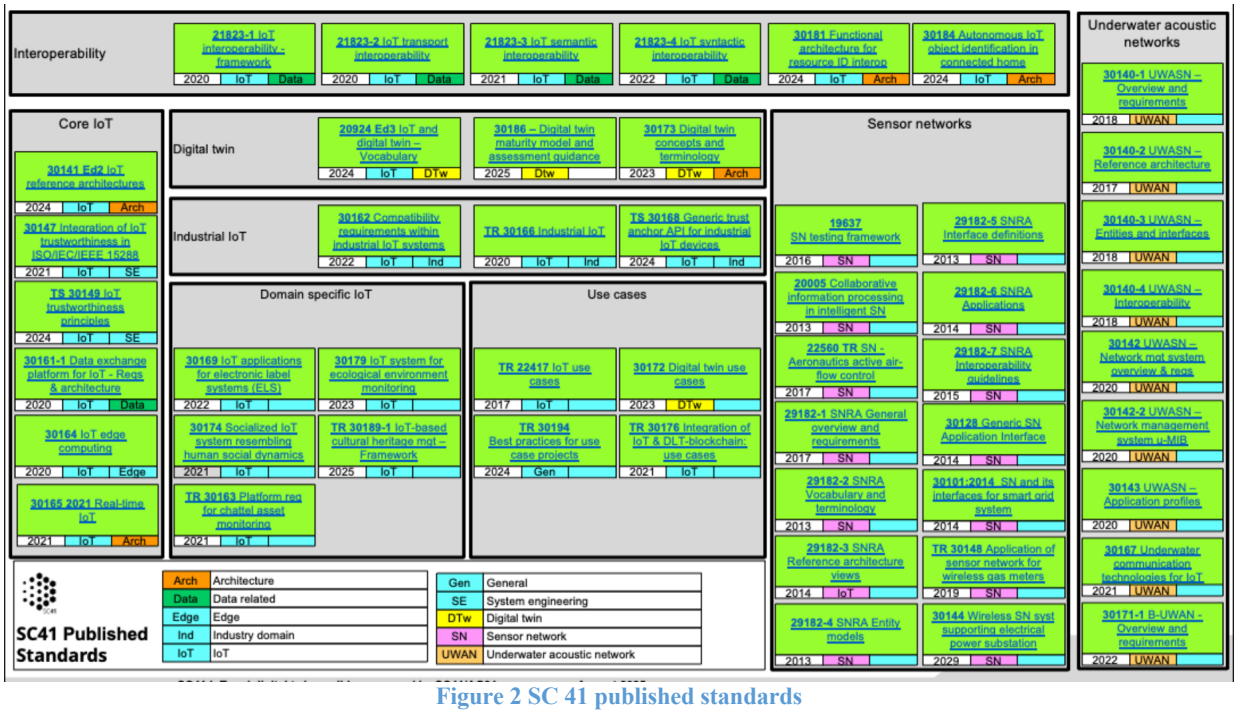

Figure 2 SC 41 published standards

2.3 Resources

SC41 has sufficient resources for its present program of work, even if this will always remain a continuous challenge. SC41 will try to leverage as much as possible the resource of other JTC 1, ISO and IEC entities as well as SDO's through cooperative work. Candidates abound when positions are open for convenorship or project editors.

2.4 Competition and Cooperation

The full SC41 Membership list, including all external and internal liaisons can be found on the IEC Web site. SC41 is making a conscious effort to increase co-operation with other standards groups by establishing an extensive network of liaisons both internal and external to JTC 1.

Noteworthy are the JWG 3 with the IEC System Committee on Smart Energy to introduce IoT and Digital Twin concepts into the smart energy domain and co-ordinate their integration into Smart Energy standardization and the JWG 27 with IEC/TC57 on IIoT applications in power management systems. 2024 saw the creation of two additional JWG: JWG 32 linked to ISO/TC 43/SC 3 and JWG33 linked to both IEC/ISO JSyC BioDigital convergence (BDC) and IEC/TC 124.

