D6.1 STANDARDIZATION PLAN

Olga Radchuk, Austrian Standards International

@AshvinH2020
ASHVIN H2020 Project
www.ashvin.eu

ASHVIN has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 958161. This document reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains.

Project Title	Assistants for Healthy, Safe, and Productive Virtual Construction Design, Operation & Maintenance using a Digital Twin
Project Acronym	ASHVIN
Grant Agreement No	958161
Instrument	Research & Innovation Action
Topic	LC-EEB-08-2020 - Digital Building Twins
Start Date of Project	1st October 2020
Duration of Project	36 Months

Name of the deliverable	Standardization Plan
Number of the deliverable	D6.1
Related WP number and name	WP 6 Social Innovation and Standardization
Related task number and name	T6.1 Standardization Plan
Deliverable dissemination level	PU
Deliverable due date	31-03-21
Deliverable submission date	12-04-21
Task leader/Main author	Olga Radchuk (Austrian Standards International) Karl Grün (Austrian Standards International)
Contributing partners	Timo Hartmann (TU Berlin) Rahul Tomar (DigitalTwin Technology GmbH) Lorenz Haspel (Schlaich Bergermann Partner) Sasa Klopanovic (Mainflux Labs) Ken Gavin (InGEO) Rogier Jongeling (PlanB) Rolando Chacón (Technical University of Catalonia)
Reviewer(s)	João Gonçalves (Erasmus University Rotterdam) Jorge Campos (Erasmus University Rotterdam) Rogier Jongeling (PlanB) Vasilis Papanikolaou (Australo)

ABSTRACT

The Standardization Plan provides an overview of the future standardization activities based on the needs of the Ashvin project consortium in the area of real-time digital representation and modelling of a building site to be undertaken during and after the end of the project. This

document serves as a guide for the project partners on how to implement such activities within their tasks and work packages, as well as how research conducted within the Ashvin project can support ongoing standardization efforts.

This Plan is drafted by Austrian Standards International (ASI) in collaboration with Berlin Technical University (TUB), Centre for Research & Technology Hellas (CERTH), Mainflux Labs (MFL), Erasmus University Rotterdam (EUR), Ingeo (NGEO), Polytechnic University of Catalonia (UPC), Infra Plan Consulting (INFCON), Plan B (PlanB), Australo (AUS), Digital Twin Technology (DTT), NCC Sverige (NCC), Fasada (FAS) and SBP GmbH (SBP).

It provides an overview of the relevant standards identified during the investigation of the standardization landscape, lists the gaps identified as a result of gap analysis, and summarizes the priority topics to be addressed within the future standardization activities. It covers topics of wide importance for all spheres of building and construction, including application of a digital twin approach for construction works, building site management and real-time monitoring, construction data transfer and assessment, as well as ensuring safe work conditions for construction workers.

KEYWORDS

digital twin, construction industry, building modelling, building management, building monitoring, continuous monitoring, construction visualization, building simulation, worker protection, worker safety, worker privacy

REVISIONS

Version	Submission date	Comments	Author
v0.1	16.03.2021	First draft of the Standardization plan	Olga Radchuk, Karl Grün, Stefan Wagmeister (ASI)
v0.2	30.03.2021	Second draft of the Standardization Plan	Olga Radchuk, Karl Grün (ASI)
v0.3	09.04.2021	Final draft of the Standardization Plan	Olga Radchuk, Karl Grün (ASI)

DISCLAIMER

Commission cannot be held responsible for any use which may be made of the information contained.

ACRONYMS & DEFINITIONS

AEC	Architecture, Engineering and Construction
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CWA	CEN and/or CENELEC Workshop Agreement; standardization deliverable from a CEN and/or CENELEC workshop
DT	Digital Twin
EN	European Standard adopted by CEN or CENELEC
ESO	European Standardization organization (CEN, CENELEC and ETSI)
ETSI	European Telecommunications Standards Institute
IEC	International Electrotechnical Commission / International standard developed by IEC
IFC	Industry Foundation Classes
IoT	Internet of Things
ISO	International Standardization Organization / International standard developed by ISO
ITU	International Telecommunication Union
KPI	Key Performance Indicators
NSB	National Standardization Body
NWIP	New Work Item Proposal: a proposal for a new work item, submitted to a Technical Body (TC or SC) of a Standards Development Organisation for approval
TC	Technical Committee established with a clearly specified scope to approve NWIP and to manage its work programme.
SC	Subcommittee, under a TC; frequently in large ISO/TCs or IEC/TCs but being phased out in CEN and CENELEC. SCs operate more independently than WGs
SDO	Standards Development Organization
SME	Small and Medium Enterprise
TR	Technical report developed by CEN, CENELEC, ISO or IEC
TS	Technical specification developed by CEN, CENELEC, ISO or IEC
WG	Working Group to which work is allocated by a TC or SC based on an approved new work items (NWI) and drafting standardization deliverables; decisions are not taken on WG-level but on TC- or SC-

	level.
WI	Work item; specifies among other the title, scope and necessary expertise for developing a standardization deliverable; the idea can also already be deposited at preliminary work item, which is further developed into a first full draft before it is activated
WTO TBT	World Trade Organization's Technical Barriers to Trade

ASHVIN PROJECT

ASHVIN aims to enable the European construction industry to significantly improve its productivity, while reducing cost and ensuring absolutely safe work conditions, by providing a proposal for a European wide digital twin standard, an open-source digital twin platform integrating IoT and image technologies. In addition, ASHVIN will also provide with a set of tools and demonstrated procedures to apply the platform and the standard proven to guarantee specified productivity, cost, and safety improvements. The envisioned platform will provide a digital representation of the construction product at hand and allows to collect real-time digital data before, during, and after production of the product to continuously monitor changes in the environment and within the production process. Based on the platform, ASHVIN will develop and demonstrate applications that use the digital twin data. These applications will allow it to fully leverage the potential of the IoT based digital twin platform to reach the expected impacts (better scheduling forecast by 20%; better allocation of resources and optimization of equipment usage; reduced number of accidents; reduction of construction projects). The ASHVIN solutions will overcome worker protection and privacy issues that come with the tracking of construction activities, provide means to fuse video data and sensor data, integrate geo-monitoring data, provide multi-physics simulation methods for digital representing the behavior of a product (not only its shape), provide evidence-based engineering methods to design for productivity and safety, provide 4D simulation and visualization methods of construction processes, and develop a lean planning process supported by real-time data. All innovations will be demonstrated on real-world construction projects across Europe. The ASHVIN consortium combines strong R&I players from 9 EU member states with strong expertise in construction and engineering management, digital twin technology, IoT, and data security / privacy.

TABLE OF CONTENTS

1 INTRODUCTION 9

1.1 Deliverable Context 9
1.1.1 Objectives of the WP6 Social Innovation and standardization 9
1.1.2 Objectives of the Task 6.1 Standardization Plan 9
1.1.3 Deliverable interdependencies 9
1.1.4 Purpose of the Deliverable 6.1 10

1.2 Standardization: An overview 10

1.3 Methodology 13
1.3.1 Overview of the standardization landscape 13
1.3.2 Analysis of standardization gaps and needs 13

2 STANDARDIZATION LANDSCAPE 15

2.1 Formal standards 15

2.2 Non-formal standards 15

3 STANDARDIZATION GAPS AND NEEDS 16

3.1 Survey results 16

3.2 Standardization focus points for the ASHVIN consortium 21

4 CONCLUSION 26

5 REFERENCES 27

ANNEX 1: GAP ANALYSIS SURVEY WITH RESPONSES 28

ANNEX 2: LIST OF IDENTIFIED FORMAL STANDARDS 35

ANNEX 3: LIST OF IDENTIFIED NON-FORMAL STANDARDS 115

INDEX OF FIGURES

Figure 1 22
Figure 2 22
Figure 3 23
Figure 4 31
Figure 5 32
Figure 6 33
Figure 7 34

1 INTRODUCTION

1.1 Deliverable Context

The current deliverable is the first out of five deliverables that will be developed within WP6. The deliverable is the result of the Task 6.1 Standardization Plan.

1.1.1 Objectives of the WP6 Social Innovation and standardization

WP6 is focused on the creation of a sustainable impact through a variety of future innovative solutions to be developed within the ASHVIN project, including standardization deliverables to be applied by the market, and new privacy-focused practices within the building and construction industry.

The general objectives of WP6 are:

1. Elaborate and implement a standardization plan based on the relevant formal and non-formal standards – existing or under development
2. Develop a set of concrete recommendations for the future standardization deliverable for Digital Building Twins at a European scale towards the end of the project
3. Determine innovative solutions that enhance and preserve workers' data and privacy while efficiently reducing workplace risks

1.1.2 Objectives of the Task 6.1 Standardization Plan

The objectives of Task 6.1 are:

1. Identify and provide an overview of the formal and non-formal standards applicable for Digital Building Twins (existing and under development)
2. Evaluate the relevant standards against the needs of the project partners
3. Elaborate a standardization plan reflecting the partners' needs and update the plan annually

1.1.3 Deliverable interdependencies

The standardization plan is developed taking into consideration the findings from the following Work Packages:

1. WP1 IoT driven digital twin platform: development of common semantic data models
2. WP2 Design for productivity and safety: establishment of evidence-based design practices based on historical digital twin data
3. WP3 Data fusion for real-time construction monitoring: development of novel algorithms for transferring the necessary features from the real world to the simulated reality
4. WP4 Control and real-time simulation of construction: development of visualizations, simulation management dashboard and applications, as well as progress controlling solutions
5. WP5 Digital twin based structural monitoring and asset management: development of measurements, calculations, prediction and decision-making KPIs; integration of spatially distributed assets into the ASHVIN platform

Consequently, this deliverable will provide inputs into the WP8 Communication, Dissemination and Exploitation.

This ensures that the Standardization Plan is developed in line with other project activities, represents the interests of the consortium members, and addresses the relevant stakeholders outside of the consortium. In addition, it provides a structured framework for the sustainable exploitation of ASHVIN solutions after the end of the project.

In addition, the Standardization Plan enables a quick market adoption of the project results. Trust into and acceptance of any proposed solution to facilitate the construction processes at the building site, as well as ensure privacy and protection of workers' data is directly related to its compliance to standards, which guarantees the reliability and interoperability of such solution.

1.1.4 Purpose of the Deliverable 6.1

The purpose of the D6.1 Standardization Plan is to address the first objective of the WP6. The deliverable elaborates and implements a Standardization Plan, based on the relevant standards (existing or under development), and provides the other WPs input for further exploitation. This will ensure that project results are aligned with current regulations and on-going standardisation activities.

The Standardization Plan outlines the standardization roadmap for application of the Digital Twin concept in building and construction sector, based on the investigation of the standardization landscape, the standardization gaps identified using an online survey, and on the standardization needs of ASHVIN consortium partners. Its final goal is to pave the way for a possible future European standard addressing Digital Twin technology in building, bridge, and industrial construction. This will contribute to the development of unified practices in the construction industry.

1.2 Standardization: An overview

In ISO/IEC Guide 2:2004[1], standardization is defined as an activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context. Important benefits of standardization are improvement of the suitability of products, processes and services for their intended purposes, prevention of barriers to trade and facilitation of technological cooperation. Standardization supports the social and economic development by ensuring safety, quality and competitiveness of products, services and processes on various levels (e.g. performance, composition, interoperability, applicability and many more). This in turn supports economic activity of businesses of all sizes and allows them access markets all over the world.

Standardization is governed by the principles of consensus, openness, inclusiveness transparency, national commitment and coherence as outlined in the Agreement on Technical Barriers to Trade of the World Trade Organisation (WTO TBT Agreement)

[1] ISO/IEC Guide 2:2004, Standardization and related activities — General vocabulary, is adopted in Europe as European Standard EN 45020:2006.

and in Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation.

The output of standardization is standards. According to ISO/IEC Guide 2:2004, a standard is a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. Standards are voluntary in their application and should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits. Standards are initiated and drafted by stakeholders such as industry, incl. SMEs (Small and Medium Enterprise), public authorities, research organisations, societal and environmental stakeholders, consumer organisations, trade unions and conformity assessment bodies.

There are numerous organizations developing standards, ranging from companies, consortia and industry in the private sector, to national, regional and international organizations. The latter three constitute the bulk of the international standardization system, required by the WTO TBT Agreement to follow its principles and requirements for standards development. There are also NGOs with specific socio-economic or environmental goals that develop and publish standards.

National Standardization Bodies (NSB) are standardization organizations located in each country. They bridge the local communities with groups of relevant stakeholders outside of their country and represent the pillars of the European and International standardization. Being member of European Standardization Organisations NSBs are obliged to implement European Standards as national standards and withdraw any conflicting national standards.

The European standardization activities are conducted within the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC), and the European Telecommunications Standards Institute (ETSI).

CEN brings together the national standardization bodies of 34 European countries and provides a platform for standardization in various areas, including products, materials, services, and processes. CENELEC ensures standardisation in the electro-technical engineering field, and ETSI produces standards for information and communications technology.

The network of European standardization includes more than 200.000 experts from different countries and from the different stakeholders, i.e. business, industry and commerce, service providers, consumers, environmental and societal organisations, public authorities and regulators, as well as other public and private institutions. The European Standardization Organisations aim to support needs of the market and of different stakeholders, promoting the European Standardization System and leading the implementation of best practice in standardization around the world. They collaborate with key stakeholders' organisations at national, European and international level, support international Standardization and cooperate closely with international Standardization Organisation such as ISO and IEC. Participation in European Standardization follows the national delegation principle, i. e. national members (NSB, NC) host national committees populated with national stakeholders and these national committees contribute to the elaboration of European Standards.

International standardization activities are conducted in three major international standardization organisations: International Organization for Standardization (ISO), International Electrotechnical Commission (IEC) and International Telecommunication Union (ITU).

ISO is an independent international organization that includes 165 national standards bodies as its members. International standards, produced by ISO, cover a wide variety of areas and represent consensus of experts from many countries. All CEN members are also members of ISO.

Members of IEC are 89 National Committees, represented by delegates from industry, research and government bodies of each country. IEC produces standards covering all aspects of production and use of electrical and electronic devices and systems. All CENELEC members are also members of IEC.

CEN and CENELEC have dedicated agreements with ISO and IEC, promoting the benefits of the international standards to international trade and markets harmonization. The high level of convergence between the European and international standards is facilitated by the ongoing technical cooperation between CEN and ISO (Vienna Agreement) and between CENELEC and IEC (Frankfurt Agreement). The main objectives of these agreements are to provide a

- framework for the optimal use of resources and expertise available for standardization work;
- mechanism for information exchange between international and European Standardization Organizations (ESOs) to increase the transparency of ongoing work at international and European levels.

Standards developed under these Agreements have the status of an International Standard as well as of an European Standard (EN ISO, EN IEC). Example: EN ISO 12006-3, Building construction - Organization of information about construction works - Part 3: Framework for object-oriented information.

ITU is an inter-governmental organization belonging to the United Nations and develops technical standards that facilitate the use of public telecommunication services and systems for communications in the area of ICT. Its membership comprises nearly 200 countries and almost 800 private-sector entities and academic institutions.

Participation in International Standardization of ISO and IEC follows the national delegation principle, i. e. national members (NSB, NC) host national committees populated with national stakeholders and these national committees contribute to the elaboration of International Standards.

A vast array of normative documents is classed under the generic label of "private standards". Generally, a normative document developed and published by an organization outside of the recognized standards development organizations at national, regional or international level is considered to be a private standard. There is not only a vast range of private standards (and growing in number), there are also significant differences between the bodies and organizations that develop these standards related to such aspects as governance, development approach, stakeholder engagement, transparency, and consensus. Some of these Private Standards Development Organisations liaise with recognized standards development

organizations. For instance, buildingSMART International liaises with ISO/TC 59/SC 13, *organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)*, and OGC, the Open Geospatial Consortium, liaises with the same ISO/TC 59/SC 13 as well as with other TCs of ISO such as ISO/TC 211, *Geographic information/Geomatics*. The same applies for OASIS which Message Queuing Telemetry Transport (MQTT) specification is adopted by ISO as ISO/IEC 20922:2016, *Information technology — Message Queuing Telemetry Transport (MQTT) v3.1.1*.

1.3 Methodology

1.3.1 Overview of the standardization landscape

The content of the overview of the standardization landscape is based on a combination of resources, derived from standards databases of the European Committee for Standardization (CEN), International Electrotechnical Commission (IEC), The International Organization for Standardization (ISO), IEEE (Institute of Electrical and Electronics Engineers), as well as contributions from the consortium partners (mainly covering non-formal standards). The final standardization landscape covers thus European and international standardization communities.

Initial literature review on the topic of building and construction with a special focus on the Digital Twin approach was conducted by Austrian Standards International. The overall areas of focus were first identified (building and construction management, Building Information Modelling, Internet of Things, Artificial Intelligence, privacy, data management, geographic information), followed by further classification according to the scope of the relevant standardization committees (e.g. Digital Twin, geospatial modelling, image processing, environmental data presentation, housing performance).

The database search for the D6.1 Standardization Plan was performed using the following keywords: digital twin, construction industry, building modelling, building management, building monitoring, continuous monitoring, construction visualization, building simulation, worker protection, worker safety, worker privacy. This list will be expanded towards the end of the project for the D6.2 Recommendations and options for future standardisation for Digital Building Twins at a European scale with the following keywords: scheduling, IoT, BIM, lean construction.

After the list of relevant standards was completed, the consortium partners were asked to identify and mark the standards relevant for each WP.

1.3.2 Analysis of standardization gaps and needs

A survey in the English language has been developed at Austrian Standards International in order to collect missing standardisation elements and identify as many gaps as possible with the help of the project consortium. Many areas of the building and construction process with regard to the Digital Twin approach are not covered by standards. Therefore, gaps in such areas can be detected by various experts from the ASHVIN consortium.

The survey aimed to:

1. Identify the standards, regulations and frameworks used by the respondents

2. Understand the shortcomings of the available standards, related to the Digital Twin technologies and applications in the construction industry
3. Understand the most important technical barriers behind the Digital Twin approach in building, including workers' safety and data security issues
4. Reveal the areas that are lacking adequate standardisation from the point of view of the respondents
5. Identify any information (gaps) that the mentioned documents miss from the point of view of the respondents

The survey was intended to provide qualitative information on standardisation gaps and mostly contains open-ended and multiple choice-questions. To cover all necessary legal aspects, the survey was complemented by an informed consent section, which was part of the survey and was presented to the respondent before the start. No personal information (i.e. name, e-mail address or phone number) was gathered, the respondents were only asked to name the organization they work in.

Austrian Standards International distributed the survey among the ASHVIN consortium members, who forwarded the link to their external partners in order to collect the largest possible spectrum of information.

The survey has been published online on 21.12.2020; the link to the survey was distributed on the same day. The deadline was set 18.01.2021, but the survey remains open in order to collect any possible inputs that could be provided later.

2 STANDARDIZATION LANDSCAPE

In total, 293 relevant standardization deliverables have been identified so far, comprised of 287 formal and 6 non-formal standards.

2.1 Formal standards

At ISO, we have identified 190 relevant standards (among them, 50 standards developed in collaboration with IEC). Of special relevance for the project were the following TCs:

1. ISO/TC 10/SC 10 Process plant documentation
2. ISO/TC 59 SC 13 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)
3. ISO/TC 59/SC 14 Design life
4. ISO/TC 59/SC 15 Framework for the description of housing performance
5. ISO/TC 59/SC 16 Accessibility and usability of the built environment
6. ISO/TC 59/SC 17 Sustainability in buildings and civil engineering works
7. ISO/TC 159/SC 4 Ergonomics of human-system interaction
8. ISO/TC 184/SC 4 Industrial data
9. ISO/TC 211 Geographic information/Geomatics
10. ISO/TC 258 Project, programme and portfolio management
11. ISO/IEC JTC 1 Information technology
12. ISO/IEC JTC 1/SC 24 Computer graphics, image processing and environmental data representation
13. ISO/IEC JTC 1/SC 41 Internet of Things and digital twin
14. ISO/IEC JTC 1/SC 42 Artificial intelligence

At IEC, we have identified 2 standards in the IEC TC 3 Documentation, graphical symbols and representations of technical information.

At CEN, we have identified 67 standards in the following TCs:

1. CEN/WS Smart CE marking for the construction industry
2. CEN/TC 169 Light and lighting
3. CEN/TC 247 Building Automation, Controls and Building Management
4. CEN/TC 250/SC 7 Eurocode 7: Geotechnical design
5. CEN/TC 442 Building Information Modelling (BIM)

Finally, at IEEE 2 relevant standards were identified in the area of Internet of Things and Electric Power Systems in Commercial Buildings.

The formal standards are summarized in **ANNEX 2**.

2.2 Non-formal standards

We have identified 5 non-formal standards, developed by ETIM International, GS1, COB Platform and The European Parliament and the Council of the European Union. Apart from that, a number of National Building Codes of all EU countries are developed on a national level.

The non-formal standards are summarized in **ANNEX 3**.

3 STANDARDIZATION GAPS AND NEEDS

3.1 Survey results

10 participants have provided their responses. All of them contained answers to all questions, no partly filled surveys have been recorded. All responses are presented in **ANNEX 1**.

Question 2: What are the major shortcomings of existing Digital Twin applications for building and construction?

10 informative answers were provided to this question. The core shortcomings were identified as follows:

1. Building lifecycle stage: concentration on building operation rather than on the building design and construction phase.
2. Building functionality: concentration on 3D-representation and reconstruction rather than on representation of physical and business processes.
3. Lacking integration of 3D-representation with IoT-based sensors and platforms to process real-time data.
4. Lacking integration of real-time data processing with information models.
5. Limited application of the Digital Twin approach in building and construction practice, including geotechnical engineering, safety management, productivity, resource management, smart scheduling, real-time asset monitoring in the operational phase and during the disposal phase of the building.
6. Lacking standardization across the processes within the Digital Twin approach: use of different standards for data modelling or data exchange, disconnection between the different specialized software.
7. Excessive simplicity of the software and its libraries available on the market which hinders in-depth analysis of building processes.

Question 3: What are the main barriers for ensuring an unambiguous, reliable data exchange between the building site and its digital presentation?

10 informative answers were provided to this question. The main barriers named by the respondents can be classified into three major groups: limited technical, methodological and organizational capabilities of the entities that apply the Digital Twin approach.

