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EU Observatory for  
**ICT Standardisation**

# Report of TWG CitiVerse: **Landscape of CitiVerse Standards**

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ICT Standardisation Observatory and Support Facility in Europe



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# 1 Foreword

CitiVerse involves techniques from many verticals and huge amounts of data from a great variety of sources. According to the definition by the EU, CitiVerse is a series of interconnected and distributed hybrid and virtual worlds representing, and synchronised with, their physical counterparts. It offers new (administrative, economic, social, policy-making, and cultural) virtual goods / services / capabilities to city and community actors such as citizens, represented as digital avatars. Since CitiVerse will create a “system of ecosystems”, there are many existing standards and standards currently being developed that have high relevance for the creation of CitiVerse and for further standardisation work regarding CitiVerse.

CitiVerse has a lot in common with Metaverse, sharing many of its challenges with Metaverse. Today there are however no precise definitions of Metaverse, nor of CitiVerse. Some people might think of CitiVerse is a special kind of Metaverse or an instantiation of Metaverse. Other people might claim they are different constructions. Regardless, there is a need to understand the specific demands and challenges we encounter when a digital 3D world is based on and are a copy of the real world. For that reason, in this document, let's consider CitiVerse as being a copy of the social physical real world. Let's use the term Metaverse for a virtual 3D world more freely designed and NOT being a copy of a specific physical area in the real world or even look like something from the real world.

Regardless of how we choose to interpret the term CitiVerse and Metaverse, many of the standards and techniques used for Metaverse will be relevant and useful for CitiVerses as well. These include standards for visualisation and computer graphics and standards for extended reality (AR, VR, MR). Methods to create and manage user and computer-controlled avatars, as well as user interaction by wearables, haptics and other means, will probably be the same in these worlds too. Ethical, social, and legal considerations and concepts, such as privacy by design, moral design processes and human-centred design often overlap in both CitiVerses and Metaverses. Infrastructure capabilities such as AI, digital twins, and characteristics including accessibility, inclusion, trust and immersiveness need to be dealt with in both worlds. And so on.

However, there are also many other aspects to take into consideration for CitiVerse that are not needed for more freely designed Metaverse. Among other things, CitiVerse may always be aligned to a Digital Twin representing the social physical real world. Thus, there is a need to keep CitiVerse in synchronisation with the real world, gathering all data required for CitiVerse to be a full and trustworthy digital copy of the real world, and keeping that data up to date. As a “digital copy” of the real world, CitiVerse can provide wider possibilities for utilising extended reality capabilities, like VR and AR, compared to a more fictive Metaverse. Some other aspects that differentiate CitiVerse from a more fictional Metaverse include that CitiVerse may be used for simulations and predictions for the real world. CitiVerse may also be used for tasks like providing people with disabilities with information and navigational aid in the real world. Therefore, the technique and functionality for CitiVerse is comprehensive and the standardisation landscape for CitiVerse is equally complex.

This version of the Landscape Report focuses primarily on standards to consider when constructing CitiVerse or developing further standards for CitiVerse. Standards for various application areas, utilising the possibilities with CitiVerse, will eventually be taken into consideration in later versions of this document but are not included for now.

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**Torbjörn Lahrin** – Project leader & main editor - Reference Architecture for IoT in ISO/IEC. Convenor of expert group for Smart Cities in JTC1/SC41



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## ■ 3 Introduction

### ■ 3.1 About the standardisation landscape

In this Landscape Report it has been our aim to divide the standards into their different verticals, as well as enablers. We have grouped these verticals and enablers in a taxonomy, in accordance with their domains. It is our hope that such structure and information will make it easier to find relevant standards in the list of this Landscape Report.

To get an overview of the standardisation landscape for CitiVerse, we also look at the CitiVerse from the point of view of different “building blocks” that are needed in order to construct CitiVerses or develop further standards regarding CitiVerse. This introduction aims to give an overview of these “building blocks”.

### ■ 3.2 A combination of Local Digital Twins and Metaverse

A basic level of CitiVerse could be said to be a combination of Local Digital Twins and Metaverse. It therefore follows that standardisation for CitiVerse includes standards related to both. The term “Local Digital Twin” is used here as a description of a Digital Twin of a physical geographic area that is a part / parts of a city, a whole city or a municipality, region, country, or even larger area. It should be noted that the term “Local” might, in some languages and countries, be interpreted as “small” or “narrow”, which can be misleading. Nevertheless, our use of “Local Digital Twins” is as an equivalent of “Urban Digital Twins”, “City Information Modelling”, “City Digital Twins” and similar terms.