As mentioned in a recently published article on SC 41[1], Operational Technologies (OT) refers to '*hardware and software that detects or causes a change through the direct monitoring and/or control of physical devices and systems, processes, and* events'[2] in organization and industrial operations. OT systems are thus cyber-physical in nature and subject to different requirements (for availability, resiliency, and safety, for instance) as well as having to operate in sometime challenging industrial environments that are not found in traditional data processing. In ISO and the IEC, IEC/TC 65 (Industrial-process measurement, control and automation) is the principal source of horizontal OT standards.

Traditionally, OT was the domain of industrial, electrical, and later, computer engineers. OT also had its own set of standards, technologies (for instance UNIX and VMS) as well as industrial suppliers, in general distinct from the traditional IT industry. The last 20 years have seen the convergence of IT and OT, convergence that was brought by a combination of a variety of factors, one of them being the coming of age of the IoT. This convergence is associated with what is commonly called the Industrial Internet of things (IIoT), the industrial application of IoT.

This is why close cooperation between JTC 1/SC 41 and IEC/TC 65 is strategically important. A Joint Advisory Group – JAG 28 – has thus been created to clarify scope and tasks between IEC TC65 and ISO/IEC JTC1 SC41 and to find potential cooperation.

[1] F. Coallier, "IoT Standardization Strategies in ISO/IEC JTC 1/SC 41," 2022 IEEE 8th World Forum on Internet of Things (WF-IoT), Yokohama, Japan, 2022, pp. 1-6, doi: 10.1109/WF-IoT54382.2022.10152233.
[2] https://gca.isa.org/blog/it-ot-convergence-managing-the-cybersecurity-risks

The underwater IoT use, is some applications, acoustic communication technologies. To address how to minimize the environmental issues of these technologies, a partnership has been put in place with ISO/TC 43/SC 3 through a new JWG 32 titled *Maritime and Underwater IoT Effects on Environment and Ecology*.

While SC 41 has many cooperative activities related to the industrial IoT, it is lacking in the health and life sciences. Thus, the creation of a JWG 33 with the IEC/ISO Joint Systems Committee on bio-digital convergence (JSyC BDC) on *Embodied IoT Systems*. IEC TC 124 and the SyC on Active Assisted Living (AAL) have been invited to join this collaborative endeavour.

Given the large number of internal entities in liaison (See Figure 3), finding liaison officers from SC41 to these entities is a challenge.

Liaison Type	No. of Liaisons
Internal Liaisons within ISO	21
Internal Liaisons within IEC	16
Internal Liaisons within ISO/IEC JTC 1	19
External Category A	8
External Category C	7

Figure 3 SC41 Liaisons

To facilitate many of these liaisons and foster cooperative work with application sectors, two Sectorial Liaisons Groups (AGs) were created at the Yokohama plenary in November 2018, with their title and scope revised at the May 2021 plenary:

- Sectorial Liaison Group 1 (AG 20) – Industrial sector
- Sectorial Liaison Group 2 (AG 21) - Smart Cities and Utilities

Since the IoT covers a technologically wide area that is still evolving, and since it's also enabling the transformation of many application domains, many SDOs and consortia are involved in the development of standards (See Figure 4). This implies that SC41 must either work with many of these entities or ensure that its work is properly communicated.

SC 41 thus created an AG (AG 31) dedicated external liaison coordination was established with the following mandate:

- interact with liaison groups (or liaison officers where there is no liaison group) to help identify standards, organizations, and topics of interest to SC 41 (e.g. Virtual Sensors, AI, CPS, data spaces).
- maintain an understanding of such information.
- provide recommendations on how to address the impact of those standards and
- topics to SC 41; and

- present a consolidated report of activities at each SC 41 plenary.