1. Technical aspects:
    a. poor Internet connectivity
    b. limited computer power
    c. lack of a clear data delivery specification and a process to apply such a specification
    d. lack of accessible tools to reliably saturate the model with the necessary information on daily basis
    e. lack of a secure distributed data sharing platform (e.g. large IoT platform that provides data broker and shared databases)
    f. need to accommodate different technologies (e.g. wristband, RFID, site image or video) for the acquisition of data to be fed into the Digital Twin

system as well as for the representation of data within the Digital Twin System

2. Organizational aspects:
    a. lack of experienced and appropriately trained personnel to apply the Digital Twin approach
    b. lack of knowledge about the advantages of the Digital Twin approach
    c. presence of confidentiality issues between all the entities participating in the construction process
3. Methodological aspects:
    a. lack of specific standards for the Digital Twin approach
    b. lack of an appropriate approach to reveal possible quality deficiencies
    c. possible delays in the construction process caused by the introduction of data capture systems

Question 4: What kind of impact do you expect for the planned Digital Twin platform to have on the future development of the BIM field?

10 informative answers were provided to this question. The expected impact included the following achievements:

1. Popularization of BIM requirements in tenders, which will influence the development of as-built information models and their parameterization
2. Development of a set of tools that applies Digital Twin data to:
    a. inform site management and asset management
    b. provide insights into the design of future projects applying the Digital Twin approach
    c. develop methods and algorithms for behavioural mapping of the real world
    d. elaborate an approach to ensure privacy during data collection
3. Development of software able to represent Digital Twin in a 4D platform and visualize the whole building lifecycle (design, construction and maintenance) in a video format, which makes any stage of the construction process accessible at any time
4. More precise information modelling, data exchange and real-time simulations based on data coming from sensors deployed in construction sites, which result in a predictive Digital Twin
5. A holistic understanding of all three phases of a structured building lifecycle (design, construction, maintenance)
6. More efficient project management and decision making
7. Improvement of collaboration between all parties involved (designer, construction company, owner)
8. Improvement of maintenance and asset management
9. Wider adoption of the Digital Twin approach by non-experts (including the application outside of BIM area) due to its simplification.

Question 5: Which KPIs best reflect the application of the Digital Twin approach for building and construction?

10 informative answers were provided to this question. The most important KPIs were defined as following:

1. Quality, including:
    a. number of defects
    b. number of defects due to workmanship
    c. time to rectify defects
    d. number of site inspections conducted
    e. ratio of the number of inspections passed to total number of inspections
    f. total cost of rework
    g. customer satisfaction
    h. prediction of failures (e.g., damaged components)
    i. real-time monitoring (e.g., concrete curing)
    j. cost predictability and reduction
    k. percentage of equipment downtime
    l. change orders
    m. return on investment
    n. level of digitalization or potential digitalization of the design
2. Employee retention, including:
    a. worker satisfaction
    b. training completion percentage rate
    c. turnover rate
3. Safety at the construction site, including:
    a. safety/incident rate
    b. number of safety meetings/communications
    c. number of accidents per supplier
    d. reaction to accidents
4. Production efficiency (e.g, percentage of equipment downtime)
5. Usability
6. Data handling
7. Level of automation the KPIs are maintained at and applied in the construction process, including higher number of connected devices and sensors (level of monitorization on site)

Question 6: What aspects limit the application of the Digital Twin approach in the construction process?

10 informative answers were provided to this question. The key limitations were defined as following:

1. Large amount of data transferred
2. Method of data transfer (some methods are more prone to transmission interference caused by e.g., steel and water)
3. Low durability of IoT sensors
4. Privacy
5. Internet connectivity
6. Lack of tools that provide managerial insights from digital twin data
7. Lack of an easy-to-use and comprehensive platform that includes both IoT platform integration and BIM platform integration

8. Lack of acceptance of the Digital Twin technology by all parties involved
9. Lack of expertise and experience among the technology users
10. Lack of knowledge about the whole span of functionality offered by the Digital Twin approach
11. A number of legal issues associated with the Digital Twin approach (e.g., data security and ownership)
12. Slow improvement of commercial software
13. Real-time data acquisition
14. Technical challenges in monitoring the construction site

Question 7: In your opinion, is safety of construction workers comprehensively addressed by the current IoT developments?

10 informative answers were provided to this question. All respondents indicated that safety of construction workers is not addressed comprehensively. They suggested the following improvements:

1. Introduce sensors that could control of access to restricted zones, ensuring that only workers with relevant permissions, and valid safety trainings have access to dangerous locations.
2. Introduce appropriate safety management tools
3. Use robots within construction environment that can move around independently
4. Ensure better integration of the Digital Twin and information models
5. Establish real KPIs to deliver real measures of safety
6. Ensure an appropriate feedback loop in the Digital Twin approach
7. Address workers' privacy concerns within the Digital Twin approach

Question 8: Do you apply any standards related to Digital Twins in your work efforts? If yes: Which of the following areas do these standards cover (Product, Process, Data structure, Data exchange, Organization, other)?

10 informative answers were provided to this question. Only four respondents (40%) stated that they apply standards in their work. These standards cover the following areas:

1. Product
2. Process
3. Data structure
4. Data exchange
5. Organization

Question 9: Please list the standards that you use the most

8 informative answers were provided to this question. The formal standards used by the respondents include:

1. ISO 12006 series "Building construction - Organization of information about construction works"

2. ISO 15926 series "Industrial automation systems and integration—Integration of life-cycle data for process plants including oil and gas production facilities",
3. ISO 19650-1 Organization and digitization of information on buildings and structures, including building information modeling (BIM) - Information management using building information modeling - Part 1: Concepts and principles
4. ISO 19650-2 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 2: Delivery phase of the assets
5. ISO 21500 Guidance on Project Management
6. IEC/ISO 81346 series "Industrial systems, installations and equipment and industrial products – structuring principles and reference designations"
7. IEC 61355-1 Classification and designation of documents for plants, systems and equipment
8. IEC 62569-1 Generic specification of information on products by properties - Part 1: Principles and methods
9. EN 17412-1 Building Information Modelling. Level of Information Need. Concepts and principles
10. IFC (Industry Foundation Class) Specification

In addition, a number of informal standards and tools (including protocols, models, systems and programs) were listed:

1. COBie (Construction Operations Building Information Exchange)
2. NBS (National BIM Object Standard)
3. IETF SenML (Sensor Measurement Lists)
4. Design standards (EC 0,1,2,3,4,5)IETF CoAP (constrained Application Protocol)
5. OMA LwM2M (Open Mobile Alliance Lightweight M2M) Protocol
6. OASIS MQTT (Message Queuing Telemetry Transport) Protocol
7. CoClass Classification System (based on ISO 12006-2 and ISO 81346)
8. ETIM Classification Model
9. CYPE Program (Software for Architecture, Engineering and Construction)
10. REVIT CAD System
11. ROBOT
12. SAP
13. Eurocodes for design Load tests for bridges
14. Lean/Agile Planning

Among the informative answers, one respondent stated that there is no comprehensive and solid standard to apply.

Question 10: What are your greatest concerns regarding the existing standards, applicable to Ashvin?

9 informative answers were provided to this question. The greatest concern included:

1. Usability issues (23,1%)

2. Coherence between different standards (19,2%)
3. Which standard to use (15,4%)
4. Lack of appropriate standards (15,4%)
5. Complexity of standards (11,5%)
6. Too generic (11,5%)

Question 11: Do you see any standardization gaps in current building and construction ecosystem in relation to the digital twin approach? If yes: In which of the following areas are these gaps (Product, Process, Data structure, Data exchange, Organization, other)?

10 informative answers were provided to this question. Four respondents (40%) indicated that they do not see any standardization gaps in the building and construction ecosystem, whereas six respondents (60%) identified Data structure and Data exchange as the areas with the standardization gaps.

Question 12: Could you name some of the standardization gaps?

3 informative answers were provided to this question. The respondents identified the following standardization gaps:

1. Data semantics, i.e. data payload formats from the sensors deployed in construction sites. Data should be exchanged via some standardized communication protocols.
2. Properties and classification in a lifecycle perspective
3. AEC industry lacks a conceptual framework for the application of Digital Twin (DT)

3.2 Standardization focus points for the ASHVIN consortium

Processes related to the design, construction, maintenance, repurposing and disposal of buildings relies heavily on information management. Different technologies, including IoT and AI, are applied for information management of the various processes that require information exchanges. DT approach, still in development in the AEC sector, but one of the technologies prioritized by industry experts [1-4], offers a great potential for a holistic representation of the complex structure and processes that comprise the building lifecycle.

The key considerations regarding future standardization are aligned with the considerations associated with the deployment and application of DT technologies in the AEC sector, or its digital service ecosystem [1, 3]. They include services such as site sensing, building progress and safety monitoring, data visualization, detection of incidents, optimization of processes at the building site [1, 7]. These services can for example be deployed at any stage of the building lifecycle.

Based on current trends in design and construction, future implementation of the DT technologies calls for a continuously enhanced representation of the processes that go beyond the mere representation of the building site. It encompasses a gradual evolution of the DT starting from a monitoring platform (Stage 1, *Figure 1*) towards a limited-intelligence semantic platform that takes into consideration the interactions of

a building with its environment (e.g., city infrastructure and traffic, ecological conditions, sustainability considerations etc., Stage 2, *Figure 2*) and finally towards a fully autonomous AI-based platform featuring self-learning and -optimization (Stage 3, *Figure 3*).

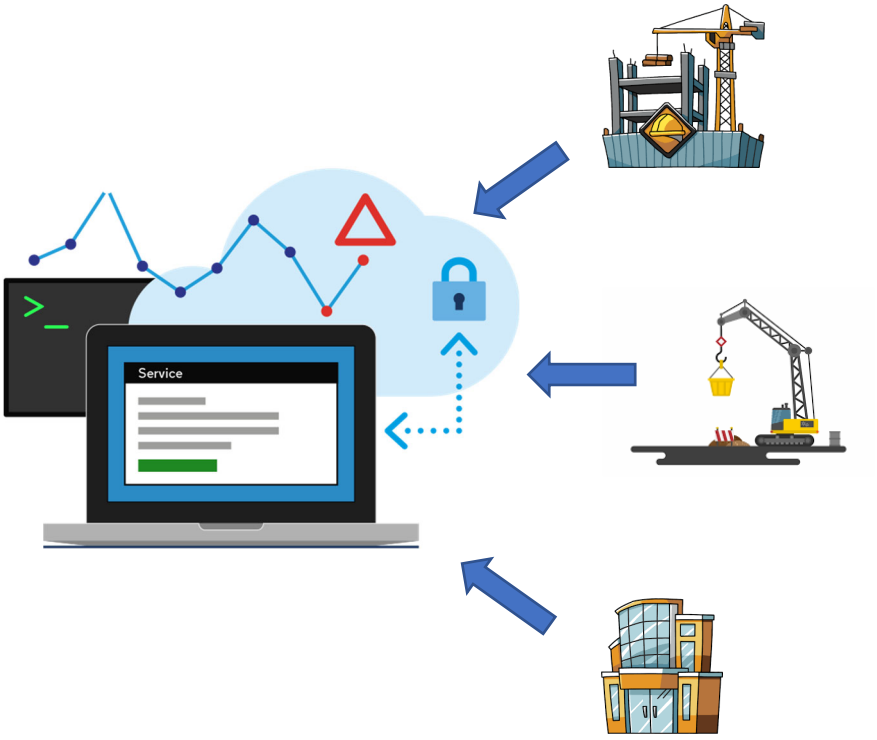

Figure 1. Monitoring platform (Maturity stage 1)

Figure 2. Limited-intelligence semantic platform (Maturity stage 2)

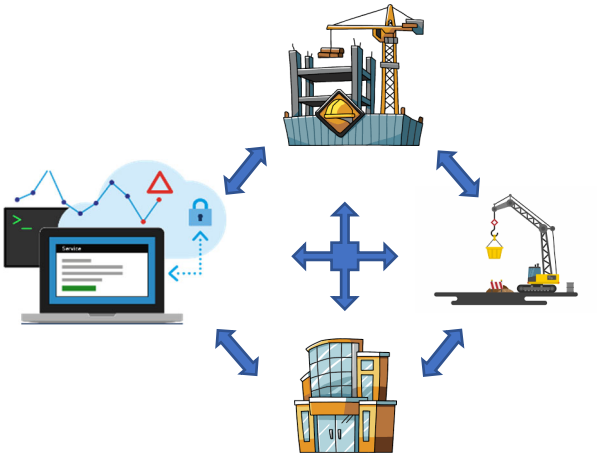

Figure 3. Fully autonomous AI-based platform featuring self-learning and -optimization (Maturity stage 3)

Such platform will represent a user-driven system able to adapt to social requirements of the environment [1, 5, 7].

Taken into consideration the perspectives of the DT application in the AEC sector outlined above and based on the information derived from the Standardization Gaps and Needs Survey, the most important focus points for the ASHVIN consortium regarding the standardization activities cover such areas as:

- DT application framework
- Data management
- Personnel and training
- Safety of construction workers
- Commercially available software and hardware to ensure the successful application of the DT technology
- Adequate representation of all building lifecycle stages and its functionality by the DT

DT application framework

The application framework of the DT concept covers all aspects the DT implementation with the special focus on:

1. A comprehensive integrating platform, able to consolidate and process the real-time data from all sensors and devices within the DT system
2. Software that visualizes the whole building lifecycle (design, construction, maintenance, disposal) in real-time and provides deferred access to a recorded visualization
3. An interface that combines necessary functionality and addresses the existing usability issues, which allows the DT applications to be used by all involved parties and supports their collaboration
4. A framework addressing quality deficiencies and safety concerns that may arise during any stage of the building lifecycle
5. Tools that facilitate the decision making based on the information obtained from the DT (management software)
6. Tools and guidelines regulating the security and confidentiality issues that arise during collaboration of various parties (on national as well as international level)

7. Documentation and reference materials covering legal issues associated with the DT approach
8. A standard specifically covering the application of the DT approach in the AEC industry

Data management

The data management issues include development of a series of standardized communication protocols between all involved actors (sensors, devices, applications, end-users) and standard data formats that ensure a proper acquisition of real-time data and their integration with information models. Security of data during its storage, usage and transfer, as well as data transfer between devices, sensors and the data integrating platform fall also within the scope of the Data Management concept.

Personnel and training

The issues that fall within this category cover the requirements (such as certificates of training), needed to be fulfilled by all involved parties in order to derive added value from the DT approach. First and foremost, they encompass proper training of the personnel dealing with DT applications on daily basis including safety- and security-related topics, followed by the acquisition of necessary level of expertise and experience. This will support understanding and acceptance of the technologies that are comprised within the DT approach, as well as provide insights into the whole span of functionality offered by it.

Safety of construction workers

Improvement of the safety level of construction workers should encompass a set of technical and organisational measures, such as introduction of sensors to control the access to restricted zones, application of appropriate safety management tools, wider use of robots in the construction environment, and better integration of the DT and information models that ensure timely prevention and reaction to incidents.

Commercially available software and hardware to ensure the successful application of the DT technology

One of the largest limitations for an adequate application of the DT approach in the AEC industry is the level of technical development of the commercially available building site hardware (e.g., sensors), as well as of the software and its parts (e.g., object libraries) for the DT applications. Overcoming these limitations will additionally support the further development and implementation of the DT technologies on the building site; however, addressing such issues lay outside of the scope of this deliverable. In spite of this, development of a set of requirements for commercially available products as a part of the future overarching DT standard will support the widespread application of the DT technologies on the building site.

Adequate representation of all building lifecycle stages and its functionality by the DT

One of the most often mentioned issues in the Gap Analysis Survey was the one-sided focus of the existing DT applications on certain stages of the building lifecycle and functionality while omitting the others. The focus should therefore be shifted to the holistic approach in representation of the building cite: address all stages of the building lifecycle (design, construction, maintenance, disposal) on one side, and cover not only 3D representation and reconstruction of a building, but also operational and

business processes that go alongside its physical modelling. Such comprehensive representation of the building site is only possible if an integrated platform that includes both IoT technologies and information models is applied. This will ensure a more precise modelling, data exchange and real-time simulations based on data derived from sensors deployed in construction sites will result in a more predictive DT.

4 CONCLUSION

Despite the extensive standardization work conducted in the area of building and construction at the European and international level (e.g., CEN/TC 247 Building Automation, Controls and Building Management, CEN/TC 442 Building Information Modelling, ISO/TC 59/SC 14 Design life, ISO/TC 59/SC 17 Sustainability in buildings and civil engineering works), there is a clear lack of standards addressing current developments in the DT technology applied to building industry. A number of soon-to-be-available standardization documents still in the development phase and address primarily the general aspects of the DT technology and its application in the manufacturing industry.

In spite of the fact that the DT technology has occupied the top of the hype cycle curve of the emerging technologies [2, 6], the technical and management implications of the DT technology in general and its application for the building and construction industry are still to be explored and developed further. The regulatory aspects of the DT are still in their infancy as well and require further work.

This deliverable serves as the first step towards the development of an overarching standard for implementation of the DT approach in an open-source platform integrating IoT, image technologies and a set of tools to ensure pre-specified productivity, cost, and safety levels within a building site.

The NWIP resulting from this project will address the focus points defined by the consortium members until now:

- a general DT application framework,
- data management,
- personnel and training,
- safety of construction workers,
- requirements to the commercially available software and hardware, as well as
- adequate representation of all building lifecycle stages and its functionality by the DT.

5 REFERENCES

1. Boje, C., Guerriero, A., Kubicki, S., & Rezgui, Y. (2020). Towards a semantic Construction Digital Twin: Directions for future research. Automation in Construction, 114, 103179.
2. Bosch-Sijtsema, P., Claeson-Jonsson, C., Johansson, M., & Roupe, M. (2021). The hype factor of digital technologies in AEC. Construction Innovation.
3. Camposano, J. C., Smolander, K., & Ruippo, T. (2021). Seven Metaphors to Understand Digital Twins of Built Assets. IEEE Access, 9, 27167-27181.
4. Deng, M., Menassa, C. C., & Kamat, V. R. (2021). From BIM to digital twins: a systematic review of the evolution of intelligent building representations in the AEC-FM industry. Journal of Information Technology in Construction (ITcon), 26(5), 58-83.
5. Evans, S., Savian, C., Burns, A., Cooper, C. (2019). Digital Twins for the Built Environment. IET. Available at: https://www.snclavalin.com/~/media/Files/S/SNC-Lavalin/documents/beyond-engineering/digital-twins-for-the-built-environment-iet-atkins.pdf
6. Panetta, K. (2018). 5 Trends Emerge in the Gartner Hype Cycle for Emerging Technologies. Available at: https://www.gartner.com/smarterwithgartner/5-trends-emerge-in-gartner-hype-cycle-for-emerging-technologies-2018/
7. Zhang, J., Zhao, L., Ren, G., Li, H., & Li, X. (2020). Special Issue “Digital Twin Technology in the AEC Industry”. Advances in Civil Engineering, 2020.

ANNEX 1: GAP ANALYSIS SURVEY WITH RESPONSES

Title: Ashvin: Standardization Gap Analysis Questionnaire

Introduction and foreword for the respondents

This survey is intended to reveal the standardization needs and gaps in the current standardization landscape addressing Digital Twin approach in Building.

Informed consent

Your data will be protected and kept safe throughout this project and accessed and analyzed by the researchers for the purpose of conducting this project. Data provided by participants will be stored for the duration of the project and kept 5 years after its final payment. The recipient of the personal data provided during this survey is Austrian Standards International, the National Standardization Body of Austria (https://www.austrian-standards.at/home/), which will process your data.

Question 1: Please indicate your organization [open-ended]

10 participants provided their responses.