### ■ 3.3 Local Digital Twins

Local Digital Twins (LTDs), in turn, use Digital Twin technologies in combination with technologies for digital 3D representation of physical areas, buildings, constructions, and objects. LTDs are built by using a large amount of data from many different sources. We therefore need to take into consideration standards for 3D modelling and visualisation of landscapes, buildings, constructions, and objects that populate a landscape. Standards, data models and ontologies for their datasets also need to be used.

Local Digital Twins are often based on time and location. They combine 3D visualisation of real-world objects, Internet of Things capabilities and municipality-based information, such as demographics. IoT provides the “twinning” side for the Local Digital Twin, bringing the twin “alive” through the ability to gather data from the real world through sensors and influence, eventually autonomously steering the real world through actuators. Therefore, standards for Internet of Things and Geospatial are also core foundations for Local Digital Twins and therefore, CitiVerse.

Today, Local Digital Twins are built in many ways, using various software like UDT platforms, GIS software, CAD software, game engines and other 3D visualisation tools. There is a critical need for harmonising standards for these branches of Local Digital Twins, as well as creating interoperability between these different technologies. Since CitiVerses will be built on Local Digital Twins, these differences will also have a large impact on the standardisation activities for CitiVerse.

## ■ 3.4 Data and interoperability

The CitiVerse needs to be “alive”. This signifies a further extension of the “systems of systems” approach, e.g., used with respect to Smart Cities and Local Digital Twins. Therefore, the data used within CitiVerse will need to be constantly updated, preferably in real-time. This places important demands on the IoT parts of the CitiVerse, but it also places demands on how other data sets are brought into CitiVerse. As a result of this, standards for Interoperability and Data Exchange also play a crucial role for CitiVerse, as do ontologies and standards for Dataspaces.

## ■ 3.5 AI and semantic communication

The CitiVerse will create and use data. This requires AI capabilities to be integrated in CitiVerse, with regulations compliance (e.g., The AI Act, in Europe). As a consequence, semantic communication capabilities are required (creation and extraction), with regulations compliance. Therefore, standards for AI trustworthiness, semantic communication and interoperability are an integral part of CitiVerse.

## ■ 3.6 Computing continuum

The CitiVerse will include a computing continuum infrastructure, integrating IoT, the edge and the cloud. The orchestration of computing capabilities in such a distributed and dynamically changing environment, including mobile edge computing, will be a key requirement. Because of this, standards enabling such orchestration while ensuring the dynamic configuration requirements of the CitiVerse will be prerequisite.

## ■ 3.7 CitiVerse and Metaverse

A lot of technology used in a more fictive Metaverse will be used in CitiVerse as well. User-controlled avatars, as well as computer-controlled characters, will be present in both worlds. Many of the tools for interaction and immersiveness will be the same, as will techniques for haptics and wearables. Tools for extended reality will be utilised together with both worlds, for example, in gamification and online shopping.

However, even if there are many similarities between Metaverse and CitiVerse there are also many other aspects regarding CitiVerse that are not of concern to a more fictive Metaverse. It is therefore very important to understand the full standardisation landscape for CitiVerse being a copy of the social physical real world, and not only rely on standards for the somewhat less restricted concept of Metaverse.

In Annex A of this Landscape Report, you may find more thoughts on the similarities and differences between CitiVerse and a more fictive Metaverse and the implications this has on the standardisation landscape for CitiVerse.



## ■ 3.8 Application domains

CitiVerse will be used for great variety of application areas. In fact, since CitiVerse is a “digital copy” of the real world, CitiVerse may be used for almost everything that also exists in the real world. Consequentially, we would need to bring in all standards for everything in the world, claiming it has relevance for CitiVerse. This, however, does not make practical sense.

On the other hand, in developing techniques and standards for CitiVerse it is critical to fully take into consideration how CitiVerse will be used in diverse application areas. This will ensure that the standards and environments built may serve across multi-purposes, for various applications. Therefore, we need to consider standards for such applications, which are already identified as “early adopters” of CitiVerse.

However, in this first version of this Landscape Report we have chosen not to include standards for application areas. There are two reasons for this. Firstly, the list of standards in this version of the Landscape Report is comprehensive. Secondly, the time limitation in order to publish this first version of the document, has meant that standards within application areas could not be researched, reviewed and included. Our plan is therefore to produce a second version of the Landscape Report later on, bringing in some of the application areas of more specific relevance in the near future for CitiVerse.