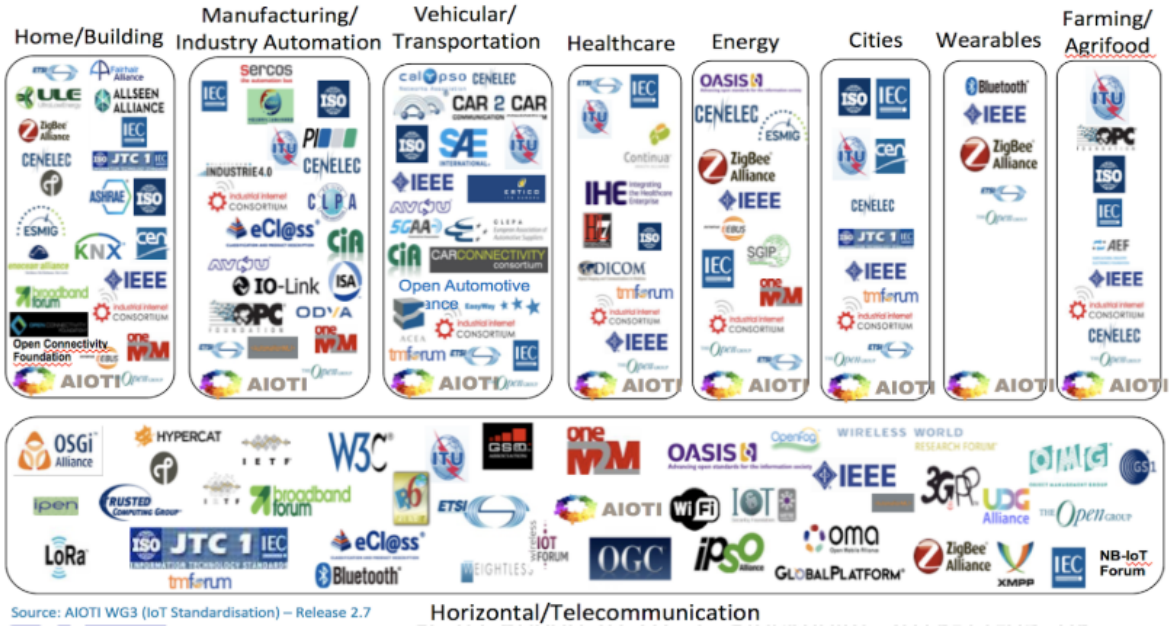

Figure 4 IoT SDOs and Alliance Landscape

3 Work Program

3.1 Structure

SC41 Work Program is done in five working groups and five joint working groups, as illustrated in Figure 5. More details can be found at https://www.iec.ch/dyn/www/f?p=103:23:5353414934081::::FSP_ORG_ID,FSP_LANG_ID:20486,25 .

These working groups operate under a governance structure that is centred on an Advisory Group (AG) chaired by the SC41 Chair and whose membership include the Committee Manager, the WG Conveners, the P members and the A liaison. As mentioned previously, two plenary and working groups meetings are held each year. The SC41 AG meets during and between each plenary.