Question 2: What are the major shortcomings of existing digital twin applications for building and construction? [open-ended]

a. Digital Twin is more concentrate on building operation and less on the design and construction phase.
b. Focus is too much on 3D representation and reconstruction. Focus needs to be on representing physical and business processes and integrating these representations with IoT based sensors.
c. Digital twin here I am referring data plus the 3D model of the infrastructure. Currently, there is no software available that can provide update to 3D model with real-time sensor data.
d. Current Digital Twin applications do not provide easy integrations with IoT platforms, which is crucial for connecting sensors and actuators and feeding real-time from construction sites into digital twin models. Furthermore, integrations with BIM models are needed.
e. Due to the main focus in our work on structural design and consultancy on erection processes during construction, we are mainly concerned with a seamless Integration of the BIM process in the design phase; digital twins seemed (up to now) in these phases of construction to be of minor interest
f. They are not yet established widely in geotechnical engineering practice
g. In general, there is a missing feedback loop. Also, different standards for data modelling or data exchange are used.
h. The main problem is the disconnection between the different specialized software. Another problem is the excessive simplicity of standard (commercial) software that does not allow in-depth analysis or detail. Another problem is that software has libraries of very underdeveloped objects and processes, and therefore everything becomes cumbersome and inefficient.
i. Concerning the potential application DT, there are lots of benefits over this technology, which have not been fully realized. Safety management,

productivity, resource management, smart scheduling, real-time asset monitoring in the operational phase, and disposal phase of the building.

j. Lack of Integrated Knowledge between Stakeholders, lack of integrated measuring devices within BIM platforms

Question 3: What are the main barriers for ensuring an unambiguous, reliable data exchange between the building site and its digital presentation? [open-ended]

a. The basic problem is the human factor. Construction workers have many other problems and do not have the time to deal with the daily models updating. There are no simple and cheap tools to saturate the model with the necessary information. The owner often sets BIM requirements but does not understand them. He just knows that want to use BIM model for building management, but and the end doesn't know how it will use it.
b. Internet connectivity
c. Unawareness, conservative nature, standards not available specifically for digital twins, simulation of digital twin in real-time is expensive due to computer power requirement.
d. Secure distributed data sharing platform, which can be in the form of larger IoT platform that provides data broker (i.e. message bus) and shared databases. These databases must be distributed, scalable, secure and encrypted.
e. In our case: lack of experience and expertise in monitoring, lack of knowledge in data handling and storing
f. Format of the data, odf. Drawings etc.
g. There is a number of aspects ranging from technical, methodological to organisational aspects. One aspect is a clear data delivery specification and a process to apply such a specification.
h. The first difficulty is the system: the participating agents and their civil responsibilities that make it doubtful that no confidentiality issues arise, or undetected quality deficiencies are revealed. The second difficulty is that construction is going at a very high speed and they are afraid that introducing data capture systems could delay them. The third is the lack of knowledge about that it is possible and useful to take this data.
i. Depends on the physical entity that it represents, DT will acquire its required data through different technologies (e.g., wristband, RFID, site image or video, etc.). The representation of data could be placed in holographic environments or MR.
j. Digitally Experienced workers are needed at both sides of the data pipelines

Question 4: What kind of impact do you expect for the planned digital twin platform to have on the future development of the BIM field? [open-ended]

a. The development of digital twin will contribute to the popularization of BIM requirements in tenders. This will have an impact on how to build as-built BIM models and how to parameterize them. Not always, the more information in the model, then better.
b. A set of tools that makes use of digital twin data to inform site management and asset management. Insights in how to use digital twins of past projects to inform the design of future ones. Methods and

algorithms for behavioural mapping of real world with the digital. Considerations for how to deal with privacy during collection of data.
c. Our vision is to have a software that can represent digital twin on 4D platform to visualise the construction process (historical, current & future) in a similar manner of any video clip moving forward and backward. Further to extend our vision goes towards design and maintenance phases also.
d. Digital twin platform will enable more correct BIM modelling, data exchange, and above all real-time simulations thanks to data coming from sensors deployed in construction sites.
e. A holistic understanding of all three phases of a structured life cycle (design/construction/maintenance); increase of collaboration and mutual understanding, and efficient project management and decision making between all parties involved (designer, construction company, owner); improvement of maintenance and asset management
f. To deliver predictive twin
g. One needs to be an expert in BIM, digital platforms and construction. The platform will allow for a wider adoption by non-experts.
h. We hope that it can improve on some of the issues outlined in the first question regarding the current capacity of the software we use.
i. I don't see this technology as a tool for improving BIM. I believe it is a much broader concept which its applications and implications could be much more than BIM. I see BIM as a part of the Digital building twin.
j. BIM may become crucial for maintenance and not only for design

Question 5: Which Key Performance Indicators (KPI) best reflect the application of the digital twin approach for building and construction? [open-ended]

a. Safety level at the construction site, production efficiency, usability
b. This is very task and project dependent.
c. Quality: number of defects, number of defects due to workmanship, time to rectify defects, number of site inspections conducted, ratio of the number of inspections passed to total number of inspections, total cost of rework, customer satisfaction, internal customer satisfaction. Employee retention: worker satisfaction, training completion percentage rate, turnover rate. Safety: safety/ incident rate, number of safety meetings/communications, number of accidents per supplier.
d. Improved reaction to accidents, better prediction of failures, better real-time monitoring, higher number of connected devices and sensors
e. Increase of productivity
f. Data handling
g. There can be many, depending on what part of the process is considered and to what extent. In general, I would say it is the level of automation on which KPIs are maintained and applied in a process.
h. A KPI that links the forecasts goodness with the measuring of the real models.
i. Number of accidents, change orders, client satisfaction, cost predictability and reduction, percentage of equipment downtime, productivity, return on investment, time to rectify defects, etc.
j. Level of Monitorization on site; level of digitalization, or digitalability of the design

Question 6: What aspects limit the application of the digital twin approach in the construction process? [open-ended]

a. Amount of data transferred, method of data transfer - communication at the construction site is very difficult, a lot of transmission interference caused by steel and water durable and useful IoT sensors
b. Privacy, internet connectivity. Most importantly: tools that allow to provide managerial insights from digital twin data
c. Wireless sensor network.
d. Easy-to-use and comprehensive platform, that includes both IoT platform integration and BIM platform integration.
e. Acceptance of the technology by all parties involved, lack of expertise and experience
f. Lack of clarity of what they can deliver.
g. There are different aspects, such as legal, cultural, technical, methodological and organisational. In general, I believe it is mainly a methodological and organisational challenge including legal aspects.
h. Basically, the not much academic nature of the construction industry and the lack of evolution in commercial software.
i. According to the dynamic nature of the construction industry, it is quite challenging to obtain real-time data from it.
j. Sensors and monitoring should not represent an added complexity for the construction site

Question 7: In your opinion, is safety of construction workers comprehensively addressed by the current IoT developments? [multiple choice and open-ended]

a. Yes
b. No: What improvements do you suggest?

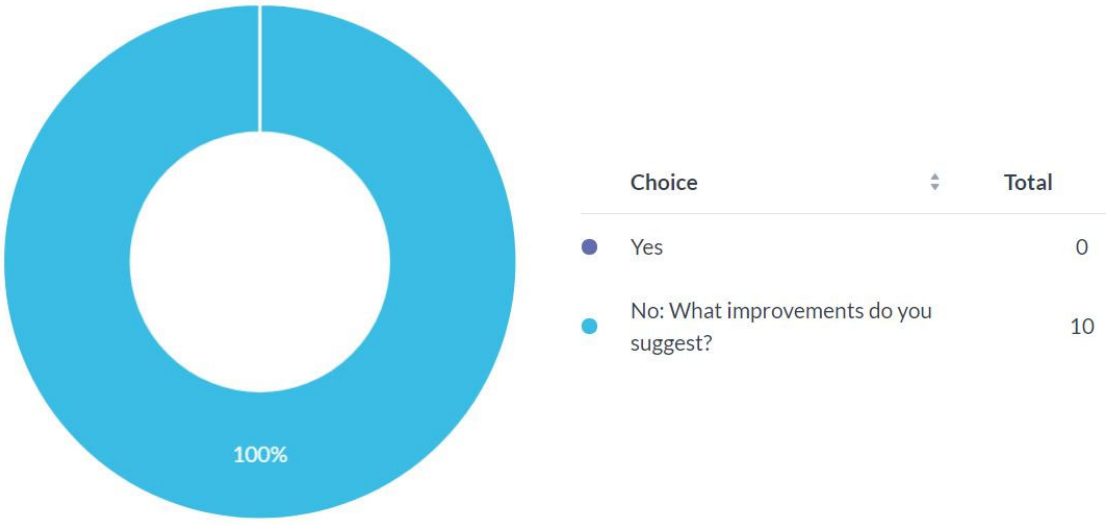

Figure 4. In your opinion, is safety of construction workers comprehensively addressed by the current IoT developments?

Suggested improvements:

a. Sensors that could control of access to restricted zones, ensuring that only workers with relevant permissions, and valid safety trainings have access to dangerous locations. Detection fall from a height or immobility.

b. There are no safety management tools
c. I am here addressing the fact of using robots within construction environment. Robots need to be more intelligent to room around independently.
d. Better integration with Digital Twin models and BIM models
e. Integration of this aspects is one of the research goals of the project
f. Establishing real KPIs to deliver real measure of safety
g. There are good examples, but on a general level there is a long way to go to state a comprehensive approach. Especially the feedback loop and real time aspect is usually missing
h. Considering our knowledge and experience, it is almost not used in the safety field in construction. Therefore, the improvements will be as wide as the sector allows them.
i. First of all, the number of fatal accidents in construction industry in recent years does not imply any successful application or implementation of these technologies. IoT developments should not be fully realized in construction industry, unless they are implemented in a generic system such as DT.
j. Privacy concerns may be not well included

Question 8: Do you apply any standards related to digital twins in your work efforts? [multiple choice and open-ended]

a. Yes: Which of the following areas do these standards cover (Product, Process, Data structure, Data exchange, Organization, other)?
b. No

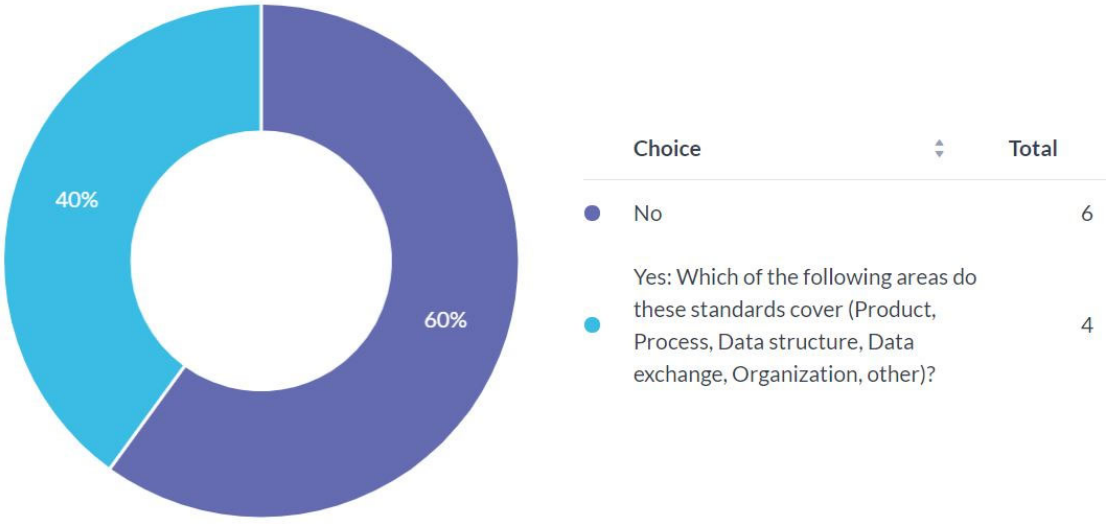

Figure 5. Do you apply any standards related to digital twins in your work efforts?

Areas covered by the used standards:

a. Product
b. Process
c. Data structure
d. Data exchange
e. Organization
f. Other: all of the above

Question 9: Please list the standards that you use the most [open-ended]

a. PN-EN ISO 19650-1, PN-EN ISO 19650-2, IFC (Industry Foundation Class)
b. ISO 19650, COBie, NBS National BIM Object Standard and IFC.
c. IETF SenML, IETF CoAP, OMA LwM2M, OASIS MQTT
d. Design standards (EC 0,1,2,3,4,5)
e. IFC, ISO 81346, CoClass, ISO 12006-1, ETIM, Lean / Agile Planning, ISO 15926, IEC 61355, IEC 62569-1:2017, ISO 19650-1:2019, ISO 21500, EN 17412
f. ROBOT, SAP, CYPE, REVIT, etc.
g. Unfortunately, I could not find any comprehensive and solid standard in this field that I could rely on.
h. Eurocodes for design Load tests for bridges

Question 10: What are your greatest concerns regarding the existing standards, applicable to Ashvin? [multiple choice and open-ended]

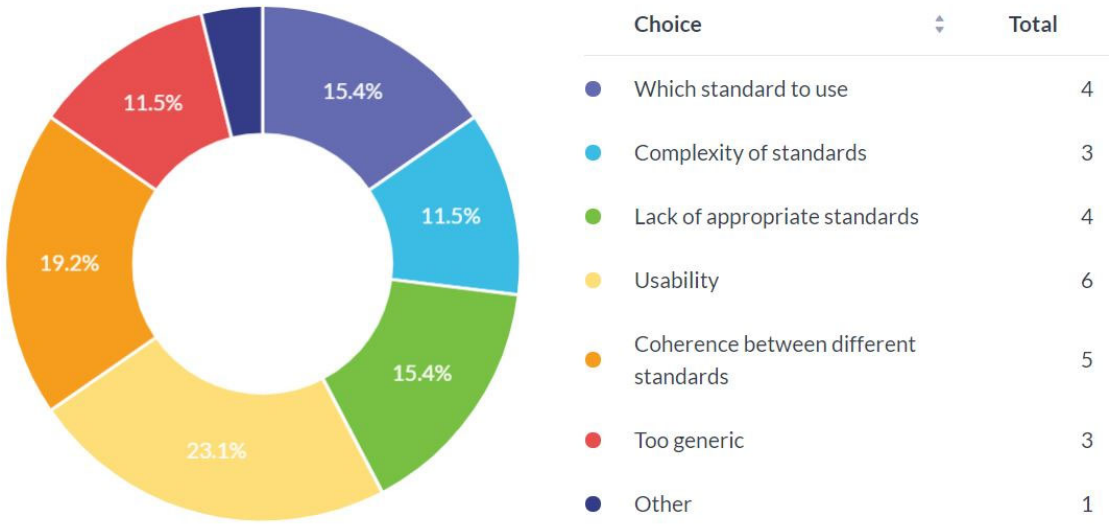

Figure 6. What are your greatest concerns regarding the existing standards, applicable to Ashvin?

The greatest concerns regarding the existing standards, applicable to Ashvin:

a. Usability
b. Coherence between different standards
c. Complexity of standards
d. Which standard to use
e. Lack of appropriate standards
f. Too generic
g. Other: n/a

Question 11: Do you see any standardization gaps in current building and construction ecosystem in relation to the digital twin approach? [multiple choice and open-ended]

a. **Yes: In which of the following areas are these gaps (Product, Process, Data structure, Data exchange, Organization, other)?**
b. **No**

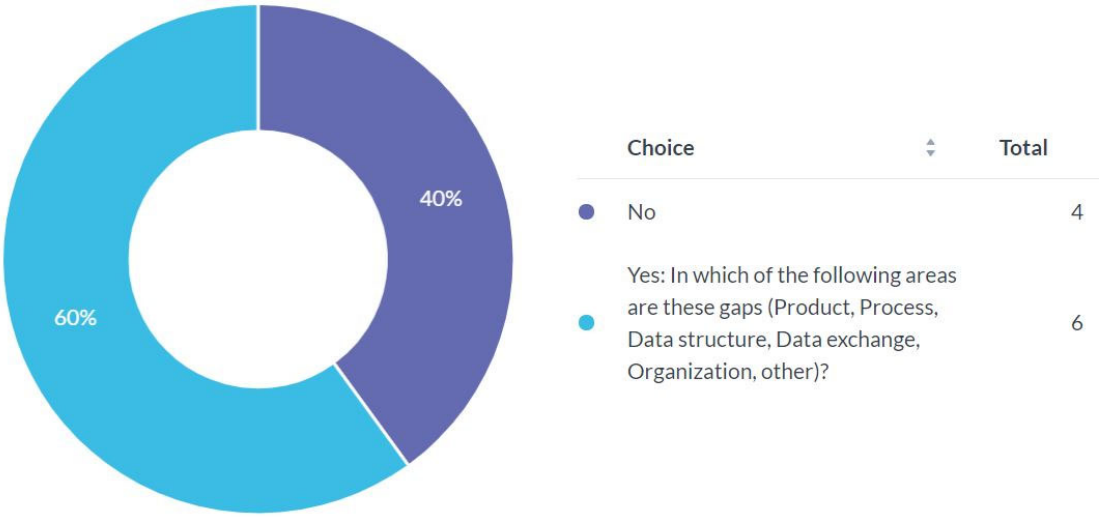

Figure 7. Do you see any standardization gaps in current building and construction ecosystem in relation to the digital twin approach?

Standardization gaps are in the following areas:

a. Data structure
b. Data exchange
c. Process industry

Question 12: Could you name some of the standardization gaps? [open-ended]

a. Data semantics, i.e. data payload formats from the sensors deployed in construction sites.
b. Data should be exchanged via some standardized communication protocols.
c. Properties and classification in a lifecycle perspective.
d. Conceptual framework for the application of Digital Twin.

ANNEX 2: LIST OF IDENTIFIED FORMAL STANDARDS

	Standardization Body	Title	Status	Summary
1.	IEEE	IEEE 2413-2019 - IEEE Standard for an Architectural Framework for the Internet of Things (IoT)	published	An architecture framework description for the Internet of Things (IoT) which conforms to the international standard ISO/IEC/IEEE 42010:2011 is defined. A conceptual basis for the notion of things in the IoT is provided and the shared concerns as a collection of architecture viewpoints is elaborated to form the body of the framework description.
2.		IEEE 241-1990 - IEEE Recommended Practice for Electric Power Systems in Commercial Buildings	published	A guide and general reference on electrical design for commercial buildings is provided. It covers load characteristics; voltage considerations; power sources and distribution systems; power distribution apparatus; controllers; services, vaults, and electrical equipment rooms; wiring systems; systems protection and coordination; lighting; electric space conditioning; transportation; communication systems planning; facility automation; expansion, modernization, and rehabilitation; special requirements by occupancy; and electrical energy management.
3.	CEN/WS Smart CE marking for the construction industry	CWA 17316:2018 - Smart CE marking for construction products	published	Smart CE marking for construction products aims to digitalise mandatory construction products information provided in the declaration of performance (DoP) according to Regulation (EU) No 305/2011 [1]. When available for their standards, manufacturers will have the option to make their DoP available in their websites in XML format (human and machine readable), the files will be accessible through the link included in the CE marking. This link will allow the use of "smart" devices connected to the internet (mobile phones, tablets, computers,

				etc) to use this information through internet browsers, applications or software. Harmonisation will be achieved through the development of XML formats for each harmonised product standard. This document provides guidance on how these formats should be developed to properly establish a consistent digital information environment.
4.	CEN/TC 247 Building Automation, Controls and Building Management	EN 12098-1:2017 Energy Performance of Buildings - Controls for heating systems - Part 1: Control equipment for hot water heating systems - Modules M3-5, 6, 7, 8	published	This European Standard applies to electronic control equipment for heating systems with water as the heating medium and a supply water temperature up to 120 °C. This control equipment controls the distribution and/or the generation of heat in relation to the outside temperature and time and other reference variables. This standard covers also controllers that contain an integrated optimum start or an optimum start-stop control function.
5.		EN 12098-3:2017 Energy Performance of Buildings - Controls for heating systems - Part 3: Control equipment for electrical heating systems - Modules M3-5,6,7,8	published	This European Standard applies to electronic control equipment for heating systems with direct electrical emission, which have an integrated outside compensated function and or optimum start/stop function. This control equipment controls the distribution and/or the generation of heat in relation to the outside temperature and time and other reference variables. This European Standard also covers controllers that contain an integrated optimum start or an optimum start-stop control function.
6.		EN 12098-5:2017 Energy Performance of Buildings - Controls for heating systems - Part 5: Start-stop schedulers for heating systems - Modules M3-5,6,7,8	published	This European Standard applies to scheduling equipment for heating systems. The signals can be processed by using either analogue or digital techniques, or both. It applies to start-stop scheduling functions and sets minimum acceptable standards for functions, performance and documentation. NOTE 1 The start-stop function can be integrated within a main control device.

7.		CEN/TR 12098-6:2016 Controls for heating systems - Part 6: Accompanying TR prEN 12098-1:2015 - Modules M3-5,6,7,8	published	This Technical Report refers to prEN 12098-1:2015, Controls for heating systems — Part 1: Control equipment for hot water heating systems — Modules M3-5,6,7,8. It contains information to support the correct understanding, use and national adaption of prEN 12098 1:2015.
8.		CEN/TR 12098-7:2016 Controls for heating systems - Part 7: Accompanying TR prEN 12098-3:2015 - Modules M3-5,6,7,8	published	This Technical Report refers to prEN 12098-3, Controls for heating systems - Part 3: Control equipment for electrical heating systems - Modules M3-5,6,7,8. It contains information to support the correct understanding, use and national adaption of prEN 12098-3:2015.
9.		CEN/TR 12098-8:2016 Controls for heating systems - Part 8: Accompanying TR prEN 12098-5:2015 - Modules M3-5,6,7,8	published	This Technical Report refers to prEN 12098-5:2015, Controls for heating systems - Part 5: Start-stop schedulers for heating systems - Modules M3-5,6,7,8. It contains information to support the correct understanding, use and national adaption of prEN 12098-5:2015.
10.		EN 13321-1:2012 Open data communication in building automation, controls and building management - Home and building electronic system - Part 1: Product and system requirements	published	This European Standard specifies, as for Home or Building Electronic Systems (HBES) for the domain of Building Automation and Control System Application and Building Management (BACS), common rules for a class of multi-application bus systems where the functions are decentralised and linked through a common communication process. This European Standard sets the basic requirements for products and systems.
11.		EN 14597:2012 Temperature control devices and temperature limiters for heat generating systems	published	This European Standard applies to electrical or non electrical temperature control devices which are used to control temperatures within heat generating systems by controlling the supply of energy. It also applies to limiting devices which ensure that the temperature in heat generating systems will not exceed a predefined limit. This European Standard specifies operating values, operating times, and operational sequences associated

				with the safety of the heat generating system. This European Standard also applies to controls using NTCs or PTCs thermistors, additional requirements for which are contained in Annex J of EN 60730-2-9:2010.
12.		EN 14908-1:2014 Open Data Communication in Building Automation, Controls and Building Management - Control Network Protocol - Part 1: Protocol Stack	published	This European Standard applies to a communication protocol for networked control systems in commercial Building Automation, Controls and Building Management. The protocol provides peer-to-peer communication for networked control and is suitable for implementing both peer-to-peer and master-slave control strategies. This specification describes services in layers 2 to 7.
13.		EN 14908-2:2014 Open Data Communication in Building Automation, Controls and Building Management - Control Network Protocol - Part 2: Twisted Pair Communication	published	This European Standard specifies the control network protocol (CNP) free-topology twisted-pair channel for networked control systems in commercial Building Automation, Controls and Building Management and is used in conjunction with EN 14908-1:2014.
14.		EN 14908-3:2014 Open Data Communication in Building Automation, Controls and Building Management - Control Network Protocol - Part 3: Power Line Channel Specification	published	This European Standard specifies all the information necessary to facilitate the exchange of data and control information over the power line medium for networked control systems in commercial Building Automation, Controls and Building Management. This European Standard establishes a minimal set of rules for compliance.
15.		EN 14908-4:2014 Open Data Communication in Building Automation, Controls and Building Management - Control Network Protocol - Part 4: IP Communication	published	This European Standard specifies the transporting of the Control Network Protocol (CNP) packets for commercial Building Automation, Controls and Building Management over Internet Protocol (IP) networks using a tunnelling mechanism wherein the CNP packets are encapsulated within IP packets. It applies to both CNP nodes and CNP routers. The purpose of this European Standard is to ensure interoperability between various CNP devices that wish to use IP networks to communicate using the CNP protocol. The main body of this European Standard is

				independent of the CNP protocol being transported over the IP network.
16.		EN 14908-5:2009 Open Data Communication in Building Automation, Controls and Building Management Implementation Guideline - Control Network Protocol - Part 5: Implementation	published	This specification contains all the information necessary to facilitate the exchange of data and control information in an interoperable fashion using EN 14908-1 and its associated data-transport media specifications. This specification establishes a minimal set of rules for compliance.
17.		EN 14908-6:2014 Open Data Communication in Building Automation, Controls and Building Management - Control Network Protocol - Part 6: Application elements	published	This European Standard provides mechanisms through which various vendors of building automation, control, and building management systems may exchange information in a standardized way. This document provides specifications for the Application Elements of Control Network Protocol packets as follows: - definitions of standardized packet (network-variable) data types; - definitions of device-interface files; - definitions of standardized configuration-property types; - definitions of standardized enumeration types; - definitions of standardized functional profiles; - definition of the standardized method of file transfer between devices. The purpose of this specification is to ensure interoperability between various CNP implementations.
18.		EN 14908-7:2019 Open communication in building automation, controls and building management - Control Network Protocol - Part 7: Communication via internet protocols	published	This document specifies a communication protocol for networked control systems. The protocol provides peer-to-peer communication for networked control using web-services. The document describes services in layer 2 and layer 3.
19.		prEN 14908-8 Open Data Communication in Building Automation, Controls and Building Management - Control Network Protocol - Part 8: Communication using Broadband over	Under development	This document specifies a communication protocol for networked control systems. The protocol provides peer-to-peer communication for networked control using web-services. This document describes services in layer 1 and layer 2. The layer 1 (physical layer) specification describes the MAC sub-layer

		Power Line Networks - with internet protocols		interface to the physical layer. The layer 2 (data link layer), as described in EN 14908 1, is integrated in UDP/IP communication using IPv4 and IPv6 protocols.
20.		prEN 14908-9 Open Data Communication in Building Automation, Controls and Building Management - Control Network Protocol - Part 9: Wireless Communication in ISM bands	Under development	This document specifies an adaptation layer for the control network protocol (CNP), as described in EN 14908 1 to utilize wireless communication network. This document defines the services of the wireless communication provided to CNP layer for delivering data and commands towards and from sensors, actuators, etc. which are wirelessly connected as part of the EN 14908 1 network. In addition, this document defines the requirements for the radio communication applicable for CNP layer operation.
21.		CEN/TS 15231:2006 Open data communication in building automation, controls and building management - Mapping between Lonworks and BACnet	published	The LONWORKS communication system is widely used in building automation systems for field-level and application-level functions for residential and non-residential controls in lighting, sun protection, HVAC, energy management and security applications. The BACnet communication system as well is also used in building automation systems for management-level and application-level functions. This technical specification defines the methods for combining BACnet networks with LONWORKS networks and standardizes the interface between BACnet and LONWORKS systems.
22.		EN 15232-1:2017 Energy Performance of Buildings - Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10	published	This European Standard specifies: - a structured list of control, building automation and technical building management functions which contribute to the energy performance of buildings; functions have been categorized and structured according to building disciplines and so called Building automation and control (BAC); - a method to define minimum requirements or any specification regarding the control, building automation and technical building management functions

				contributing to energy efficiency of a building to be implemented in building of different complexities; - a factor based method to get a first estimation of the effect of these functions on typical buildings types and use profiles; - detailed methods to assess the effect of these functions on a given building.
23.		CEN/TR 15232-2:2016 Energy performance of buildings - Part 2: Accompanying TR prEN 15232-1:2015 - Modules M10-4,5,6,7,8,9,10	published	This Technical Report refers to prEN 15232-1, Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10. It contains information to support the correct understanding, use and national adaption of standard prEN 15232-1:2015.
24.		CEN/TS 15379:2006 Building management - Terminology and scope of services	published	The document provides a structure of Building Management (BM) and its Building Services and gives terms and definitions in the field of Building Management for general understanding.
25.		EN 15500-1:2017 Energy Performance of Buildings - Control for heating, ventilating and air conditioning applications - Part 1: Electronic individual zone control equipment - Modules M3-5, M4-5, M5-5	published	The purpose of this standard is to specify the applications, functionality set and application performance for electronic individual zone control equipment. The applications are for cooling and hot water or electrical heating as described in Annex B. This standard applies specifically to individual zone control equipment for maintaining temperature, humidity and air flow as a function of occupancy and demand operated with auxiliary electrical energy.
26.		CEN/TR 15500-2:2016 Energy Performance of Buildings - Control for heating, ventilating and air-conditioning applications — Part 2: Accompanying TR prEN 15500-1:2015 - Modules M3-5,M4-5,M5-5	published	This Technical Report refers to prEN 15500 1, Control for heating, ventilating and air-conditioning applications — Part 1: Electronic individual zone control equipment — Modules M3-5, M4-5, M5-5. It contains information to support the correct understanding, use and national adaption of prEN 15500 1:2016.

27.		CEN/TS 15810:2008 Graphical symbols for use on integrated building automation equipment	published	This document provides a synopsis of graphical symbols which are intended to be placed on building equipment and/or technical documentation of products in order to instruct the person(s) using the equipment. These graphical symbols are primary intended: to identify control or automation or technical management equipment or part of these equipment: electronic devices (e.g. controller, scheduler, optimiser, etc.), sensors, actuators, to indicate functions and their operating modes, to indicate settings for modes and functions parameters introduction, to designate connexions, to provide instruction to users (professional and/or end user) for the operation of the equipment.
28.		EN ISO 16484-1:2010 Building automation and control systems (BACS) - Part 1: Project specification and implementation	published	It specifies guiding principles for project design and implementation and for the integration of other systems into the building automation and control systems (BACS). ISO 16484-1:2010 specifies the phases required for the BACS project, including: design (determination of project requirements and production of design documents including technical specifications), engineering (detailed function and hardware design), installation (installing and commissioning of the BACS), and completion (handover, acceptance and project finalization). ISO 16484-1:2010 also specifies the requirements for as-built documentation and training.
29.		EN ISO 16484-2:2004 Building automation and control systems (BACS) - Part 2: Hardware	published	It specifies the requirements for the hardware to perform the tasks within a building automation and control system (BACS). It provides the terms, definitions and abbreviations for the understanding of ISO 16484-2 and ISO 16484-3. ISO 16484-2:2004 relates only to physical items/devices, i.e. devices for management functions, operator stations and other human system interface devices; controllers, automation stations and

				application specific controllers; field devices and their interfaces; cabling and interconnection of devices; engineering and commissioning tools.
30.		EN ISO 16484-3:2005 Building automation and control systems (BACS) - Part 3: Functions	published	It specifies the requirements for the overall functionality and engineering services to achieve building automation and control systems. It defines terms, which shall be used for specifications and it gives guidelines for the functional documentation of project/application specific systems. It provides a sample template for documentation of plant/application specific functions, called BACS points list.
31.		EN ISO 16484-5:2017 Building automation and control systems (BACS) - Part 5: Data communication protocol EN ISO 16484-5:2017/A1:2020	published	The purpose of ISO 16484-5:2017 is to define data communication services and protocols for computer equipment used for monitoring and control of HVAC&R and other building systems and to define, in addition, an abstract, object-oriented representation of information communicated between such equipment, thereby facilitating the application and use of digital control technology in buildings.
32.		EN ISO 16484-6:2020 Building automation and control systems (BACS) - Part 6: Data communication conformance testing	published	This standard provides a comprehensive set of procedures for verifying the correct implementation of each capability claimed on a BACnet PICS including: (a) support of each claimed BACnet service, either as an initiator, executor, or both, (b) support of each claimed BACnet object-type, including both required properties and each claimed optional property, (c) support of the BACnet network layer protocol, (d) support of each claimed data link option, and (e) support of all claimed special functionality.
33.		EN 16946-1:2017 Energy Performance of Buildings - Inspection of Automation,	published	This European Standard defines guidelines for the inspection of installed an operational Functions of Building Automation,

		Controls and Technical Building Management - Part 1: Module M10-11		Controls and Technical Building Managment System including its configuration.
34.		CEN/TR 16946-2:2016 Energy Performance of Buildings - Inspection of Building Automation, Controls and Technical Building Management - Part 2: Accompanying TR prEN 16946-1:2015 - Modules M10-11	published	This Technical Report refers to prEN 16946 1, Inspection of Building Automation, Controls and Technical Building Management — Module M10-11. It contains information to support the correct understanding, use and national adaption of standard prEN 16946 1:2015.
35.		EN 16947-1:2017 Energy Performance of Buildings - Building Management System - Part 1: Module M10-12	published	This European Standard specifies operational activities, overall alarming, fault detection and diagnostics, reporting, monitoring, energy management functions, functional interlocks and optimizations to set and maintain energy performance of buildings.
36.		CEN/TR 16947-2:2016 Building Management System - Part 2: Accompanying prEN 16947-1:2015 - Modules M10-12	published	This Technical Report refers to prEN 16947-1:2015, Building Management System - Module M10-12. It contains information to support the correct understanding, use and national adaption of prEN 16947-1:2015.
37.		prEN 17609 Building automation and control systems - Control applications	Under development	This document specifies control applications and function blocks focusing on but not limited to lighting, solar protection and HVAC applications. It describes how energy performance, comfort, and operational requirements of buildings are translated into functional specifications for integrated plant and room control.
38.		EN ISO 22510:2020 Open data communication in building automation, controls and building management - Home and building electronic systems - KNXnet/IP communication	published	This document defines the integration of KNX protocol implementations on top of Internet protocol (IP) networks, called KNXnet/IP. It describes a standard protocol for KNX devices connected to an IP network, called KNXnet/IP devices. The IP network acts as a fast (compared to KNX twisted pair transmission speed) backbone in KNX installations.

39.		prEN ISO 52120-1 Energy performance of buildings - Contribution of building automation and controls and building management - Part 1: Modules M10-4,5,6,7,8,9,10	Under development	This European Standard specifies: - a structured list of control, building automation and technical building management functions which contribute to the energy performance of buildings; functions have been categorized and structured according to building disciplines and so called Building automation and control (BAC); - a method to define minimum requirements or any specification regarding the control, building automation and technical building management functions contributing to energy efficiency of a building to be implemented in building of different complexities; - a factor based method to get a first estimation of the effect of these functions on typical buildings types and use profiles; - detailed methods to assess the effect of these functions on a given building.
40.		FprCEN ISO/TR 52120-2 Energy performance of buildings - Contribution of building automation, controls and building management - Part 2: Explanation and justification of ISO 52120-1	Under development	This Technical Report refers to EN 15232-1, Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10. It contains information to support the correct understanding, use and national adaption of standard EN 15232-1. This technical report does not contain any normative provision.
41.		ISO 52127-1:2021(en) Energy performance of buildings — Building management system — Part 1: Module M10-12	published	This document specifies operational activities, overall alarming, fault detection and diagnostics, reporting, monitoring, energy management functions, functional interlocks and optimizations to set and maintain energy performance of buildings.
42.		ISO/TR 52127-2:2021(en) Energy performance of buildings — Building automation, controls and building management — Part 2: Explanation and justification of ISO 52127-1	published	This document contains information to support the correct understanding, use and adoption of ISO 52127-1.

43.	CEN/TC 442 Building Information Modelling (BIM)	EN ISO 12006-2:2020 Building construction - Organization of information about construction works - Part 2: Framework for classification	published	It defines a framework for the development of built environment classification systems. It identifies a set of recommended classification table titles for a range of information object classes according to particular views, e.g. by form or function, supported by definitions. It shows how the object classes classified in each table are related, as a series of systems and sub-systems, e.g. in a building information model.
44.		EN ISO 12006-3:2016 Building construction - Organization of information about construction works - Part 3: Framework for object-oriented information	published	It specifies a language-independent information model which can be used for the development of dictionaries used to store or provide information about construction works. It enables classification systems, information models, object models and process models to be referenced from within a common framework.
45.		EN ISO 16739-1:2020 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries - Part 1: Data schema	published	The standard includes definitions that cover data required for buildings over their life cycle.
46.		EN ISO 16757-1:2019 Data structures for electronic product catalogues for building services - Part 1: Concepts, architecture and mode	published	The primary purpose of ISO 16757 is the provision of data structures for electronic product catalogues to transmit building services product data automatically into models of building services software applications. This includes a meta model for the specification of product classes and their properties and a meta model for the product data which is exchanged in product catalogues. Product data has to follow the specifications for their product groups.
47.		EN ISO 16757-2:2019 Data structures for electronic product catalogues for building services - Part 2: Geometry	published	ISO 16757-2:2016 describes the modelling of building services product geometry. The description is optimized for the interchange of product catalogue data and includes - shapes for representing the product itself, - symbolic shapes for the

				visualization of the product's function in schematic diagrams, - spaces for functional requirements, - surfaces for visualization, and - ports to represent connectivity between different objects.
48.		EN 17412-1:2020 Building Information Modelling - Level of Information Need - Part 1: Concepts and principles	published	This document specifies concepts and principles to establish a methodology for specifying level of information need and information deliveries in a consistent way when using Building Information Modelling (BIM). This document specifies the characteristics of different levels used for defining the detail and extent of information required to be exchanged and delivered throughout the life cycle of built assets. It gives guidelines for principles required to specify information needs.
49.		CEN/TR 17439:2020 Guidance on how to implement EN ISO 19650-1 and -2 in Europe	published	The scope of this guidance is deliberately restricted only to refer to EN ISO 19650-1 and -2, highlighting and describing the manner in which to use it -and not extending or contradicting the scope and content of the standard. The document aims simply to provide minimum supporting text to achieve a basic understanding and ability to implement EN ISO 19650-1 and -2.
50.		prEN 17549-1 Building Information Modelling (BIM) - Information structure based on EN ISO 16739 1:2018 to exchange data templates and data sheets for construction objects - Part 1: Data templates and configured construction objects	Under development	The part 1 of the standard describes a way to represent information templates and configured products in a library based on a structure based on ISO 16739-1 (prEN ISO 16739-1) and how this relates to the upcoming standards prEN ISO 23386 and prEN ISO 23387.The part 2 will define the way, how a (requirements) request can be formulated with EN ISO 16739 and how this can be used to represent variants of configurable products. The requests by part 2 will be applicable to product libraries based on part 1. The part 2 will furthermore define a way, to create a constraint-based product library for highly configurable products to support an interactive selection process. The application of a request to a "Part1-Library" and to a "Part2-Library" shall response same products as the result. It

				is up to the manufacturers to choose the way, they want to represent their products ("Part1-Library" and/or"Part2-Library"), they just have to be sure, that all requests can be applied to both types of libraries.
51.		prEN 17632 Semantic Modelling and Linking Standard (SMLS) for data integration in the built environment	Under development	This document provides an integrated approach and a unified approach to data aspects, and particularly for assets and the built environment, using EIF terminology. The aim of this document is to standardize the application of linked data to the built environment in order to make them correspond to the FAIR principle. This document specifies how the construction and software industry apply this linked data and semantic web technology. Applying this document to new or existing software becomes future-proof lead semantic data interoperability, or interoperability that emphasizes the importance of data model understood by the participating systems within the context of the subject area. In addition, the data sets and data models are compatible, reusable and combinable and thus integrally applicable. This document enables decision making regarding the duration of the whole Lifecycle and of the involved supply chain.
52.		EN ISO 19650-1:2018 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 1: Concepts and principles	published	This document outlines the concepts and principles for information management at a stage of maturity described as "building information modelling (BIM) according to the ISO 19650 series". This document provides recommendations for a framework to manage information including exchanging, recording, versioning and organizing for all actors.
53.		EN ISO 19650-2:2018 Organization and digitization of information about buildings and civil engineering works,	published	This document specifies requirements for information management, in the form of a management process, within the context of the delivery phase of assets and the exchanges of

		including building information modelling (BIM) - Information management using building information modelling - Part 2: Delivery phase of the assets		information within it, using building information modelling. This document can be applied to all types of assets and by all types and sizes of organizations, regardless of the chosen procurement strategy.
54.		EN ISO 19650-3:2020 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 3: Operational phase of the assets	published	This document specifies requirements for information management, in the form of a management process, within the context of the operational phase of assets and the exchanges of information within it, using building information modelling.
55.		prEN ISO 19650-4 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling — Part 4 : Information exchange	Under development	ISO 19650 part 4 provides detailed process and criteria for the decision points in the process of executing an information exchange within information management as defined by ISO 19650. It promotes a sustainable approach to information exchange where the immediate delivery of information does not preclude its future use. It is applicable to any information exchange within project stages (ISO 19650 part 2) and within in-use events (ISO 19650 part 3). All development and information exchanges should be executed under the appropriate security controls (ISO 19650 part 5). It supports the satisfaction of a specific EIR/AIR related to an individual information exchange of any type of information by enumerating criteria relating to completeness, compliance to formal exchange schemas, the continuity of concepts between exchanges and the elimination of spatial and specification conflicts
56.		EN ISO 19650-5:2020 Organization and digitization of information about buildings and civil engineering works, including building information modelling	published	This document specifies the principles and requirements for security-minded information management at a stage of maturity described as "building information modelling (BIM) according to the ISO 19650 series", and as defined in ISO 19650-1, as well

		(BIM) - Information management using building information modelling - Part 5: Security-minded approach to information management		as the security-minded management of sensitive information that is obtained, created, processed and stored as part of, or in relation to, any other initiative, project, asset, product or service. It addresses the steps required to create and cultivate an appropriate and proportionate security mindset and culture across organizations with access to sensitive information, including the need to monitor and audit compliance.
57.		EN ISO 21597-1:2020 Information container for linked document delivery - Exchange specification - Part 1: Container	published	This document defines an open and stable container format to exchange files of a heterogeneous nature to deliver, store and archive documents that describe an asset throughout its entire lifecycle. It is suitable for all parties dealing with information concerning the built environment, where there is a need to exchange multiple documents and their interrelationships, either as part of the process or as contracted deliverables.
58.		EN ISO 21597-2 Information container for linked document delivery - Exchange specification - Part 2: Link types	published	This document provides the opportunity to add information about the contents of a container by further specializing the generic types of links specified in ISO 21597-1. The defined link types have been chosen to enhance the use of the container by allowing the addition of semantic relationships that are human interpretable to provide greater clarity about those links.
59.		EN ISO 23386:2020 Building information modelling and other digital processes used in construction - Methodology to describe, author and maintain properties in interconnected data dictionaries	published	This document establishes the rules for defining properties used in construction and a methodology for authoring and maintaining them, for a confident and seamless digital share among stakeholders following a BIM process.
60.		EN ISO 23387:2020 Building information modelling (BIM) - Data templates for construction objects used	published	This document sets out the principles and structure for data templates for construction objects. It is developed to support digital processes using machine-readable formats using a standard data structure to exchange information about any type

		in the life cycle of built assets - Concepts and principles		of construction object, e.g. product, system, assembly, space, building etc., used in the inception, brief, design, production, operation and demolition of facilities. This document provides the specification of a taxonomy model that defines concepts from ISO 12006-3:2007, i.e. objects, collections and relationships between them, to support the information need for the specific purpose of the data template.
61.		EN ISO 29481-1:2017 Building information models - Information delivery manual - Part 1: Methodology and format	published	ISO 29481-1:2016 specifies - a methodology that links the business processes undertaken during the construction of built facilities with the specification of information that is required by these processes, and - a way to map and describe the information processes across the life cycle of construction works.
62.		EN ISO 29481-2:2016 Building information models - Information delivery manual - Part 2: Interaction framework	published	ISO 29481-2:2012 specifies a methodology and format for describing coordination acts between actors in a building construction project during all life cycle stages. It therefore specifies a methodology that describes an interaction framework, an appropriate way to map responsibilities and interactions that provides a process context for information flow, a format in which the interaction framework should be specified.
63.		FprCEN/TR 17654 (WI=00442024) Guideline for the implementation of BIM Execution Plans (BEP) and Exchange Information Requirements (EIR) on European level based on EN ISO 19650-1 and -2	Under development	BIM Execution Plans (BEP) and Exchange Information requirements (EIR) are central complementary documents for the definition of information requirements and how to process them in collaborative BIM environments. Where EIR defines the Exchange information requirements of an appointing party and BEP – the BIM execution Plan – is the plan how to fulfill these requirements by the appointed parties. This work item will • examine and explain the demands for Exchange Information Requirements (EIR) and BIM execution Plans (BEP) based on EN/ISO 19650-1 and -2. • Provide guidance for the

				implementation of EIR and BEP • Provide templates for the creation of EIR and BEP
64.		prCEN/TR (WI=00442031) Framework and Implementation of Common Data Environment Solutions, in accordance with EN ISO 19650	Preliminary	This New Work Item will extend the basic information given in the EN ISO19650 and in the "Guidance to EN ISO 19650". It will detail and structure the concept of a Common Data Environment (CDE) as a workflow for the collaborative process of managing the information and information containers as solutions that fit to the management and project processes inherent for BIM It may be necessary to introduce further concept details as elements for understanding and implementation. Archiving and versioning of information containers can become very complex when considering various typical information situations of a project. Further elements, rules and terminology for information management and digitisation may need to be explained and technically framed in the context of a CDE. It will be a large advantage developing at the same time the "Open API for CDE" in TC442 WG2 In particular this Work Item will describe - how to link a CDE according to EN ISO 19650 to an already existing Asset Management Systems of the Asset Owner. - how to maintain and manage "living documents" like Information Models (AIM, PIM) - how to maintain, exchange and manage Information Requirements like (OIR, AIR, EIR) as well as BIM Execution Plans (BEP) - how to use and implement Information Delivery Plans for the above entities (MIDP and TIDP in ISO 19650) - how to manage and collaborate between various Information Containers like models, requirements, container states - how to support Process Workflow by a CDE based on the IDM concept It will simply have to describe how to provide "Common Data Environment" throughout the whole life cycle (horizontal aspect) and throughout the spectrum of management levels and stakeholders (vertical aspect). In the work item

				proposed here, all important terms, processes and targets are to be expanded around the CDE concept. Relations to already existing normatives will be given. Informative attachments such as templates and examples could be provided to the benefit of planner, supplier and operator as further guidelines.
65.		prCEN/TR XXX (WI=00442023) Guideline on how to understand and utilize EN/ISO 29481 Building information models - Information delivery manual - Part 1: Methodology and format and Part 2: Interaction framework	Under development	This WI will generate a guideline, that explains how to understand and utilize the IDM standard. It will also complement any missing parts of the IDM standard if needed. These additions can be later used to improve the IDM standard or to develop a stand-alone part for EN/ISO 29481 series. The manner in which a use case framework could be exploited to utilize EN/ISO 29481 will be explored.
66.		prEN (WI=00442033) Building information modelling - Exchange structure for product data templates and product data sheets based on ISO 16739-1 - Part 2: Requirements and configurable products	Under development	The digital transformation of the construction industry includes also the digital transformation of the supply chaine of construction products. With EN ISO 16739-1 exists an open language to design, transfer and maintain construction models. The construction models (e.g. of a building) contain a digital twin of real-life products. The data of these products should be transported in a digital format on the way from the factory to the building owner. This product data should be expressed also in an easy and open way. The creators of product data files should be able to do this manually or automatically, as they like it. The users of product data should be able to use it to: • Express their requirements related to products • Describe configurable products • Import product data easily in the BIM models at any stage of the project (design, construction, operation) • Export product data easily from the BIM models at any stage of the project (design, construction, operation) These scenarios fit in the business models of manufacturers, planners, construction companies and facility managers. The working group 4 of CEN-

				TC442 has published proposals for creating new work items in the sector of CEN regarding the storage and the transport of product data in the sector of building information modelling (BIM): EN ISO 16739-1:2018: Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries- Part 1: Data schema EN ISO 12006-3: Building construction – Organization of information about construction works – Part 3: Framework for object-oriented information prEN ISO 23386: Building information modelling and other digital processes used in Construction – Methodology to describe, author and maintain properties in interconnected dictionaries prEN ISO 23387: Data templates for construction works entities, Part 1: Objects, collections, and relationships defining the general structure of data templates This standard defines a format to negotiate product data templates, express requirements and describe configurable products and therefore fills the missing link between the product data sources (e.g. catalogs) from the manufacturers and the BIM models of the designers, builders, and owners.
67.		prEN ISO 12006-3 rev (WI=00442019) Building construction -- Organization of information about construction works -- Part 3: Framework for object-oriented information	Under development	
68.		prEN ISO 29481-3 (WI=00442034) Building information models — Information delivery manual — Part 3: Data schema and classification	Under development	This part of ISO 29481 Information Delivery Manual (IDM) specifies: • a data schema for exchanging the data required in specific data exchange scenarios during the building lifecycle in the extensible markup language (XML) schema format. • a classification system for IDM specifications. This part of ISO 29481 is intended to facilitate interoperability and reusability of

				IDM specifications. It promotes digital collaboration between actors in the construction process and provides a basis for accurate, reliable, repeatable and high-quality information exchange.
69.		(WI=00442030) Building Information Modelling – Level of information need – Part 2: Guidance for application	Preliminary	
70.		(WI=00442027) BIM in infrastructure – standardization need and recommendations	Preliminary	
71.		(WI=00442035) Building information modelling (BIM) — Data templates for construction objects used in the life cycle of built assets — Data templates based on European standards and technical specifications	Preliminary	
72.		(WI=00442029) Building Information Modelling – Level of information need – Part 3: Data Schema	Preliminary	
73.		(WI=00442032) Common Data Environments (CDE) for BIM projects –Open data exchange between platforms of different vendors via an open CDE API	Preliminary	

74.	CEN/TC 169 Light and lighting	EN 15193-1:2017 Energy performance of buildings - Energy requirements for lighting - Part 1: Specifications, Module M9	published	This standard specifies the methodology for evaluating the energy performance of lighting systems for providing general illumination in residential and non-residential buildings and for calculating or measuring the amount of energy required or used for lighting in buildings. The method may be applied to new, existing or refurbished buildings. It also provides a methodology (LENI) as the measure of the energy efficiency of the lighting installations in buildings.
75.		CEN/TR 15193-2:2017 Energy performance of buildings - Energy requirements for lighting - Part 2: Explanation and justification of EN 15193-1, Module M9	published	This Technical Report will provide information to support the correct understanding, use and national implementations of EN 15193–1. It will give explanations on the procedures and background information. It will also provide justifications of the choices that have been made and give validations of the calculation procedures given in the standards.
76.		EN 17037:2018 Daylight in buildings	published	This document specifies elements for achieving, by means of natural light, an adequate subjective impression of lightness indoors, and for providing an adequate view out. In addition, recommendations for the duration of sunshine exposure within occupied rooms are given. This document gives information on how to use daylighting to provide lighting within interiors, and how to limit glare. This document defines metrics used for the evaluation of daylighting conditions and gives principles of calculation and verification.
77.		CEN/TS 17623 BIM Properties for lighting - Luminaires and sensing devices	published	This document identifies and clarifies lighting properties for digital building design and maintenance. This document provides all the needed properties to design and to describe luminaires and sensing devices. These properties are intended to be used as mapping properties for property providers and requesters. The mapping of the identifiers enables the exchange of luminaire and sensing device data within different databases.