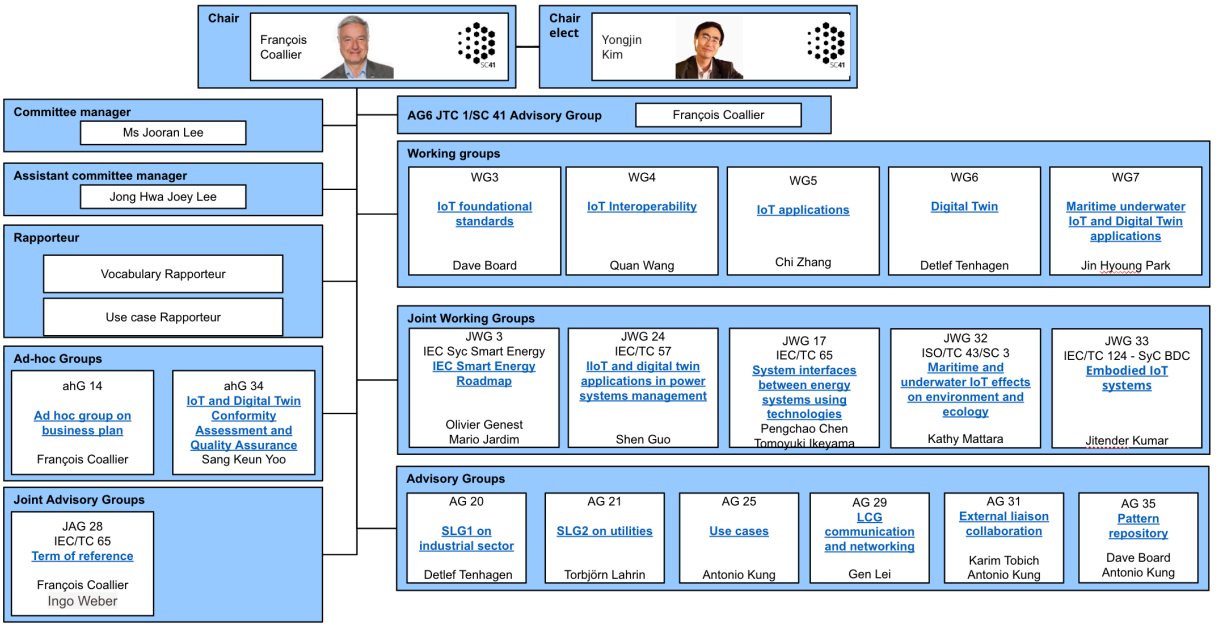

Figure 5 SC41 Structure

The current projects and preliminary work items (PWI) of SC 41 are in Figure 6.