				The unambiguous mapping and description of properties improve the data quality, reduce misinterpretations and the processing time in digital environments. Therefore, the properties listed in this document establish the essential description of luminaires and sensing devices in BIM systems and databases. The listed properties in this document are used to structure the product data sheet which is complemented with real product information.
78.	ISO/TC 10/SC 10 Process plant documentation	ISO 81346-12:2018 Industrial systems, installations and equipment and industrial products — Structuring principles and reference designations — Part 12: Construction works and building services	published	This document establishes rules for structuring of systems and the formulation of reference designations and provides classes for systems in the field of construction works and building services. This document also specifies a classification of objects and corresponding letter codes for use in reference designations of object occurences.
79.	ISO/TC 59/SC 13 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)	ISO/TS 12911:2012 Framework for building information modelling (BIM) guidance	published	It establishes a framework for providing specifications for the commissioning of building information modelling (BIM).
80.		ISO 16354:2013 Guidelines for knowledge libraries and object libraries	published	The aim of ISO 16354:2013 is to distinguish categories of knowledge libraries and to lay the foundation for uniform structures and content of such knowledge libraries and for commonality in their usage.
81.		ISO 16739-1:2018 Industry Foundation Classes (IFC) for data sharing in the	published	The Industry Foundation Classes, IFC, are an open international standard for Building Information Model (BIM) data that are exchanged and shared among software applications used by

		construction and facility management industries — Part 1: Data schema		the various participants in the construction or facility management industry sector. The standard includes definitions that cover data required for buildings over their life cycle. This release, and upcoming releases, extend the scope to include data definitions for infrastructure assets over their life cycle as well. The Industry Foundation Classes specify a data schema and an exchange file format structure. The data schema is defined in - EXPRESS data specification language, defined in ISO 10303-11, - XML Schema definition language (XSD), defined in XML Schema W3C Recommendation, whereas the EXPRESS schema definition is the source and the XML schema definition is generated from the EXPRESS schema according to the mapping rules defined in ISO 10303-28. The exchange file formats for exchanging and sharing data according to the conceptual schema are - Clear text encoding of the exchange structure, defined in ISO 10303-21, - Extensible Markup Language (XML), defined in XML W3C Recommendation. Alternative exchange file formats may be used if they conform to the data schemas. ISO 16739-1:2017 of IFC consists of the data schemas, represented as an EXPRESS schema and an XML schema, and reference data, represented as definitions of property and quantity names, and formal and informative descriptions.

				A subset of the data schema and referenced data is referred to as a Model View Definition (MVD). A particular MVD is defined to support one or many recognized workflows in the construction and facility management industry sector. Each workflow identifies data exchange requirements for software applications. Conforming software applications need to identity the model view definition they conform to.
82.		ISO 16757-1:2015 Data structures for electronic product catalogues for building services — Part 1: Concepts, architecture and model	published	The primary purpose of ISO 16757 is the provision of data structures for electronic product catalogues to transmit building services product data automatically into models of building services software applications. This includes a meta model for the specification of product classes and their properties and a meta model for the product data which is exchanged in product catalogues. Product data has to follow the specifications for their product groups. ISO 16757-1:2015 specifies the underlying concepts, a generic model specifying the available modelling elements and their relationships, and a framework for the specification of the Content Parts by describing the elements which are to be provided by these Parts.
83.		ISO 16757-2:2016 Data structures for electronic product catalogues for building services — Part 2: Geometry	published	ISO 16757-2:2016 describes the modelling of building services product geometry. The description is optimized for the interchange of product catalogue data and includes - shapes for representing the product itself, - symbolic shapes for the visualization of the product's function in schematic diagrams,

				- spaces for functional requirements, - surfaces for visualization, and - ports to represent connectivity between different objects. The shape and space geometry is expressed as Constructive Solid Geometry (CSG) based on geometric primitives concatenated to boundary representations by Boolean operations. ISO 16757-2:2016 uses the applicable primitives from ISO 10303-42 and from ISO 16739 and adds primitives which are required for the special geometry of building services products. For symbolic shapes, line elements are also used. ISO 16757-2:2016 neither describes the inner structure and internal functionality of the product nor the manufacturing information because this is typically not published within a product catalogue. Building services products can have millions of variant dimensions. To avoid the exchange of millions of geometries, a parametric model is introduced which allows the derivation of variant-specific geometries from the generic model. This is necessary to reduce the data to be exchanged in a catalogue to a manageable size. The parametric model will result in smaller data files, which can be easier transmitted during data exchanges. The geometry model used does not contain any drawing information such as views, line styles or hatching.
84.		ISO 19650-1:2018 Organization and digitization of information about buildings and civil engineering works,	published	This document outlines the concepts and principles for information management at a stage of maturity described as

		including building information modelling (BIM) — Information management using building information modelling — Part 1: Concepts and principles		"building information modelling (BIM) according to the ISO 19650 series". This document provides recommendations for a framework to manage information including exchanging, recording, versioning and organizing for all actors. This document is applicable to the whole life cycle of any built asset, including strategic planning, initial design, engineering, development, documentation and construction, day-to-day operation, maintenance, refurbishment, repair and end-of-life. This document can be adapted to assets or projects of any scale and complexity, so as not to hamper the flexibility and versatility that characterize the large range of potential procurement strategies and so as to address the cost of implementing this document.
85.		ISO 19650-2:2018 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 2: Delivery phase of the assets	published	This document specifies requirements for information management, in the form of a management process, within the context of the delivery phase of assets and the exchanges of information within it, using building information modelling. This document can be applied to all types of assets and by all types and sizes of organizations, regardless of the chosen procurement strategy.
86.		ISO 19650-3:2020 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using	published	This document specifies requirements for information management, in the form of a management process, within the context of the operational phase of assets and the exchanges of information within it, using building information modelling.

		building information modelling — Part 3: Operational phase of the assets		This document can be applied to all types of assets and by organizations of all types and sizes involved in the operational phase of assets. The requirements in this document can be achieved through direct actions carried out by the organization in question or can be delegated to another party.
87.		ISO 19650-5:2020 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 5: Security-minded approach to information management	published	This document specifies the principles and requirements for security-minded information management at a stage of maturity described as "building information modelling (BIM) according to the ISO 19650 series", and as defined in ISO 19650-1, as well as the security-minded management of sensitive information that is obtained, created, processed and stored as part of, or in relation to, any other initiative, project, asset, product or service. It addresses the steps required to create and cultivate an appropriate and proportionate security mindset and culture across organizations with access to sensitive information, including the need to monitor and audit compliance. The approach outlined is applicable throughout the lifecycle of an initiative, project, asset, product or service, whether planned or existing, where sensitive information is obtained, created, processed and/or stored. This document is intended for use by any organization involved in the use of information management and technologies in the creation, design, construction, manufacture, operation, management, modification, improvement, demolition and/or

				recycling of assets or products, as well as the provision of services, within the built environment. It will also be of interest and relevance to those organizations wishing to protect their commercial information, personal information and intellectual property.
88.		ISO 21597-1:2020 Information container for linked document delivery — Exchange specification — Part 1: Container	published	This document defines an open and stable container format to exchange files of a heterogeneous nature to deliver, store and archive documents that describe an asset throughout its entire lifecycle. It is suitable for all parties dealing with information concerning the built environment, where there is a need to exchange multiple documents and their interrelationships, either as part of the process or as contracted deliverables. The format is intended to use resources either included in the container (such as documents) or referenced remotely (such as web resources). A key feature is that the container can include information about the relationships between the documents. Relevant use-cases reflect the need for information exchange during the entire life cycle of any built asset and can include, but are not limited to, the handover of - a published bidding package, - required project deliverables at a specific project stage (e.g. when proposing different design scenarios), - shared information as background or for further development, - published approval packages, or

				- information about versions between partners to provide a means to reference particular states of the information and track changes.
89.		ISO 21597-2:2020 Information container for linked document delivery — Exchange specification — Part 2: Link types	published	This document provides the opportunity to add information about the contents of a container by further specializing the generic types of links specified in ISO 21597-1. The defined link types have been chosen to enhance the use of the container by allowing the addition of semantic relationships that are human interpretable to provide greater clarity about those links.
90.		ISO 22263:2008 Organization of information about construction works — Framework for management of project information	published	It specifies a framework for the organization of project information (process-related as well as product-related) in construction projects.
91.		ISO 23386:2020 Building information modelling and other digital processes used in construction — Methodology to describe, author and maintain properties in interconnected data dictionaries	published	This document establishes the rules for defining properties used in construction and a methodology for authoring and maintaining them, for a confident and seamless digital share among stakeholders following a BIM process. Regarding the definition of properties and groups of properties, this document provides: — definitions of properties and groups of properties as a list of attributes; — definitions of all the provided attributes. Regarding the authoring and maintaining process, this document provides: — definitions and roles of applicants; — definitions and roles of experts and the commission of experts;

				— definitions of request's attributes; — definitions of expert's attributes; — requirements to establish the management rules to interconnect data dictionaries through the mapping process for properties and groups of properties. To apply the methodology of this document, it is presupposed that the following are in place: — an established governance model for a data dictionary; — a framework for a network of data dictionaries. It is not in the scope of this document to provide the content of the interconnected data dictionaries.
92.		ISO 29481-1:2016 Building information models — Information delivery manual — Part 1: Methodology and format	published	ISO 29481-1:2016 specifies - a methodology that links the business processes undertaken during the construction of built facilities with the specification of information that is required by these processes, and - a way to map and describe the information processes across the life cycle of construction works. ISO 29481-1:2016 is intended to facilitate interoperability between software applications used during all stages of the life cycle of construction works, including briefing, design, documentation, construction, operation and maintenance, and demolition. It promotes digital collaboration between actors in the construction process and provides a basis for accurate, reliable, repeatable and high-quality information exchange.
93.		ISO/CD 12006-3 Building construction — Organization of information about	Under development	

		construction works — Part 3: Framework for object-oriented information		
94.		ISO/WD 12911 Framework for building information modelling (BIM) guidance	Under development	
95.		ISO/CD 19650-4 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 4: Information exchange	Under development	
96.		ISO/PRF TR 23262 GIS (geospatial) / BIM interoperability	Under development	
97.		ISO/CD 29481-3 Building information modelling — Information delivery manual — Part 3: Data schema and classification	Under development	
98.	ISO/TC 59/SC 14 Design life	ISO 15686-1:2011 Buildings and constructed assets — Service life planning — Part 1: General principles and framework	published	ISO 15686-1:2011 identifies and establishes general principles for service life planning and a systematic framework for undertaking service life planning of a planned building or construction work throughout its life cycle (or remaining life cycle for existing buildings or construction works).
99.		ISO 15686-2:2012 Buildings and constructed assets — Service life planning — Part 2: Service life prediction procedures	published	ISO 15686-2:2012 describes procedures that facilitate service life predictions of building components, based on technical and functional performance. It provides a general framework, principles and requirements for conducting and reporting such studies.

100.		ISO 15686-3:2002 Buildings and constructed assets — Service life planning — Part 3: Performance audits and reviews	published	ISO 15686-3:2002 is concerned with ensuring the effective implementation of service life planning. It describes the approach and procedures to be applied to pre-briefing, briefing, design, construction and, where required, the life care management and disposal of buildings and constructed assets to provide a reasonable assurance that measures necessary to achieve a satisfactory performance over time will be implemented.
101.		ISO 15686-4:2014 Building Construction — Service Life Planning — Part 4: Service Life Planning using Building Information Modelling	published	ISO 15686-4:2014 provides information and guidance on the use of standards for information exchange for service life planning of buildings and constructed assets and their components as well as the required supporting data. It provides guidance on structuring information from existing data sources to enable delivery of their information content in a structure that conforms to international standards for information exchange.
102.		ISO 15686-5:2017 Buildings and constructed assets — Service life planning — Part 5: Life-cycle costing	published	ISO 15686-5:2017 provides requirements and guidelines for performing life-cycle cost (LCC) analyses of buildings and constructed assets and their parts, whether new or existing.
103.		ISO 15686-7:2017 Buildings and constructed assets — Service life planning — Part 7: Performance evaluation for feedback of service life data from practice	published	ISO 15686-7:2017 provides a generic basis for performance evaluation for feedback of service life data from existing buildings and constructed assets, including a definition of the terms to be used and the description of how the (technical) performance can be described and documented to ensure consistencies.
104.		ISO 15686-8:2008 Buildings and constructed assets — Service-life planning — Part 8: Reference service life and service-life estimation	published	ISO 15686-8:2008 provides guidance on the provision, selection and formatting of reference service-life data and on the application of these data for the purposes of calculating estimated service life using the factor method.

105.		ISO/TS 15686-9:2008 Buildings and constructed assets — Service-life planning — Part 9: Guidance on assessment of service-life data	published	ISO/TS 15686-9:2008 gives guidance for the derivation and presentation of reference service-life data. It is applicable to manufacturers or producers that provide reference service-life data for use in service-life planning in accordance with ISO 15686-1, ISO 15686-2, ISO 15686-3, ISO 15686-5, ISO 15686-6, ISO 15686-7 and ISO 15686-8.
106.		ISO 15686-10:2010 Buildings and constructed assets — Service life planning — Part 10: When to assess functional performance	published	ISO 15686-10:2010 establishes when to specify or verify functional performance requirements during the service life of buildings and building-related facilities, and when to check the capability of buildings and facilities to meet identified requirements.
107.	ISO/TC 59/SC 15 Framework for the description of housing performance	ISO/TR 15686-11:2014 Buildings and constructed assets — Service life planning — Part 11: Terminology	published	ISO/TR 15686-11:2014 provides a compilation of the terms and definitions of concepts that have been standardized to establish a vocabulary applicable to the aspects of both the construction and use of a building or civil engineering works and the service life planning of the same, as applied in the documents of ISO/TC 59/SC 14 Design life.
108.		ISO 9836:2017 Performance standards in building — Definition and calculation of area and space indicators	published	ISO 9836:2017 specifies the definition and calculation of surface area and volume indicators. In defining area measurement, ISO 9836:2017 uses three measurement concepts: a) the intra-muros and extra-muros concept used in many parts of the world; b) the wall centre method of measurement used in many parts of the world; c) variations on these methods to comply with certain national laws or for particular types of buildings.
109.		ISO 11863:2011 Buildings and building-related facilities — Functional and user requirements and performance — Tools for assessment and comparison	published	ISO 11863:2011 specifies how to determine functional performance requirements (demand) for buildings and building-related facilities, and how to check the capability of buildings and facilities to meet identified requirements (supply). It specifies how to determine the relative importance of each requirement, establish thresholds for capability, and evaluate

				the significance of differences between what is required and actual capabilities.
110.		ISO 15928-1:2015 Houses — Description of performance — Part 1: Structural safety	published	ISO 15928-1:2015 sets out a method for describing the structural safety performance of houses. It covers objectives, provides performance descriptions, establishes parameter descriptions, and outlines evaluation processes. It includes a description of permanent, imposed, wind, seismic, snow and other actions as well as structural resistance.
111.		ISO 15928-2:2015 Houses — Description of performance — Part 2: Structural serviceability	published	ISO 15928-2:2015 sets out a method for describing the structural serviceability performance of houses. It covers objectives, provides performance descriptions, establishes parameter descriptions and outlines evaluation processes.
112.		ISO 15928-3:2015 Houses — Description of performance — Part 3: Structural durability	published	ISO 15928-3:2015 sets out a method for describing the structural durability performance of houses. It covers objectives, provides performance descriptions, establishes parameter descriptions and outlines evaluation processes.
113.		ISO 15928-4:2017 Houses — Description of performance — Part 4: Fire safety	published	ISO 15928-4:2017 sets out a method for describing the fire safety performance of houses. It covers user needs, provides performance descriptions, and outlines evaluation processes. It includes the description of relevant parameters for early warning, fire suppression, fire containment, means of escape, control of structural behaviour, and emission and spread of fire effluent.
114.		ISO 15928-5:2013 Houses — Description of performance — Part 5: Operating energy	published	ISO 15928-5:2013 sets out a method for describing the operating energy performance of houses. It covers user needs, provides performance descriptions and outlines evaluation processes. It includes the description of relevant parameters for external and internal climatic conditions, user functional

				requirements, energy used by the house and energy generated by the house.
115.		ISO/DIS 15928-6 Houses — Description of performance — Part 6: Contribution to sustainable development	Under development	
116.		ISO/DIS 15928-7 Houses — Description of performance — Part 7: Accessibility and usability	Under development	This document sets out a method for describing the performance of houses. It covers user needs, provides performance descriptions, and outlines evaluation processes. It includes the description of relevant parameters necessary to ensure accessibility and usability in houses. It also includes features to ensure safety during daily use, i.e., reasonable consideration to prevent accident like tripping, falls, or collision. This document is intended for use in the evaluation of the design and construction of houses, in the international trading of houses or their sub-systems, and in developing risk-management tools for the protection of houses. It does not specify a level of performance and it is not intended to provide design method and/or criteria.
117.		ISO 19208:2016 Framework for specifying performance in buildings	published	ISO 19208:2016 provides the framework for specifying the performance of a building as a whole or a part thereof in order to satisfy specified user requirements and societal expectations. ISO 19208:2016 covers buildings as constructed and inbuilt fixed components. It does not cover a) the use of the land for buildings, b) the design and operation of the environment within which buildings are located, and c) moveable contents within buildings.
118.	ISO/TC 59/SC 16 Accessibility and	ISO 21542:2011 Building construction — Accessibility and usability of the built environment	published	ISO 21542:2011 specifies a range of requirements and recommendations for many of the elements of construction, assemblies, components and fittings which comprise the built environment. These requirements relate to the constructional

	usability of the built environment			aspects of access to buildings, to circulation within buildings, to egress from buildings in the normal course of events and evacuation in the event of an emergency. It also deals with aspects of accessibility management in buildings.
119.	ISO/TC 59/SC 17 Sustainability in buildings and civil engineering works	ISO/TS 12720:2014 Sustainability in buildings and civil engineering works — Guidelines on the application of the general principles in ISO 15392	published	SO/TS 12720:2014 provides guidance for the application of the general principles of sustainability in buildings and civil engineering works elaborated in ISO 15392. It shows the different actors involved with the construction works how to take these principles into account in their decision-making processes in order to increase the contribution of the construction works to sustainability and sustainable development.
120.		ISO 15392:2019 Sustainability in buildings and civil engineering works — General principles	published	This document identifies and establishes general principles for the contribution of buildings, civil engineering works and other types of construction works (hereinafter referred to collectively as construction works) to sustainable development. It is based on the concept of sustainable development as it applies to the life cycle of construction works, from inception to the end-of-life.
121.		ISO 16745-1:2017 Sustainability in buildings and civil engineering works — Carbon metric of an existing building during use stage — Part 1: Calculation, reporting and communication	published	ISO 16745-1:2017 provides requirements for determining and reporting a carbon metric of an existing building, associated with the operation of the building. It sets out methods for the calculation, reporting and communication of a set of carbon metrics for GHG emissions arising from the measured energy use during the operation of an existing building, the measured user-related energy use, and other relevant GHG emissions and removals.
122.		ISO 16745-2:2017 Sustainability in buildings and civil engineering works — Carbon metric of an existing building during use stage — Part 2: Verification	published	ISO 16745-2:2017 specifies requirements for the verification of a carbon metric calculation for GHG emissions of an existing building during the use stage, where the carbon metric calculation is performed in accordance with ISO 16745‑1.

123.		ISO 20887:2020 Sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance	published	This document provides an overview of design for disassembly and adaptability (DfD/A) principles and potential strategies for integrating these principles into the design process.
124.		ISO 21678:2020 Sustainability in buildings and civil engineering works — Indicators and benchmarks — Principles, requirements and guidelines	published	This document defines principles, requirements and guidelines for the development and use of benchmarks when assessing the economic, social and/or environmental performance of buildings and civil engineering works by using sustainability indicators. It complements and supports the application of ISO 21929-1 and ISO/TS 21929-2 by creating principles and requirements for the establishment of benchmarks that support target setting, decision making and communication to third parties.
125.		ISO/WD 21928-2 Sustainability in buildings and civil engineering works — Sustainability indicators — Part 2: Framework for the development of indicators for civil engineering works	Under development	
126.		ISO 21929-1:2011 Sustainability in building construction — Sustainability indicators — Part 1: Framework for the development of indicators and a core set of indicators for buildings	published	ISO 21929-1:2011 establishes a core set of indicators to take into account in the use and development of sustainability indicators for assessing the sustainability performance of new or existing buildings, related to their design, construction, operation, maintenance, refurbishment and end of life. Together, the core set of indicators provides measures to express the contribution of a building(s) to sustainability and sustainable development. These indicators represent aspects of buildings that impact on areas of protection related to sustainability and sustainable development.

127.		ISO/TS 21929-2:2015 Sustainability in building construction — Sustainability indicators — Part 2: Framework for the development of indicators for civil engineering works	published	ISO/TS 21929-2:2015 establishes a list of aspects and impacts which should be taken as the basis for the development of sustainability indicators for assessing the sustainability performance of new or existing civil engineering works, related to their design, construction, operation, maintenance, refurbishment and end-of-life. Together, the indicators developed from this list of aspects and impacts provide measures to express the contribution of a civil engineering works to sustainability and sustainable development.
128.		ISO 21930:2017 Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services	published	ISO 21930:2017 provides the principles, specifications and requirements to develop an environmental product declaration (EPD) for construction products and services, construction elements and integrated technical systems used in any type of construction works.
129.		ISO 21931-1:2010 Sustainability in building construction — Framework for methods of assessment of the environmental performance of construction works — Part 1: Buildings	published	ISO 21931-1:2010 provides a general framework for improving the quality and comparability of methods for assessing the environmental performance of buildings and their related external works. It identifies and describes issues to be taken into account in the use and development of methods of assessment of the environmental performance for new or existing buildings in their design, construction, operation, maintenance and refurbishment, and in the deconstruction stages.
130.		ISO 21931-2:2019 Sustainability in buildings and civil engineering works — Framework for methods of assessment of the environmental, social and economic performance of construction works as a basis for sustainability assessment — Part 2: Civil engineering works	published	This document provides a general framework for improving the quality and comparability of methods for assessing the contribution of civil engineering works and their related external works to sustainable development based on a life cycle approach. This document aims to bridge the gap between regional and national methods for the assessment of the sustainability performance of civil engineering works by providing a common framework for their expression.

131.		ISO/TR 21932:2013 Sustainability in buildings and civil engineering works — A review of terminology	published	ISO/TR 21932:2013 provides a compilation of terms and definitions of concepts related to both the construction and use of a building or civil engineering works, and the effect of such construction works on sustainability and sustainable development, as applied in the documents of ISO/TC 59/SC 17, Sustainability in buildings and civil engineering works.
132.		ISO/DIS 22057 Sustainability in buildings and civil engineering works – Data templates for the use of EPDs for construction products in BIM	Under development	This document provides the principles and requirements to enable environmental and technical data provided in environmental product declarations (EPDs) for construction products and services, construction elements and integrated technical systems to be used in building information modelling (BIM) to assist in the assessment of the environmental performance of the construction works over its life cycle. The mechanism used in this document to enable this is a data template created following ISO 23386 and ISO 23387 and the resulting data sheet. This includes both mandatory and optional data from different types of EPD, such as generic, specific, average and representative, and other relevant information necessary for use of EPDs at the construction works level within a BIM environment. This document gives requirements on structuring EPD information using a data template, to make EPD data machine-interpretable, and enable their integration into information-driven design, construction and operational processes. This document is also appropriate to structure generic life cycle assessment (LCA) data for use within a BIM environment, as these data are required in the absence of suitable EPD data to enable assessment of the environmental performance at the construction works level.

133.	ISO/TC 211 Geographic information/Geomatics	ISO/TS 19158:2012 Geographic information — Quality assurance of data supply	published	ISO/TS 19158:2012 provides a framework for quality assurance specific to geographic information. It is based upon the quality principles and quality evaluation procedures of geographic information identified in ISO 19157 and the general quality management principles defined in ISO 9000.
134.		ISO/TS 19159-1:2014 Geographic information — Calibration and validation of remote sensing imagery sensors and data — Part 1: Optical sensors	published	ISO/TS 19159-1:2014 defines the calibration and validation of airborne and spaceborne remote sensing imagery sensors. The term "calibration" refers to geometry, radiometry, and spectral, and includes the instrument calibration in a laboratory as well as in situ calibration methods. The validation methods address validation of the calibration information.
135.		ISO/TS 19159-2:2016 Geographic information — Calibration and validation of remote sensing imagery sensors and data — Part 2: Lidar	published	ISO/TS 19159-2:2016 defines the data capture method, the relationships between the coordinate reference systems and their parameters, as well as the calibration of airborne lidar (light detection and ranging) sensors. ISO/TS 19159-2:2016 also standardizes the service metadata for the data capture method, the relationships between the coordinate reference systems and their parameters and the calibration procedures of airborne lidar systems as well as the associated data types and code lists that have not been defined in other ISO geographic information international standards.
136.		ISO/TS 19159-3:2018 Geographic information — Calibration and validation of remote sensing imagery sensors and data — Part 3: SAR/InSAR	published	This document defines the calibration of SAR/InSAR sensors and validation of SAR/InSAR calibration information. This document addresses earth based remote sensing. The specified sensors include airborne and spaceborne SAR/InSAR sensors. This document also addresses the metadata related to calibration and validation.
137.		ISO/DTS 19159-4 Geographic information — Calibration and validation of remote sensing imagery sensors —	Under development	

		Part 4: Space-borne passive microwave radiometers		
138.		ISO/TS 19163-1:2016 Geographic information — Content components and encoding rules for imagery and gridded data — Part 1: Content model	published	ISO/TS 19163-1:2016 classifies imagery and regularly spaced gridded thematic data into types based on attribute property, sensor type and spatial property, and defines an encoding-neutral content model for the required components for each type of data. It also specifies logical data structures and the rules for encoding the content components in the structures.
139.		ISO/TS 19163-2:2020 Geographic information — Content components and encoding rules for imagery and gridded data — Part 2: Implementation schema	published	This document specifies an implementation schema based on the content models for geographic imagery and gridded thematic data defined in the ISO/TS 19163-1. This document defines a structure that is suitable for binding content components and specific encoding formats. It also provides an implementation schema for binding a concrete, implementable, conformance-testable coverage structure as defined in ISO 19123-2.
140.		ISO 19165-1:2018 Geographic information — Preservation of digital data and metadata — Part 1: Fundamentals	published	ISO 19165-1:2018 defines a preservation metadata extension of ISO 19115-1. ISO 19165-1:2018 defines the requirements for the long-term preservation of digital geospatial data. These data also include metadata, representation information, provenance, context and any other content items that capture the knowledge that are necessary to fully understand and reuse the archived data. This document also refers to characteristics of data formats that are useful for the purpose of archiving.
141.		ISO/PRF TS 19166 Geographic information — BIM to GIS conceptual mapping (B2GM)	Under development	
142.		ISO 19116:2019 Geographic information — Positioning services	published	This document specifies the data structure and content of an interface that permits communication between position-providing

				device(s) and position-using device(s) enabling the position-using device(s) to obtain and unambiguously interpret position information and determine, based on a measure of the degree of reliability, whether the resulting position information meets the requirements of the intended use.
143.		ISO/TR 19121:2000 Geographic information — Imagery and gridded data	published	This Technical Report reviews the manner in which raster and gridded data is currently being handled in the Geomatics community in order to propose how this type of data should be supported by geographic information standards. This Technical Report identifies those aspects of imagery and gridded data that have been standardized or are being standardized in other ISO committees and external standards organizations, and that influence or support the establishment of raster and gridded data standards for geographic information. It also describes the components of those identified ISO and external imagery and gridded data standards that can be harmonized with the ISO 19100 series of geographic information/geomatics standards. A plan is presented for ISO/TC 211 to address imagery and gridded data in an integrated manner, within the ISO 19100 series of geographic information standards.
144.		ISO/AWI TS 19124-1 Geographic information — Calibration and validation of remote sensing data and derived products — Part 1: Fundamentals	Under development	
145.		ISO/TS 19129:2009 Geographic information — Imagery, gridded and coverage data framework	published	ISO/TS 19129:2009 defines the framework for imagery, gridded and coverage data. This framework defines a content model for the content type imagery and for other specific content types that can be represented as coverage data. These content models are represented as a set of generic UML patterns for application schemas.

146.		ISO 19130-1:2018 Geographic information — Imagery sensor models for geopositioning — Part 1: Fundamentals	published	This document identifies the information required to determine the relationship between the position of a remotely sensed pixel in image coordinates and its geoposition. It supports exploitation of remotely sensed images. It defines the metadata to be distributed with the image to enable user determination of geographic position from the observations.
147.		ISO/PRF TS 19130-3 Geographic information — Imagery sensor models for geopositioning — Part 3: Implementation Schema	Under development	This Technical Specification defines the XML Schema implementation of imagery sensor geopositioning models defined in ISO 19130-1:2018 Geographic information — Imagery sensor models for geopositioning — Part 1: Fundamentals, and ISO/TS 19130-2:2014 Geographic information — Imagery sensor models for geopositioning — Part 2: SAR, InSAR, lidar and sonar. It applies XML Schema inheritance and extension based on the OGC SensorML and OGC SWE Common Data Model. Instead of introducing an XML Schema based on the UML models defined in ISO 19130-1 and ISO 19130-2, it leverages the existing OGC SensorML by first introducing a semantic mapping from the model elements defined in 19130-1 and 19130-2 to OGC SensorML, and then defining the detailed schema inheritance and extensions based on OGC SensorML to fully support encoding of the imagery sensor models for geopositioning defined in ISO 19130-1 and ISO 19130-2.
148.	ISO/TC 258 Project, programme and portfolio management	ISO 21500:2012(en) Guidance on project management (ISO/DIS 21500(en))	published	This International Standard provides guidance on concepts and processes of project management that are important for, and have impact on, the performance of projects.
149.	ISO/IEC JTC 1 Information technology	ISO/IEC 20922:2016 Information technology — Message Queuing Telemetry Transport (MQTT) v3.1.1	published	ISO/IEC 20922:2016 is a Client Server publish/subscribe messaging transport protocol. It is light weight, open, simple, and designed so as to be easy to implement. These characteristics make it ideal for use in many situations, including

				constrained environments such as for communication in Machine to Machine (M2M) and Internet of Things (IoT) contexts where a small code footprint is required and/or network bandwidth is at a premium.
150.	ISO/IEC JTC 1/SC 24 Computer graphics, image processing and environmental data representation	ISO/IEC WD 3721-2 Information model for mixed and augmented reality: — Part 2: Augmentation Style Specification	Under development	
151.		ISO/IEC 18025:2014 Information technology — Environmental Data Coding Specification (EDCS)	published	ISO/IEC 18025:2014 provides mechanisms to specify unambiguously objects used to model environmental concepts.
152.		ISO/IEC 18026:2009 Information technology — Spatial Reference Model (SRM)	published	ISO/IEC 18026:2009 specifies the Spatial Reference Model (SRM) defining relevant aspects of spatial positioning and related information processing. The SRM allows precise and unambiguous specification of geometric properties such as position (location), direction, and distance.
153.		ISO/IEC 18038:2020 Information technology — Computer graphics, image processing and environmental representation — Sensor representation in mixed and augmented reality	published	This document defines the framework and information reference model for representing sensor-based 3D mixed-reality worlds. It defines concepts, an information model, architecture, system functions, and how to integrate 3D virtual worlds and physical sensors in order to provide mixed-reality applications with physical sensor interfaces. It defines an exchange format necessary for transferring and storing data between physical sensor-based mixed-reality applications.
154.		ISO/IEC 18039:2019 Information technology — Computer graphics, image processing and environmental data representation — Mixed and	published	This document defines the scope and key concepts of mixed and augmented reality, the relevant terms and their definitions and a generalized system architecture that together serve as a reference model for mixed and augmented reality (MAR)

		augmented reality (MAR) reference model		applications, components, systems, services and specifications. This architectural reference model establishes the set of required sub-modules and their minimum functions, the associated information content and the information models to be provided and/or supported by a compliant MAR system.
155.		ISO/IEC 18040:2019 Information technology — Computer graphics, image processing and environmental data representation — Live actor and entity representation in mixed and augmented reality (MAR)	published	This document defines a reference model and base components for representing and controlling a single LAE or multiple LAEs in an MAR scene. It defines concepts, a reference model, system framework, functions and how to integrate a 2D/3D virtual world and LAEs, and their interfaces, in order to provide MAR applications with interfaces of LAEs. It also defines an exchange format necessary for transferring and storing LAE-related data between LAE-based MAR applications.
156.		ISO/IEC 18520:2019 Information technology — Computer graphics, image processing and environmental data representation — Benchmarking of vision-based spatial registration and tracking methods for mixed and augmented reality (MAR)	published	This document identifies the reference framework for the benchmarking of vision-based spatial registration and tracking (vSRT) methods for mixed and augmented reality (MAR). The framework provides typical benchmarking processes, benchmark indicators and trial set elements that are necessary to successfully identify, define, design, select and apply benchmarking of vSRT methods for MAR. It also provides definitions for terms on benchmarking of vSRT methods for MAR. In addition, this document provides a conformance checklist as a tool to clarify how each benchmarking activity conforms to this document in a compact form by declaring which benchmarking processes and benchmark indicators are included and what types of trial sets are used in each benchmarking activity.
157.		ISO/IEC 19775-1:2013 Information technology — Computer graphics, image processing and environmental	published	ISO/IEC 19775, X3D, defines a software system that integrates network-enabled 3D graphics and multimedia. Conceptually, each X3D application is a 3D time-based space that contains

		data representation — Extensible 3D (X3D) — Part 1: Architecture and base components		graphic and aural objects that can be dynamically modified through a variety of mechanisms. ISO/IEC 19775-1:2013 defines the architecture and base components of X3D.
158.		ISO/IEC 19775-2:2015 Information technology — Computer graphics, image processing and environmental data representation — Extensible 3D (X3D) — Part 2: Scene access interface (SAI)	published	ISO/IEC 19775-2:2015 specifies a standard set of services that are made available by a browser so that an author can access the scene graph while it is running. Such access is designed to support inspection and modification of the scene graph.
159.		ISO/IEC CD 23488 Information technology — Computer graphics, image processing and environmental data representation — Image based Object/Environmental for Virtual/Mixed and Augmented Reality (VR/MAR)	Under development	
160.		ISO/IEC AWI 23763 Information technology — Computer graphics, image processing and environmental data representation — Display device interface for mixed and augmented reality	Under development	
161.		ISO/IEC CD TS 23884 Information technology — Computer graphics, image processing and environmental data representation — Material Property and Parameter Representation for Model based Haptic Simulation of Objects in Virtual, Mixed and Augmented Reality (VR, MAR)	Under development	

162.	ISO/IEC JTC 1/SC 41 Internet of Things and digital twin	ISO/IEC NP 30173 Digital twin — Concepts and terminology	Under development	This document establishes terminology for Digital Twin and describes concepts in the field of Digital Twin, including the terms and definitions of Digital Twin, concepts of Digital Twin (e.g., Digital Twin ecosystem, lifecycle process for Digital Twin, and classifications of Digital Twin), Functional view of Digital Twin and Digital Twin stakeholders. This document can be used in the development of other standards and in support of communications among diverse, interested parties/stakeholders. This document is applicable to all types of organizations (e.g., commercial enterprises, government agencies, not-for-profit organizations).
163.		ISO/IEC 20005:2013 Information technology — Sensor networks — Services and interfaces supporting collaborative information processing in intelligent sensor networks	published	ISO/IEC 20005:2013 specifies services and interfaces supporting collaborative information processing (CIP) in intelligent sensor networks which includes: - CIP functionalities and CIP functional model, - common services supporting CIP, - common service interfaces to CIP.
164.		ISO/IEC 20924:2018 Information technology — Internet of Things (IoT) — Vocabulary	published	ISO/IEC 20924:2018(E) provides a definition of Internet of Things along with a set of terms and definitions forming a terminology foundation for the Internet of Things
165.		ISO/IEC 21823-1:2019 Internet of things (IoT) — Interoperability for IoT systems — Part 1: Framework	published	ISO/IEC 21823-1:2019(E) provides an overview of interoperability as it applies to IoT systems and a framework for interoperability for IoT systems. This document enables IoT systems to be built in such a way that the entities of the IoT system are able to exchange information and mutually use the information in an efficient way.
166.		ISO/IEC 21823-2:2020 Internet of things (IoT) — Interoperability for IoT systems — Part 2: Transport interoperability	published	ISO/IEC 21823-2:2020(E) specifies a framework and requirements for transport interoperability, in order to enable the construction of IoT systems with information exchange, peer-to-peer connectivity and seamless communication both between

				different IoT systems and also among entities within an IoT system.
167.		ISO/IEC TR 22417:2017 Information technology — Internet of things (IoT) use cases	published	ISO/IEC TR 22417:2017(E) This technical report identifies IoT scenarios and use cases based on real-world applications and requirements. The use cases provide a practical context for considerations on interoperability and standards based on user experience.
168.		ISO/IEC 29182-1:2013 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 1: General overview and requirements	published	ISO/IEC 29182-1:2013 provides a general overview of the characteristics of a sensor network and the organization of the entities that comprise such a network. It also describes the general requirements that are identified for sensor networks.
169.		ISO/IEC 29182-2:2013 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 2: Vocabulary and terminology	published	ISO/IEC 29182-2:2013 is intended to facilitate the development of International Standards in sensor networks. It presents terms and definitions for selected concepts relevant to the field of sensor networks. It establishes a general description of concepts in this field and identifies the relationships among those concepts.
170.		ISO/IEC 29182-3:2014 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 3: Reference architecture views	published	ISO/IEC 29182-3:2014 provides Sensor Network Reference Architecture (SNRA) views. The architecture views include business, operational, systems, and technical perspectives, and these views are presented in functional, logical, and/or physical views where applicable.
171.		ISO/IEC 29182-4:2013 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 4: Entity models	published	ISO/IEC 29182-4 presents models for the entities that enable sensor network applications and services according to the Sensor Network Reference Architecture (SNRA).
172.		ISO/IEC 29182-5:2013 Information technology — Sensor networks: Sensor	published	ISO/IEC 29182-5:2013 provides the definitions and requirements of sensor network (SN) interfaces of the entities in

		Network Reference Architecture (SNRA) — Part 5: Interface definitions		the Sensor Network Reference Architecture and covers the following aspects: - interfaces between functional layers to provide service access for the modules in the upper layer to exchange messages with modules in the lower layer; - interfaces between entities introduced in the Sensor Network Reference Architecture enabling sensor network services and applications.
173.		ISO/IEC 29182-6:2014 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 6: Applications	published	ISO/IEC 29182-6:2014, describes and provides a compilation of sensor network applications for which International Standardized Profiles (ISPs) are needed, guidelines for the structured description of sensor network applications, and examples for structured sensor network applications.
174.		ISO/IEC 29182-7:2015 Information technology — Sensor networks: Sensor Network Reference Architecture (SNRA) — Part 7: Interoperability guidelines	published	ISO/IEC 29182-7:2015 provides a general overview and guidelines for achieving interoperability between sensor network services and related entities in a heterogeneous sensor network.
175.		ISO/IEC 30101:2014 Information technology — Sensor networks: Sensor network and its interfaces for smart grid system	published	ISO/IEC 30101:2014 is for sensor networks in order to support smart grid technologies for power generation, distribution, networks, energy storage, load efficiency, control and communications, and associated environmental challenges. This International Standard characterizes the requirements for sensor networks to support the aforementioned applications and challenges.
176.		ISO/IEC 30128:2014 Information technology — Sensor networks — Generic Sensor Network Application Interface	published	ISO/IEC 30128:2014 specifies the interfaces between the application layers of service providers and sensor network gateways, which is Protocol A in interface 3, defined in ISO/IEC 29182-5. This International Standard covers: - description of generic sensor network applications' operational requirements, - description of sensor network capabilities, and - mandatory and

				optional interfaces between the application layers of service providers and sensor network gateways
177.		ISO/IEC 30141:2018 Internet of Things (IoT) — Reference Architecture	published	ISO/IEC 30141:2018 This document provides a standardized IoT Reference Architecture using a common vocabulary, reusable designs and industry best practices.
178.		ISO/IEC AWI 30147 Information technology — Internet of things — Methodology for trustworthiness of IoT system/service	Under development	
179.		ISO/IEC AWI 30149 Internet of things (IoT) — Trustworthiness framework	Under development	
180.		ISO/IEC 30161 Internet of Things (IoT) — Requirements of IoT data exchange platform for various IoT services	published	The document specifies requirements for an Internet of Things (IoT) data exchange platform for various services in the technology areas of: - the middleware components of communication networks allowing the co-existence of IoT services with legacy services; - the end-points performance across the communication networks among the IoT and legacy services; - the IoT specific functions and functionalities allowing the efficient deployment of IoT services; - the IoT service communication networks, - framework and infrastructure; - the IoT service implementation guideline for the IoT data exchange platform
181.		ISO/IEC 30163 Internet of Things (IoT) — System requirements of IoT/SN technology-based integrated platform for chattel asset monitoring supporting financial services	Under development	
182.		ISO/IEC AWI 30165 Internet of Things (IoT) — Real-time IoT framework	Under development	

183.	ISO/IEC JTC 1/SC 42 Artificial intelligence	ISO/IEC WD 5339 Information Technology — Artificial Intelligence — Guidelines for AI applications	Under development	Provide a set of guidelines for identifying the context, opportunities, and processes for developing and applying AI Applications. It can be used by ISO, IEC, and JTC1 Technical Committees and Sub-Committees to build on this work in developing standards for AI Applications in their areas of interest. The guidelines provide a macro level view of the AI Application context, the stakeholders and their roles, relationship to the life cycle of the system, and common AI application characteristics. The guidelines will reference but not duplicate or overlap other AI-related standards to build details.
184.		ISO/IEC WD 5392 Information technology — Artificial intelligence — Reference architecture of knowledge engineering	Under development	This document defines a reference architecture of Knowledge Engineering (KE) in Artificial Intelligence (AI). The reference architecture describes KE roles, activities, constructional layers, components and their relationships from user and functional views. This document also provides a common KE vocabulary by defining KE terms.
185.		ISO/IEC AWI TR 5469 Artificial intelligence — Functional safety and AI systems	Under development	
186.		ISO/IEC 20546:2019 Information technology — Big data — Overview and vocabulary	published	This document provides a set of terms and definitions needed to promote improved communication and understanding of this area. It provides a terminological foundation for big data-related standards.
187.		ISO/IEC TR 20547-1:2020 Information technology — Big data reference architecture — Part 1: Framework and application process	published	This document describes the framework of the big data reference architecture and the process for how a user of the document can apply it to their particular problem domain.