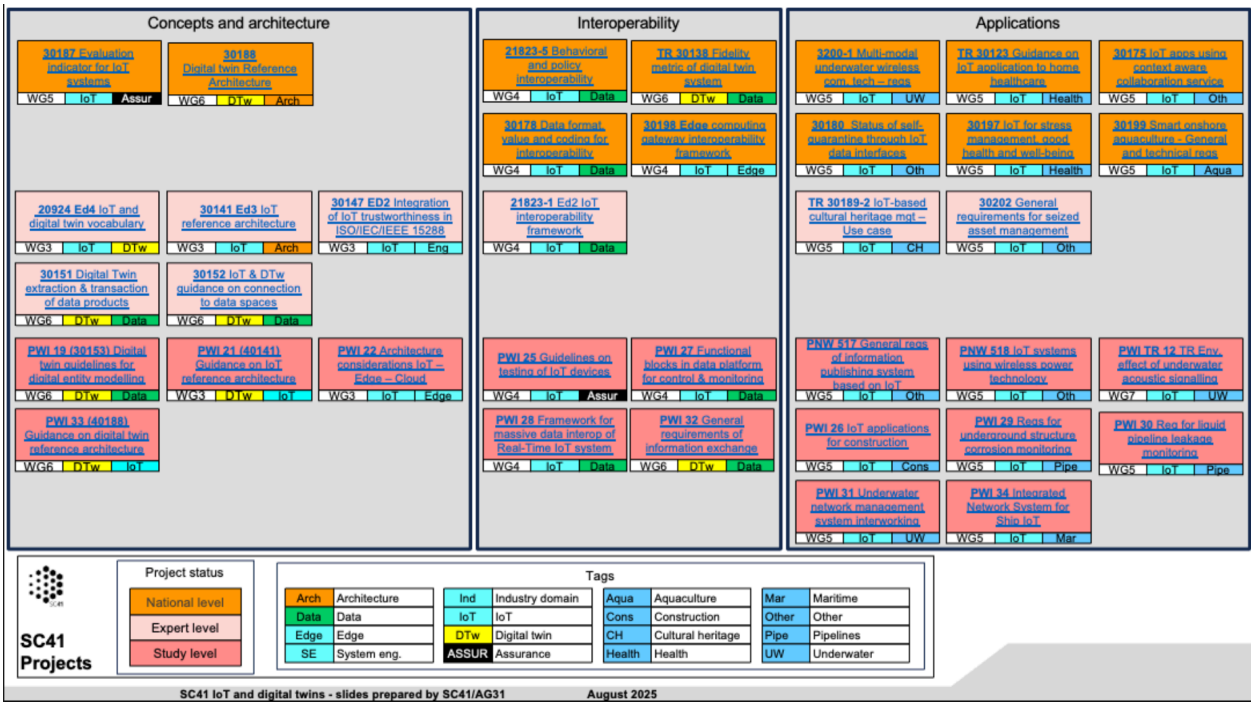

Figure 6 SC 41 Standards under development (yellow dot indicates digital twin)

As mentioned previously, IoT systems as well as digital twins are data intensive. A significant part of the data consumed by digital twins come from sensors. Thus, the need to develop an

integrated and complementary set of data management standards or, to use a more encompassing term, data space standards. Figure 7 illustrates the vision for this data space standards architecture, a vision that encompasses relevant work developed by experts from SC 7, SC 27, SC 32 and SC 38.Integration of IoT and digital twins in data spaces

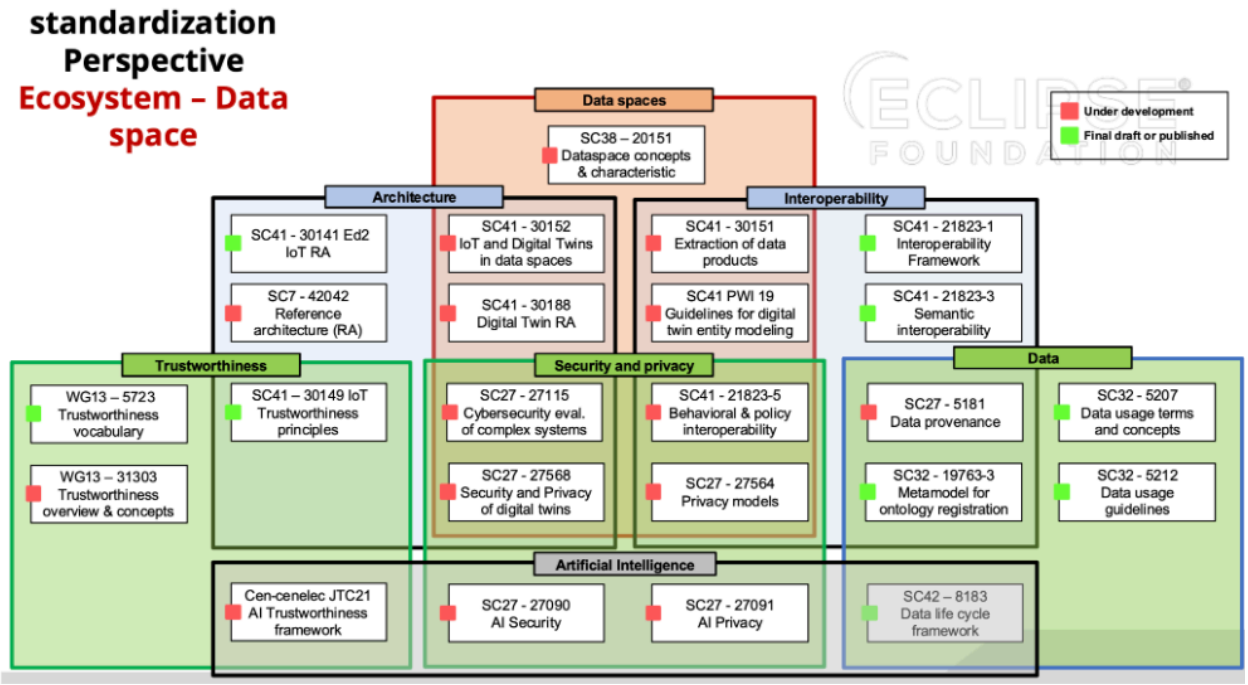

Figure 7 Integration of IoT and digital twins in data spaces as of 2024-10-21

3.2 WG3 – IoT Foundational Standards

The terms of reference of WG3 are: *Development of IoT foundational standards, including IoT and Digital Twin vocabulary*

From a horizontal point of view, JTC 1/SC 41/WG 3 will undertake standardization activities for reference architecture, frameworks, and vocabulary, in order to establish and maintain a flexible base platform. From a vertical point of view, aspects from the wide range of vertical markets are considered, and cooperation between ICT experts and vertical domain experts is an essential element of the success of this group.

Assigned Standards: 29182-1, 2, 3, 4, 5; 30141 Ed2; 20924; 30164; 30165; 30147
New Publications:
Projects: Revision of 30141 & 20924
PWIs: TR JTC1-SC41-21 (AWI) (ISO/IEC TR 40141) & TR JTC1-SC41-22

3.3 WG4 – IoT Interoperability

The terms of reference of WG4 are: *Standardization in the area of IoT interoperability, connectivity, IoT platform, middleware, conformance and testing*.

WG4's focus during the next work period is summarized as shown in Figure 8. In addition to the series of ISO/IEC 21823 standards, one objective of WG 4 is to develop interoperability standards for other topics, such as underwater acoustic sensor networks, and web-oriented architecture system model for interoperability. Moreover, WG 4 will also try to develop standards for testing, such as IoT interoperability testing and IoT conformance testing. To explore this further, WG4 has initiated study groups in these areas.

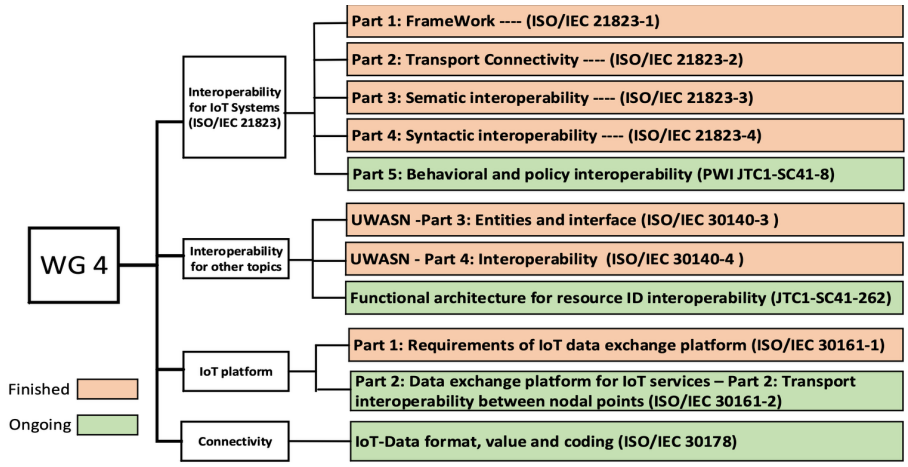

Figure 8 WG4 work program focus

Assigned Standards: 19637; 29182-7; 21823-1, 2, 3; 30161-1, 2; 21823-4
New Publications: 30181
Projects: 21823-1, 5, 30178, 30198
PWIs: TR JTC1-SC41-25, JTC1-SC41-27, JTC1-SC41-28

3.4 WG5 – IoT Applications

The terms of reference of WG5 are: *Standardization in the area of IoT applications, Uses Cases, tools and implementation guidance*.