188.		ISO/IEC TR 20547-2:2018 Information technology — Big data reference architecture — Part 2: Use cases and derived requirements	published	ISO/IEC TR 20547-2:2018 provides examples of big data use cases with application domains and technical considerations derived from the contributed use cases.
189.		ISO/IEC 20547-3:2020 Information technology — Big data reference architecture — Part 3: Reference architecture	published	This document specifies the big data reference architecture (BDRA). The reference architecture includes concepts and architectural views.
190.		ISO/IEC TR 20547-5:2018 Information technology — Big data reference architecture — Part 5: Standards roadmap	published	ISO/IEC TR 20547-5:2018 describes big data relevant standards, both in existence and under development, along with priorities for future big data standards development based on gap analysis.
191.		ISO/IEC CD 22989.2 Artificial intelligence — Concepts and terminology	Under development	
192.		ISO/IEC CD 23894 Information Technology — Artificial Intelligence — Risk Management	Under development	
193.		ISO/IEC TR 24028:2020 Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence	published	This document surveys topics related to trustworthiness in AI systems, including the following: — approaches to establish trust in AI systems through transparency, explainability, controllability, etc.; — engineering pitfalls and typical associated threats and risks to AI systems, along with possible mitigation techniques and methods; — approaches to assess and achieve availability, resiliency, reliability, accuracy, safety, security and privacy of AI systems.
194.		ISO/IEC CD TR 24030 Information technology — Artificial Intelligence (AI) — Use cases	Under development	

195.		ISO/IEC AWI TR 24368 Information technology — Artificial intelligence — Overview of ethical and societal concerns	Under development	
196.		ISO/IEC DTR 24372 Information technology — Artificial intelligence (AI) — Overview of computational approaches for AI systems	Under development	
197.		ISO/IEC CD 24668 Information technology — Artificial intelligence — Process management framework for Big data analytics	Under development	
198.		ISO/IEC AWI 25059 Software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality model for AI-based systems	Under development	
199.		ISO/IEC WD 42001 Information Technology — Artificial intelligence — Management system	Under development	The document will contain AI specific process requirements which would allow for assessment or conformance of auditability of the processes. It will also and provide guidance for establishing, implementing, maintaining and continually improving an artificial intelligence management system within the context of an organization. The standard will help organizations develop or use AI responsibly in pursuing their objectives, and to meet applicable regulatory requirements, obligations related to interested parties and expectations from them.
200.	ISO/TC 184/SC 4 Industrial data	ISO/TS 8000 Data quality management (series of standards)	published	ISO 8000 is the global standard for Data Quality and Enterprise Master Data. It describes the features and defines the

				requirements for standard exchange of Master Data among business partners. It establishes the concept of Portability as a requirement for Enterprise Master Data, and the concept that true Enterprise Master Data is unique to each organization. Master Data is commonly used to manage critical business information about products, services and materials, constituents, clients and counterparties, and for certain immutable transactional and operational records.
201.		ISO/DIS 23247-1 Automation systems and integration — Digital Twin framework for manufacturing — Part 1: Overview and general principles	Under development	This part of ISO 23247 provides an overview and general principles of a Digital Twin for manufacturing. The ISO 23247 series defines a framework to guide the creation of Digital Twins of observable manufacturing elements including personnel, equipment, materials, processes, facilities, environment, products, and supporting documents. The following are within the scope of this part of ISO 23247: — scope statement for ISO 23247 as a whole; — terms and definitions used throughout ISO 23247; — overview and requirements of the Digital Twin framework for manufacturing.
202.		ISO/DIS 23247-2 Automation systems and integration — Digital Twin framework for manufacturing — Part 2: Reference architecture	Under development	This part of ISO 23247 provides a reference architecture for the Digital Twin in manufacturing. The ISO 23247 series defines a framework to guide the creation of Digital Twins of observable manufacturing elements including personnel, equipment, materials, processes, facilities, environment, products, and supporting documents. The following are within the scope of this part of ISO 23247: — reference architecture goals and objectives; — reference model; — functional view.
203.		ISO/DIS 23247-3 Automation systems and integration — Digital Twin framework for manufacturing — Part 3:	Under development	This part of ISO 23247 provides a list of basic information attributes for the observable manufacturing elements. The ISO 23247 series defines a framework to guide the creation of Digital Twins of observable manufacturing elements including

		Digital representation of manufacturing elements		personnel, equipment, materials, processes, facilities, environment, products, and supporting documents. The following are within the scope of this part of ISO 23247: — digital representation of observable manufacturing elements.
204.		ISO/DIS 23247-4 Automation systems and integration — Digital Twin framework for manufacturing — Part 4: Information exchange	Under development	This part of ISO 23247 identifies technical requirements for information exchange between entities within the reference architecture. The ISO 23247 series defines a framework to guide the creation of Digital Twins of observable manufacturing elements including personnel, equipment, materials, processes, facilities, environment, products, and supporting documents. The requirements for information exchange in the following networks are within the scope of this part of ISO 23247: — User network that connects the User entity and Core entity; — Service network that connects sub-entities within the Core entity; — Access network that connects the Data collection and device control entity to the Core entity and to the User entity; — Proximity network that connects the Data collection and device control entity to the observable manufacturing elements.
205.		ISO/TR 24464:2020 Automation systems and integration — Industrial data — Visualization elements of digital twins	published	This document analyses visualization elements that are key components of the interface between the physical asset and the avatar (digital replica of the physical asset).
206.	IEC TC 3 Documentation, graphical symbols and representations of technical information	IEC 61335-1 Classification and designation of documents for plants, systems and equipment - Part 1: Rules and classification tables	published	The document describes rules and guidelines for the uniform classification and identification of documents based on their characteristic content of information. It is applied for all documents within the life cycle of a technical products like plants, systems or equipment. It also includes non-technical documents.

207.		IEC 62569-1:2017 Generic specification of information on products by properties - Part 1: Principles and methods	published	IEC 62569-1:2017 specifies several qualifiers to be used with object or (dictionary) properties and their values indicating life cycle and other aspects of the property. It is a prerequisite for the usage of the other parts of IEC 62569. This first edition cancels and replaces IEC PAS 62569-1:2009. This edition constitutes a technical revision.
208.	ISO/TC 159/SC 4 Ergonomics of human-system interaction	ISO 9241-1:1997, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 1: General introduction	published	This part of IS0 9241 - introduces the multipart standard on ergonomic requirements for the use of visual display terminals for office tasks; - provides guidelines for a user-performance approach; - gives an overview of all parts of IS0 9241 currently published and of the anticipated content of those in preparation; - provides some guidance on how to use IS0 9241; - describes how conformance to IS0 9241 should be reported. For the purposes of IS0 9241, office tasks are taken to include a wide range of generic text and data processing tasks. Due to the similarity of these tasks to tasks performed in other environments, e.g. medical, scientific, telecommunications, control rooms and public access, many of the requirements in IS0 9241 are appropriate to these environments as well. IS0 9241 does not cover electrical safety of VDTs.
209.		ISO 9241-1:1997/AMD 1:2001, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 1: General introduction — Amendment 1	published	The goal of this Amendment (complementing ISO 9241-1) is to help readers of ISO 9241-10 to ISO 9241-17 in — gaining an overview on the content of ISO 9241-10 to ISO 9241-17, — understanding the relationship between the individual software parts of ISO 9241, — providing guidance on the relevance of individual parts to the development process, i.e. understanding where and when to use the software parts of ISO 9241, — understanding how to select and combine dialogue techniques which are described in ISO 9241-14 to ISO 9241-17.

210.		ISO 9241-2:1992, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 2: Guidance on task requirements	published	This part of ISO 9241 provides guidelines to users of VDT-based information processing systems with reference to office tasks. This guidance is relevant to both the organization implementing the system and the people using the equipment. The guidance should be applied in accordance with local, regional or national agreements and regulations. The objective of this part of ISO 9241 is to enhance the efficiency and well-being of the individual user by applying ergonomics knowledge in the light of practical experience, to the design of tasks. The ergonomics principles concerned are set out in ISO 6385.
211.		ISO 9241-5:1998, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 5: Workstation layout and postural requirements	published	This part of ISO 9241 specifies ergonomic guiding principles which apply to the user requirements, design, and procurement of workstation equipment for office tasks using VDTs. In particular, the general principles and requirements specified in this part of ISO 9241 apply to the standards specifying technical design of furniture and equipment constituting the workplace.
212.		ISO 9241-6:1999, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 6: Guidance on the work environment	published	This part of ISO 9241 provides guidance on basic principles for the ergonomic design of the work environment and the workstation, taking into account lighting, effects of noise and mechanical vibrations, electrical and magnetic fields and static electricity, thermal environment, space organization and workplace layout. This part of ISO 9241 is applicable to the work environment and workstation in those work systems where a visual display terminal (VDT) is used for office work.
213.		ISO 9241-11:2018, Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts	published	This document provides a framework for understanding the concept of usability and applying it to situations where people use interactive systems, and other types of systems (including built environments), and products (including industrial and consumer products) and services (including technical and personal services). This document: — explains that usability is

				an outcome of use; — defines key terms and concepts; — identifies the fundamentals of usability; and — explains the application of the concept of usability.
214.		ISO 9241-13:1998, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 13: User guidance	published	This part of ISO 9241 provides recommendations for user guidance attributes of software user interfaces and their evaluation. User guidance as defined in this part of ISO 9241 is information additional to the regular user-computer-dialogue that is provided to the user on request or is automatically provided by the system. In addition to the general guidance provided in this part of ISO 9241, recommendations concerning dialogue-specific user guidance are provided in ISO 9241-12, ISO 9241-14, ISO 9241-15, ISO 9241-16 and ISO 9241-17. This part of ISO 9241 is applicable to interaction components that aid users in recovering from error conditions. User guidance as covered by this part of ISO 9241 includes recommendations specific to prompts, feedback and status, error management and on-line help as well as general recommendations common to all these types of user guidance.
215.		ISO 9241-14:1997, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 14: Menu dialogues	published	This part of ISO 9241 provides conditional recommendations for menus used in user-computer dialogues to accomplish typical office tasks. The recommendations cover menus presented by various techniques including windowing, panels, buttons, fields, etc. These recommendations can be utilized throughout the design process (e.g., as guidance for designers during design, as a basis for heuristic evaluation, as guidance for usability testing).
216.		ISO 9241-20:2008, Ergonomics of human-system interaction — Part 20: Accessibility guidelines for	published	This part of ISO 9241 is intended for use by those responsible for planning, designing, developing, acquiring, and evaluating information/communication technology (ICT) equipment and services. It provides guidelines for improving the accessibility of

		information/communication technology (ICT) equipment and services		ICT equipment and services such that they will have wider accessibility for use at work, in the home, and in mobile and public environments. It covers issues associated with the design of equipment and services for people with a wide range of sensory, physical and cognitive abilities, including those who are temporarily disabled, and the elderly.
217.		ISO/DIS 9241-20, Ergonomics of human-system interaction — Part 20: An ergonomic approach to accessibility within the ISO 9241 series	under development	
218.		ISO/TR 9241-100:2010, Ergonomics of human-system interaction — Part 100: Introduction to standards related to software ergonomics	published	This part of ISO 9241 enables users of standards related to software ergonomics to identify ergonomics standards particularly relevant to software development, gain an overview on the content of software-ergonomics standards, understand the role of software-ergonomics standards in specifying user requirements as well as designing and evaluating user interfaces and understand the relationship between the various standards. The software-ergonomics standards are applicable to all those software components of an interactive system affecting usability, including: — application software (including web-based applications); — operating systems; — embedded software; — software development tools; — assistive technologies.
219.		ISO 9241-110:2020, Ergonomics of human-system interaction — Part 110: Interaction principles	published	This document describes principles for interaction between a user and a system that are formulated in general terms (i.e. independent of situations of use, application, environment or technology). This document provides a framework for applying those interaction principles and the general design recommendations for interactive systems.
220.		ISO 9241-112:2017, Ergonomics of human-system interaction — Part 112:	published	This document establishes ergonomic design principles for interactive systems related to the software-controlled

		Principles for the presentation of information		presentation of information by user interfaces. It applies to the three main modalities (visual, auditory, tactile/haptic) typically used in information and communication technology. These principles apply to the perception and understanding of presented information. These principles are applicable in the analysis, design, and evaluation of interactive systems. This document also provides recommendations corresponding to the principles. The recommendations for each of the principles are not exhaustive and are not necessarily independent from one another.
221.		ISO 9241-125:2017, Ergonomics of human-system interaction — Part 125: Guidance on visual presentation of information	published	ISO 9241-125 provides requirements and recommendations for the visual presentation of information and specific properties such as the syntactic or semantic aspects of information, e.g. coding techniques. These requirements and recommendations can be utilised throughout the design process (e.g., as specification and guidance for designers during design or as a basis for heuristic evaluation). This International Standard applies to visual user interfaces controlled by software. Requirements or recommendations that do not apply to specific types of visual interfaces clearly indicate any limitations to their applicability. It does not address specific details of charts, graphs or information visualization.
222.		ISO/TS 9241-126:2019, Ergonomics of human-system interaction — Part 126: Guidance on the presentation of auditory information	published	This document provides guidance for the auditory presentation of information controlled by software, irrespective of the device. It includes specific properties such as the syntactic or semantic aspects of information, e.g. coding techniques, and gives provisions for the organization of information taking account of human perception and memory capabilities.

223.		ISO 9241-129:2010, Ergonomics of human-system interaction — Part 129: Guidance on software individualization	published	This part of ISO 9241 provides ergonomics guidance on individualization within interactive systems, including recommendations on — where individualization might be appropriate or inappropriate, and — how to apply individualization. It focuses on individualization of the software user interface to support the needs of users as individuals or as members of a defined group.
224.		ISO 9241-143:2012, Ergonomics of human-system interaction — Part 143: Forms	published	This part of ISO 9241 provides requirements and recommendations for the design and evaluation of forms — in which the user fills-in, selects entries for, or modifies labelled fields on, a “form” or dialogue box presented by the system. Often the system then creates or updates the data associated with the form. Form-based entries typically are in the form of typed input (abbreviations, or full names) or selections from available option lists. This part of ISO 9241 is applicable to forms regardless of the modality in which they are rendered (visual, spatial, vocal). However, much of the guidance is based on a model of visual and spatial relationship. In addition, this part of ISO 9241 specifies the use of non-text methods for providing forms entries (e.g. list boxes) and pertains to dialogue boxes which utilize form techniques. Guidance is provided on the selection and design of those user-interface elements relevant to forms.
225.		ISO 9241-154:2013, Ergonomics of human-system interaction — Part 154: Interactive voice response (IVR) applications	published	This part of ISO 9241 gives guidance on, and requirements for, the user interface design of interactive voice response (IVR) applications. It covers both IVR systems that employ touchtone input and those using automated speech recognition (ASR) as the input mechanism. It is equally applicable to cases in which the caller or the IVR system itself (e.g. in some telemarketing

				applications) initiates the call. This part of ISO 9241 is intended to be used together with ISO/IEC 13714.
226.		ISO 9241-161:2016, Ergonomics of human-system interaction — Part 161: Guidance on visual user-interface elements	published	This part of ISO 9241 describes visual user-interface elements presented by software and provides requirements and recommendations on when and how to use them. This part of ISO 9241 is concerned with software components of interactive systems to make human-system interaction usable as far as the basic interaction aspects are concerned. This part of ISO 9241 provides a comprehensive list of generic visual user-interface elements, regardless of a specific input method, visualization, and platform or implementation technology. The guidance given in this part of ISO 9241 is intended to be used in conjunction with ISO 9241 guidance on dialogue techniques. It recognizes that additional elements can evolve. It also addresses derivates, compositions (assemblies) and states of user-interface elements. It gives requirements and recommendations on selection, usage and dependencies of user-interface elements and their application. It is applicable regardless of a fixed, portable or mobile interactive system.
227.		ISO 9241-171:2008, Ergonomics of human-system interaction — Part 171: Guidance on software accessibility	published	This part of ISO 9241 provides ergonomics guidance and specifications for the design of accessible software for use at work, in the home, in education and in public places. It covers issues associated with designing accessible software for people with the widest range of physical, sensory and cognitive abilities, including those who are temporarily disabled, and the elderly. It addresses software considerations for accessibility that complement general design for usability as addressed by ISO 9241-110-, ISO 9241-11 to ISO 9241-17, ISO 14915 and ISO 13407. This part of ISO 9241 is applicable to the accessibility of

				interactive systems. It addresses a wide range of software (e.g. office, Web, learning support and library systems).
228.		ISO 9241-210:2019, Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems	published	This document provides requirements and recommendations for human-centred design principles and activities throughout the life cycle of computer-based interactive systems. It is intended to be used by those managing design processes, and is concerned with ways in which both hardware and software components of interactive systems can enhance human–system interaction.
229.		ISO 9241-220:2019, Ergonomics of human-system interaction — Part 220: Processes for enabling, executing and assessing human-centred design within organizations	published	This document describes the processes and specifies the outcomes by which human-centred design (HCD) is carried out within organizations. Human-centred design aims to meet requirements for human-centred quality (see Annex E) throughout the life cycle of interactive systems. The processes are described from the viewpoint of those responsible for the analysis, design and evaluation of the human use of interactive systems. The process descriptions include the purpose, benefits, outcomes, typical activities and work products for each process, and are for use in the specification, implementation, assessment and improvement of the activities used for human-centred design and operation in any type of system life cycle. They can also provide the basis for professional development and certification.
230.		ISO/WD 9241-221 Ergonomics of human-system interaction — Part 221: HCD Process Assessment Model (PAM) and Process Reference Model (PRM)	under development	
231.		ISO 9241-300:2008, Ergonomics of human-system interaction — Part 300:	published	This part of ISO 9241 provides an introduction to the other parts in the ISO 9241 “300” subseries and explains its modular structure. The ISO 9241 “300” subseries establishes

		Introduction to electronic visual display requirements		requirements for the ergonomic design of electronic visual displays. These requirements are stated as performance specifications, aimed at ensuring effective and comfortable viewing conditions for users with normal or adjusted-to-normal eyesight. Test methods and metrology, yielding conformance measurements and criteria, are provided for design evaluation. The ISO 9241 “300” subseries is applicable to the visual ergonomics design of electronic visual displays for a diversity of tasks in a wide variety of work environments.
232.		ISO 9241-302:2008, Ergonomics of human-system interaction — Part 302: Terminology for electronic visual displays	published	This part of ISO 9241 provides a comprehensive terminology for electronic visual displays and explains the terms and definitions used in the other parts of ISO 9241.
233.		ISO 9241-303:2011, Ergonomics of human-system interaction — Part 303: Requirements for electronic visual displays	published	This part of ISO 9241 establishes image-quality requirements, as well as providing guidelines, for electronic visual displays. These are given in the form of generic — independent of technology, task and environment — performance specifications and recommendations that will ensure effective and comfortable viewing conditions for users with normal or adjusted-to-normal eyesight.
234.		ISO 9241-304:2008, Ergonomics of human-system interaction — Part 304: User performance test methods for electronic visual displays	published	This part of ISO 9241 provides guidance for assessing the visual ergonomics of display technologies with user performance test methods (as opposed to the optical test methods given in ISO 9241-305). Its use will help to ensure that, for a given context of use, a display meets minimum visual ergonomics requirements. It covers only visual attributes and does not address the ergonomics or usability of the whole product that houses a visual display.
235.		ISO 9241-305:2008, Ergonomics of human-system interaction — Part 305:	published	This part of ISO 9241 establishes optical test and expert observation methods for use in predicting the performance of a

		Optical laboratory test methods for electronic visual displays		display vis-à-vis the ergonomics requirements given in ISO 9241-303.
236.		ISO 9241-306:2018, Ergonomics of human-system interaction — Part 306: Field assessment methods for electronic visual displays	published	This document establishes optical, geometrical and visual inspection methods for the assessment of a display in various contexts of use according to ISO 9241-303.
237.		ISO 9241-307:2008, Ergonomics of human-system interaction — Part 307: Analysis and compliance test methods for electronic visual displays	published	This part of ISO 9241 establishes test methods for the analysis of a variety of visual display technologies, tasks and environments. It uses the measurement procedures of ISO 9241-305 and the generic requirements of ISO 9241-303 to define compliance routes suitable for the different technologies and intended context of use.
238.		ISO/TR 9241-308:2008, Ergonomics of human-system interaction — Part 308: Surface-conduction electron-emitter displays (SED)	published	This part of ISO 9241 introduces surface-conduction electron-emitter display (SED) technology into the ISO 9241 series and international ergonomics standardization (it is not yet addressed in ISO 9241-307, for instance, or in other ergonomics standards), and has been developed as a set of initial guidelines for the assessment of the ergonomic properties of SED-based products.
239.		ISO/TR 9241-309:2008, Ergonomics of human-system interaction — Part 309: Organic light-emitting diode (OLED) displays	published	This part of ISO 9241 introduces the OLED (organic light-emitting diode) display technology and provides guidance for the assessment of OLED-based products. OLED technology is not addressed by ISO 9241-307 (which establishes test methods for the analysis of a variety of visual display technologies, tasks and environments) or other parts of the “300” subseries.
240.		ISO/TR 9241-310:2010, Ergonomics of human-system interaction — Part 310: Visibility, aesthetics and ergonomics of pixel defects	published	This part of ISO 9241 provides a summary of existing knowledge on ergonomics requirements for pixel defects in electronic displays at the time of its publication. It also gives guidance on the specification of pixel defects, visibility

				thresholds and aesthetic requirements for pixel defects. It does not itself give requirements related to pixel defects, but it is envisaged that its information could be used in the revision of other parts in the ISO 9241 series.
241.		ISO/AWI TR 9241-311, Ergonomics of human-system interaction — Part 311: Guidance on application of ISO 9241-307: LCD screens for workstations	under development	
242.		ISO/TR 9241-312:2020, Ergonomics of human-system interaction — Part 312: Readability of electrophoretic displays	published	This document provides an overview of recent research on readability of electrophoretic displays. It also provides information for evaluating readability of electrophoretic displays and defining the context of their use.
243.		ISO/TR 9241-331:2012, Ergonomics of human-system interaction — Part 331: Optical characteristics of autostereoscopic displays	published	This part of ISO 9241 establishes an ergonomic point of view for the optical properties of autostereoscopic displays (ASDs), with the aim of reducing visual fatigue caused by stereoscopic images on those displays. It gives terminology, performance characteristics and optical measurement methods for ASDs. It is applicable to spatially interlaced autostereoscopic displays (two-view, multi-view and integral displays) of the transmissive and emissive types. These can be implemented by flat-panel displays, projection displays, etc.
244.		ISO 9241-333:2017, Ergonomics of human-system interaction — Part 333: Stereoscopic displays using glasses	published	This document specifies ergonomic requirements for stereoscopic displays using glasses designed to produce or facilitate binocular parallax. These requirements are stated as performance specifications, aimed at ensuring effective and comfortable viewing conditions for users, and at reducing visual fatigue caused by stereoscopic images on stereoscopic display using glasses. Test methods and metrology, yielding conformance measurements and criteria, are provided for design evaluation. See Annex B for measurement procedures.

				This document is applicable to temporally or spatially interlaced types of display. These are implemented by flat-panel displays, projection displays, etc.
245.		ISO/CD TR 9241-380, Ergonomics of human-system interaction — Part 380: Survey result of HMD (Head-Mounted Displays) characteristics related to human-system interaction	under development	
246.		ISO/WD 9241-381, Ergonomics of human-system interaction — Part 381: Requirements for optical characteristics of head-mounted displays related to human-system interaction	under development	
247.		ISO/WD 9241-382, Ergonomics of human-system interaction — Part 382: General requirements for reducing undesirable biomedical effects during visual interactive tasks using head-mounted displays	under development	
248.		ISO 9241-391:2016, Ergonomics of human-system interaction — Part 391: Requirements, analysis and compliance test methods for the reduction of photosensitive seizures	published	his part of ISO 9241 provides requirements and recommendations for reducing photosensitive seizures (PSS), while viewing images on electronic displays. The requirements and recommendations in this part of ISO 9241 are designed to be applied to image contents. By image contents, reference is made to the images independent of the device or environment in which they are displayed. The requirements and recommendations in this part of ISO 9241 are for the protection of the vulnerable individuals in the viewing population who are photosensitive and who are therefore liable to seizures triggered

				by flashing lights and regular patterns, including certain repetitive images.
249.		ISO 9241-392:2015, Ergonomics of human-system interaction — Part 392: Ergonomic recommendations for the reduction of visual fatigue from stereoscopic images	published	This part of ISO 9241 establishes recommendations for reducing the potential visual discomfort and visual fatigue experienced during viewing of stereoscopic images under defined viewing conditions. Visual fatigue and discomfort might be produced by the stereoscopic optical stimulus of disparate images that were presented binocularly. This part of ISO 9241 is also applicable to the final products of stereoscopic presentations which depend on stereoscopic image content and stereoscopic displays when viewed under appropriate defined conditions. Therefore, the recommendations are intended for people responsible for the design, development, and supply of stereoscopic image content as well as stereoscopic displays.
250.		ISO/TR 9241-393:2020, Ergonomics of human-system interaction — Part 393: Structured literature review of visually induced motion sickness during watching electronic images	published	This document gives the scientific summaries of visually induced motion sickness resulting from images presented visually on or by electronic display devices. Electronic displays include flat panel displays, electronic projections on a flat screen, and head-mounted displays.
251.		ISO 9241-394:2020, Ergonomics of human-system interaction — Part 394: Ergonomic requirements for reducing undesirable biomedical effects of visually induced motion sickness during watching electronic images	published	This document establishes the requirements and recommendations for image contents and electronic display systems to reduce visually induced motion sickness (VIMS), while viewing images on electronic displays. This document is applicable to electronic display systems, including flat panel displays, projectors with a screen, and virtual reality (VR) type of head mounted displays (HMDs), but not including HMDs that present electronic images on/with real-world scenes.
252.		ISO 9241-400:2007, Ergonomics of human—system interaction — Part 400:	published	This part of ISO 9241 gives guidelines for physical input devices for interactive systems. It provides guidance based on ergonomic factors for the following input devices: keyboards,

		Principles and requirements for physical input devices		mice, pucks, joysticks, trackballs, trackpads, tablets and overlays, touch sensitive screens, styli, light pens, voice-controlled devices, and gesture controlled devices. This part of ISO 9241 defines and formulates ergonomic principles valid for the design and use of input devices. These principles are to be used to generate recommendations for the design of products and for their use. This part of ISO 9241 defines relevant terms for the entire 400 series of ISO 9241. For some applications, e.g. in areas where safety is the major concern, other additional principles may apply and take precedence over the guidance given here. This part of ISO 9241 also determines properties of input devices relevant for usability including functional, electrical, mechanical, maintainability and safety related properties. Additionally included are aspects of interdependency with the use environment and software.
253.		ISO 9241-410:2008, Ergonomics of human-system interaction — Part 410: Design criteria for physical input devices	published	This part of ISO 9241 specifies criteria based on ergonomics factors for the design of physical input devices for interactive systems including keyboards, mice, pucks, joysticks, trackballs, trackpads, tablets and overlays, touch-sensitive screens, styli and light pens, and voice- and gesture-controlled devices. It gives guidance on the design of these devices, taking into consideration the capabilities and limitations of users, and specifies generic design criteria for physical input devices, as well as specific criteria for each type of device. Requirements for the design of products are given either as a result of context-free considerations, or else can be determined based on the specified design criteria for the intended use; such specified criteria generally having been subdivided into task-oriented categories, wherever applicable.

254.		ISO 9241-410:2008/AMD 1:2012, Ergonomics of human-system interaction — Part 410: Design criteria for physical input devices — Amendment 1	published	The Amendment has been made necessary by the later development of ISO/TS9241-411, to which reference is needed in ISO9241-410.
255.		ISO/TS 9241-411:2012, Ergonomics of human-system interaction — Part 411: Evaluation methods for the design of physical input devices	published	This part of ISO 9241 specifies evaluation methods for the design of physical input devices for interactive systems. It provides guidance for the laboratory assessment of conformance with ISO 9241--410 for keyboards, mice, pucks, joysticks, trackballs, touch pads, tablets/overlays, touch-sensitive screens, and styli/light pens. Its provisions apply only to keyboards identified as “full-size” or “compact” by the manufacturer, but nevertheless could provide useful guidance in the design of other keyboards. It is not applicable to those of the requirements of ISO 9241-410 that relate to gesture- and voice-input systems.
256.		ISO 9241-420:2011, Ergonomics of human-system interaction — Part 420: Selection of physical input devices	published	This part of ISO 9241 provides guidance for the selection of input devices for interactive systems, based on ergonomic factors, considering the limitations and capabilities of users and the specific tasks and context of use. It describes methods for selecting a device or a combination of devices for the task at hand. It can also be used for evaluating the acceptability of trade-offs under the existing conditions.
257.		ISO/DTS 9241-430, Ergonomics of human-system interaction — Part 430: Recommendations for the design of non-touch gestural input for the reduction of biomechanical stress	under development	
258.		ISO 9241-500:2018, Ergonomics of human-system interaction — Part 500:	published	This document specifies ergonomic principles which apply to the user requirements, design, and procurement of the physical

		Ergonomic principles for the design and evaluation of environments of interactive systems		equipment and environment, which contribute to the context of use of interactive systems. It provides requirements, recommendations and explanations related to these principles. In particular, the general principles and requirements specified in this document apply to the standards specifying functional design of furniture and equipment constituting the environment. The principles specified in this document utilize ergonomic knowledge (from the disciplines anthropometry, acoustics, vision, thermal environments, indoor air quality, mechanical vibrations, etc.) to design and evaluate environments that enhance usability (effectiveness, efficiency and satisfaction), accessibility, performance and well-being for organized and non-organized use of interactive systems.
259.		ISO/TR 9241-514:2020, Ergonomics of human-system interaction — Part 514: Guidance for the application of anthropometric data in the ISO 9241-500 series	published	This document is intended to provide guidance in the use of anthropometric data within the ISO 9241-500 series.
260.		ISO/CD TR 9241-610, Ergonomics of human-system interaction — Part 610: Impact of light and lighting on humans	under development	
261.		ISO/TR 9241-810:2020, Ergonomics of human-system interaction — Part 810: Robotic, intelligent and autonomous systems	published	This document addresses: — physically embodied RIA systems, such as robots and autonomous vehicles with which users will physically interact; — systems embedded within the physical environment with which users do not consciously interact, but which collect data and/or modify the environment within which people live or work such as smart building and, mood-detection; — intelligent software tools and agents with which users actively interact through some form of user interface; — intelligent software agents which act without active user input to modify or

				tailor the systems to the user's behaviour, task or some other purpose, including providing context specific content/information, tailoring adverts to a user based on information about them, user interfaces that adapt to the cognitive or physiological state, "ambient intelligence"; — the effect on users resulting from the combined interaction of several RIA systems such as conflicting behaviours between the RIA systems under the same circumstances; — the complex system-of-systems and sociotechnical impacts of the use of RIA systems, particularly on society and government.
262.		ISO 9241-910:2011, Ergonomics of human-system interaction — Part 910: Framework for tactile and haptic interaction	published	This part of ISO 9241 provides a framework for understanding and communicating various aspects of tactile/haptic interaction. It defines terms, describes structures and models, and gives explanations related to the other parts of the ISO 9241 “900” subseries. It also provides guidance on how various forms of interaction can be applied to a variety of user tasks. It is applicable to all types of interactive systems making use of tactile/haptic devices and interactions.
263.		ISO 9241-920:2009, Ergonomics of human-system interaction — Part 920: Guidance on tactile and haptic interactions	published	This part of ISO 9241 gives recommendations for tactile and haptic hardware and software interactions. It provides guidance on the design and evaluation of hardware, software, and combinations of hardware and software interactions, including — the design/use of tactile/haptic inputs, outputs, and/or combinations of inputs and outputs, with general guidance on their design/use as well as on designing/using combinations of tactile and haptic interactions for use in combination with other modalities or as the exclusive mode of interaction, — the tactile/haptic encoding of information, including textual data, graphical data and controls, — the design of tactile/haptic

				objects, — the layout of tactile/haptic space, and — interaction techniques.
264.		ISO 9241-940:2017, Ergonomics of human-system interaction — Part 940: Evaluation of tactile and haptic interactions	published	This document — describes the types of methods that can be used for the evaluation of haptic devices and of systems that include haptic devices, — specifies a procedure for the evaluation of haptic interactions by a usability walkthrough or usability test (see Annex J), and — provides guidance on the types of methods that are appropriate for the evaluation of specific attributes of haptic systems, cross-referenced to the guidance in the relevant clauses of other International Standards (see Annexes A, B, C, D, E, F and G).
265.		ISO 9241-960:2017, Ergonomics of human-system interaction — Part 960: Framework and guidance for gesture interactions	published	This document gives guidance on the selection or creation of the gestures to be used in a gesture interface. It addresses the usability of gestures and provides information on their design, the design process and relevant parameters that are to be considered. In addition, it provides guidance on how gestures should be documented. This document is concerned with gestures expressed by a human and not with the system response generated when users are performing these gestures.
266.		ISO 9241-971, Ergonomics of human-system interaction — Part 971: Guidance on physical (tactile/haptic) accessibility	published	This document provides both general and specific ergonomic requirements and recommendations for accessible tactile/haptic interactive systems, including accessible tactile/haptic interactions. This document provides guidance for increasing the accessibility of interactive systems making use of tactile/haptic input/output modalities such as gestures, vibration, and force feedback. The guidance provided also supports alternative input modalities and the use of different output representations. This document provides guidance for tactile/haptic interactions that is applicable to a variety of interactive systems, including assistive technologies (AT).

267.		ISO 9355-1:1999, Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with displays and control actuators	published	This part of ISO 9355 applies to the design of displays and control actuators on machinery. It specifies general principles for human interaction with displays and control actuators, to minimize operator errors and to ensure an efficient interaction between the operator and the equipment. It is particularly important to observe these principles when an operator error may lead to injury or damage to health.
268.		ISO 9355-2:1999, Ergonomic requirements for the design of displays and control actuators — Part 2: Displays	published	This part of ISO 9355 gives guidance on the selection, design and location of displays to avoid potential ergonomic hazards associated with their use. It specifies ergonomics requirements and covers visual, audible and tactile displays. It applies to displays used in machinery (e.g. devices and installations, control panels, operating and monitoring consoles) for occupational and private use. Specific ergonomics requirements for visual display terminals (VDTs) used for office tasks are given in the standard ISO 9241.
269.		ISO 9355-3:2006, Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators	published	This part of ISO 9355 gives ergonomic requirements for, and guidance on, the selection, design and location of control actuators adapted to the needs of the operator, suitable for the control task in question and taking account of the circumstances of their use. It is applicable to manual control actuators used in equipment for both occupational and private use.
270.		ISO 11064-1:2000, Ergonomic design of control centres — Part 1: Principles for the design of control centres	published	This part of ISO 11064 specifies ergonomic principles, recommendations and requirements to be applied in the design of control centres, as well as in the expansion, refurbishment and technological upgrades of control centres. It covers all types of control centres typically employed for process industries, transportation and logistic control systems and people deployment services. Although this part of ISO 11064 is primarily intended for non-mobile control centres, many of the

				principles specified in this document could be applicable to mobile control centres, such as those found on ships and aircraft.
271.		ISO 11064-2:2000, Ergonomic design of control centres — Part 2: Principles for the arrangement of control suites	published	This part of ISO 11064 covers ergonomic design principles for control centres and, more specifically, the various arrangements of rooms and spaces in a control suite. The principles are based on an analysis of functions and tasks that have to be supported by the control room and functionally related rooms. They include identifying functional areas, estimating the space provisions for each functional area, determining operational links between functional areas and developing preliminary layouts for the control suite to facilitate the transition between all the activities conducted in the control suite.
272.		ISO 11064-3:1999, Ergonomic design of control centres — Part 3: Control room layout	published	This part of ISO 11064 establishes ergonomic principles for the layout of control rooms. It includes requirements, recommendations and guidelines on control room layouts, workstation arrangements, the use of off-workstation visual displays and control room maintenance. It covers all types of control centres, including those for the process industry, transport and dispatching systems in the emergency services. Although this part of ISO 11064 is primarily intended for non-mobile control centres, many of the principles could be relevant/applicable to mobile centres, such as those found on ships and aircraft.
273.		ISO 11064-3:1999/COR 1:2002, Ergonomic design of control centres — Part 3: Control room layout — Technical Corrigendum 1	published	Technical Corrigendum 1 to International Standard ISO 11064-3:1999 to address a mistake in the text.

274.		ISO 11064-4:2013, Ergonomic design of control centres — Part 4: Layout and dimensions of workstations	published	This part of ISO 11064 specifies ergonomic principles, recommendations and requirements for the design of workstations found in control centres. It covers control workstation design with particular emphasis on layout and dimensions. It is applicable primarily to seated, visual-display-based workstations, although control workstations at which operators stand are also addressed. These different types of control workstation are to be found in applications such as transportation control, process control and security installations. Most of these workstations now incorporate flat-display screens for the presentation of information.
275.		ISO 11064-5:2008, Ergonomic design of control centres — Part 5: Displays and controls	published	This part of ISO 11064 presents principles and gives requirements and recommendations for displays, controls, and their interaction, in the design of control-centre hardware and software.
276.		ISO 11064-6:2005, Ergonomic design of control centres — Part 6: Environmental requirements for control centres	published	This part of ISO 11064 gives environmental requirements as well as recommendations for the ergonomic design, upgrading or refurbishment of control rooms and other functional areas within the control suite. The following aspects are covered: — thermal environment (temperate regions); — air quality; — lighting environment; — acoustic environment; — vibration; — aesthetics and interior design.
277.		ISO 11064-7:2006, Ergonomic design of control centres — Part 7: Principles for the evaluation of control centres	published	This part of ISO 11064 establishes ergonomic principles for the evaluation of control centres. It gives requirements, recommendations and guidelines on evaluation of the different elements of the control centre, i.e. control suite, control room, workstations, displays and controls, and work environment. It covers all types of control centres, including those for the process industry, transport systems and dispatching rooms in the emergency services. Although this part of ISO 11064 is

				primarily intended for non-mobile control centres, many of the principles could be relevant/applicable to mobile centres, such as those found on ships and aircraft.
278.		ISO/TR 11064-10:2020, Ergonomic design of control centres — Part 10: Introduction to the control room design series of standards	published	This document describes the different parts of the ISO 11064 series. The overall content of each of the parts is presented, the most likely users of that part and the relevance of each part to different stages in the control room design process.
279.		ISO 14915-1:2002, Software ergonomics for multimedia user interfaces — Part 1: Design principles and framework	published	This part of ISO 14915 establishes design principles for multimedia user interfaces and provides a framework for handling the different considerations involved in their design. It addresses user interfaces for applications that incorporate, integrate and synchronize different media. This includes static media such as text, graphics, or images, and dynamic media such as audio, animation, video or media related to other sensory modalities. Detailed design issues within a single medium (e.g. the graphical design of an animation sequence) are only addressed as far as they imply ergonomic consequences for the user. This part of ISO 14915 gives requirements and recommendations for the ergonomic design of multimedia applications mainly intended for professional and vocational activities such as work or learning. It does not specifically address applications outside this area such as entertainment, although some recommendations can also be applicable in such domains.
280.		ISO 14915-2:2003, Software ergonomics for multimedia user interfaces — Part 2: Multimedia navigation and control	published	This part of ISO 14915 provides recommendations and requirements for the design of multimedia user interfaces with respect to the following aspects: design of the organization of the content, navigation and media-control issues. This part of ISO 14915 is limited to the design of the organization of the content and does not deal with the design of the content in

				general. Design issues within a single medium (e.g. the lighting of a film sequence) are only addressed with respect to the ergonomic issues related to user controls. This part of ISO 14915 provides — a framework for the structuring of multimedia applications, — information and recommendations on the design of navigation structures and navigation mechanisms for use within multimedia applications, and — information and recommendations on the design of controls for use within multimedia applications.
281.		ISO/TR 16982:2002, Ergonomics of human-system interaction — Usability methods supporting human-centred design	published	This Technical Report provides information on human-centred usability methods which can be used for design and evaluation. It details the advantages, disadvantages and other factors relevant to using each usability method. It explains the implications of the stage of the life cycle and the individual project characteristics for the selection of usability methods and provides examples of usability methods in context.
282.		ISO/TS 18152:2010, Ergonomics of human-system interaction — Specification for the process assessment of human-system issues	published	This Technical Specification presents a human-systems (HS) model for use in ISO/IEC 15504-conformant assessment of the maturity of an organization in performing the processes that make a system usable, healthy and safe. It describes processes that address human-system issues and the outcomes of these processes. It details the practices and work products associated with achieving the outcomes of each process. The model describes processes for specifying and evaluating usability, health and safety, but it does not address all processes relating to their achievement.
283.		ISO/TR 20278:2015, Unwanted reflections from the active and inactive areas of display surfaces visible during use	published	This Technical Report provides users a summary of the existing knowledge about ergonomics requirements for unwanted reflections on electronic displays. The document furthermore

				provides some guidance on specification of unwanted reflections.
284.		ISO/TS 20282-2:2013, Usability of consumer products and products for public use — Part 2: Summative test method	published	This part of ISO/TS 20282 specifies a user-based summative test method for the measurement of the usability and/or accessibility of consumer products and products for public use (including walk-up-and-use products) for one or more specific user groups. This test method treats accessibility as a special case of usability where the users taking part in the test represent the extremes of the range of characteristics and capabilities within the general user population. When the test method refers to usability, the method can also be used to test accessibility (unless otherwise specified). This test method is for use when valid and reliable measures of effectiveness, efficiency, and satisfaction are needed.
285.		ISO 25065:2019, Systems and software engineering — Software product Quality Requirements and Evaluation (SQuaRE) — Common Industry Format (CIF) for Usability: User requirements specification	published	This document provides a framework and consistent terminology for specifying user requirements. It specifies the common industry format (CIF) for a user requirement specification including the content elements and the format for stating those requirements.
286.	CEN/TC 250/SC 7 Eurocode 7: Geotechnical design	EN 1997-1:2004 Eurocode 7: Geotechnical design - Part 1: General rules	published	EN 1997-1 is intended to be used as a general basis for the geotechnical aspects of the design of buildings and civil engineering works.
287.		EN 1997-2:2007 Eurocode 7: Geotechnical design - Part 2: Ground investigation and testing	published	The standard contains requirements for the execution, interpretation and use of results of laboratory tests to assist in the geotechnical design of structures

ANNEX 3: LIST OF IDENTIFIED NON-FORMAL STANDARDS

	Standardization Body	Title	Summary
1.	ETIM International	ETIM	ETIM is the international classification standard for technical products. ETIM also covers the classification of HVAC & plumbing, building materials and shipbuilding sector related products, including tools.
2.	GS1	Global Trade Item Number (GTIN) Management Standard	This standard has been developed in accordance with the GS1 Global Standards Management Process (GSMP) and is considered a part of the GS1 system of standards. The GTIN provides a global supply chain solution by identifying any trade item that may be priced, ordered or invoiced at any point in the supply chain and upon which there is a need to retrieve pre-defined information.
3.	COB Plattform	CUR 166 Damwandconstructies	This handbook deals with sheet pile structures that derive their earth-retaining function in principle from the clamping or anchoring in the grand and the resistance to bending moments and shear forces. To a limited extent, alternative constructions are also discussed, such as a bored pile wall or a diaphragm wall. The so-called casket dam, which is often used for flood defense, is also discussed.
4.	National building codes in all EU countries		
5.	DIRECTIVE 2010/31/EU, Energy Performance of Buildings Directive	The European Parliament and the Council of the European Union	This Directive aims to promote the energy performance of buildings and building units.
6.	DIRECTIVE 2012/27/EU, Energy Efficiency Directive to reducing the energy consumption of buildings	The European Parliament and the Council of the European Union	Directive 2012/27/EU establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020.