From the horizontal point of view, SC 41/WG 5 will undertake standardization activities for IoT uses cases, tools and implementation guidance promoting interrelationships among various application domains, adapting and expanding the work of WG 3 (Architecture) and WG 4 (Interoperability). From the vertical point of view, SC 41/WG 5 will undertake standardization activities to specify a variety of applications and services per each vertical market.

Assigned Standards: 22417; 22560; 29182-6; 20005; 30101; 30128; 30144; 30148; 30163; 30166; 30174; 30176, 30162, 30169, 30179.
New Publications: 30189-1, 30184, 30180
Projects: 30123, 30175, 30187
PWIs: JTC1-SC41-26

3.5 WG6 – Digital Twin

The terms of reference of WG6 are: *Standardization in the area of Digital Twin*.

SC 41/WG 6 will undertake the development of horizontal standards for Digital Twin (DTw) foundational standards.

Assigned Standards: 30173
New Publications: 30194, 30186
Projects: 30138, 30151, 30152, 30172, 30188
PWIs: JTC1-SC41-19, JTC1-SC41-32, JTC1-SC41-33

3.6 WG7 – Maritime, underwater IoT and Digital Twin Applications

The terms of reference of WG7 are: *Standardization in the application of Internet of maritime, underwater and inland waterways things, digital twin and related technologies*.

SC 41/WG 7 will undertake standardization activities for IoT and digital twin horizontal standards for maritime applications.

Assigned Standards: 30140-1, 2, 3, 4; 30142; 30143; 30167, 30171-1, 30171-2,
New Publications: 30177, 30183, 30185
Projects: 3200-1
PWIs: JTC1-SC41-31

3.7 JWG17 – System interfaces between energy systems using operational technologies managed by IEC/TC 65

This work will identify, profile and extend where needed, the standards needed to allow industrial facilities, and the industrial automation systems within such industrial facilities, to communicate with energy systems for the purpose of planning, negotiating, and managing the flow of related information between them..

Assigned Standards: IEC 62872-1,2
Publications:
Projects: 65353, 63655-1, 63657-2
PWIs: JTC1-SC41-34

3.8 JWG3 – IEC Smart Energy Roadmap, managed by SyC Smart Energy

Map the main Use Cases over the relevant systems architectures within the Smart Energy domain. This includes:

- Provide guidelines in offering standard users ways to select a most appropriate set of standards/specifications (either existing or coming, from IEC but possibly coming from other bodies) fulfilling the set of Use Cases. This includes the breakdown of Smart Energy scope into typical systems and system architectures.
- *Work with ISO/IEC JTC1 SC41 to introduce IoT and digital twin concepts into the smart energy domain and co-ordinate their integration into Smart Energy standardization.*
- Identify and rank possible standard gaps/overlaps/recommendations
- Feed the IEC Smart Energy mapping tool with the above findings

3.9 JWG24 – IIoT and digital twin applications in power systems management managed by IEC/TC 57

To develop Industrial Internet of Things (IIoT) and digital twin standards for applications in power distribution systems management

Projects: IEC TR 63353

3.10 JWG32 – Maritime and Underwater IoT Effects on Environment and Ecology linked to ISO/TC 43/SC 3

Development of AWI (Approved Work Item) on Internet of Things (IoT) – Environmental and ecological effects, risks, and considerations of underwater acoustic signalling.

Projects: PWI TR JTC1-SC41-12

3.11 JWG33 – Embodied IoT Systems, linked to IEC/ISO JSyC bio digital convergence and IEC/TC 124 Wearable electronic devices and technologies.

Standardization for embodied IoT Systems. Embodied IoT Systems are based on the embodied computing paradigm, also known as body-centred computing. This is ‘a paradigm on the merging of information technology and an organism’. This includes wearable, implantable and ingestible devices as well as bionics. Ref: https://www.iec.ch/basecamp/bio-digital-convergence-standardization-opportunities

Projects: ISO/IEC 30197 ED1