## ■ 3.9 Smart City Standards

Similarly, in this first version, standards on Smart Cities has also been purposely left out. Several of these standards deal with application areas for Smart Cities. These standards, especially those on how to build core functionalities and technology for Smart Cities, will be included in the future second version of this Landscape Report.

## ■ 3.10 Some ongoing standardisation activities

Here is additional information regarding standardisation for some of the core building blocks for CitiVerse:

- ▷ A new version of ISO/IEC 30141, the international reference architecture for Internet of Things, will most likely be published the spring of 2024.
- ▷ ISO/IEC 30188, the digital twin reference architecture was started in 2023.
- ▷ ISO/IEC 30178, on data format, value and coding is on-going.
- ▷ IEEE Metaverse Standards Committee, developing and maintaining standards, recommended practices, and guides for Metaverse, virtual reality and augmented reality.

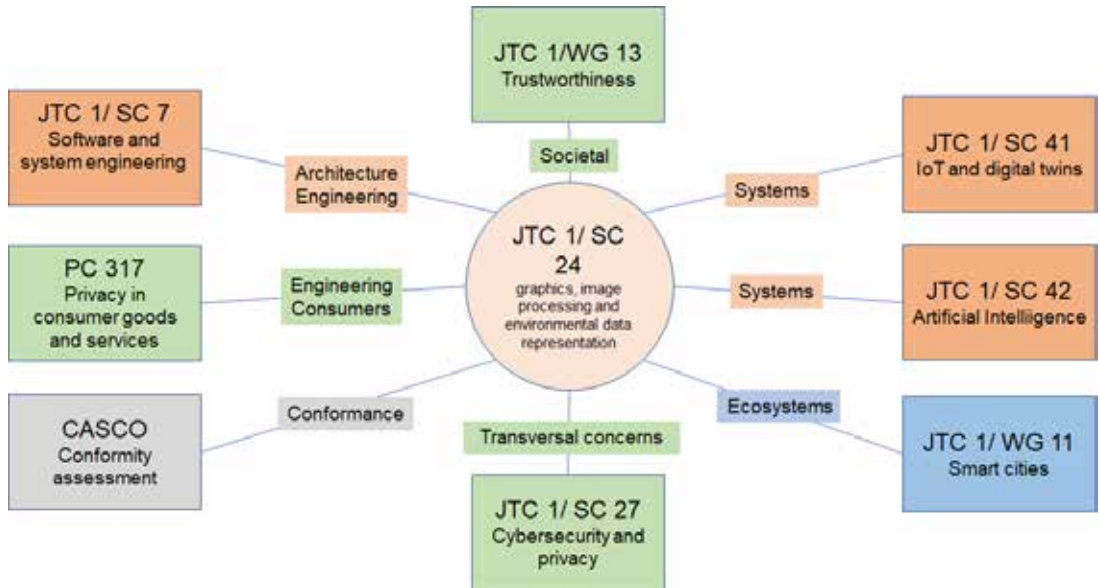
Regarding Local Digital Twins we can find many valuable standards forming building blocks, but no common standard yet. As mentioned above, Local Digital Twins are today built in many ways, using various software like UDT platforms, GIS software, CAD software, game engines and other 3D visualisation tools. However, ISO/IEC JTC1 has November 2023 agreed to engage in a JWG (Joint Working Group) together with IEC/SyC Smart Cities (and probably also ITU-T later) to address this. The JWG will start by carrying out a worldwide case study on Urban Digital Twins and City Information Modelling. This case study will capture the needs for an official international reference architecture for Local Digital Twins. This will also make it possible for the JWG to give advice to SDOs within the field of Local Digital Twins on how to develop and harmonise their existing standards and ongoing standardisation projects.

Furthermore, several activities and initiatives are ongoing, regarding definitions, standards and guidelines for Metaverse. All these will most likely form vital and important parts of what will be needed for CitiVerse.

## ■ 3.11 It is all about integration

The figure below shows one example on how technology and standards have to be integrated to support the CitiVerse. Taking the viewpoint of JTC 1/SC 24, we need to integrate the following:

- ▶ consumer concerns on privacy (PC317), transversal concerns on cybersecurity and privacy (JTC 1/SC 27), societal concerns on trustworthiness (JTC 1/WG 13);
- ▶ architecture and system concerns at the software and system engineering level (JTC 1/SC 7), at the IoT and digital twin level (JTC 1/SC 41), and at the AI level (JTC 1/SC 42);
- ▶ conformance concerns (CASCO); and
- ▶ ecosystem concerns in smart cities (JTC 1/WG 11).

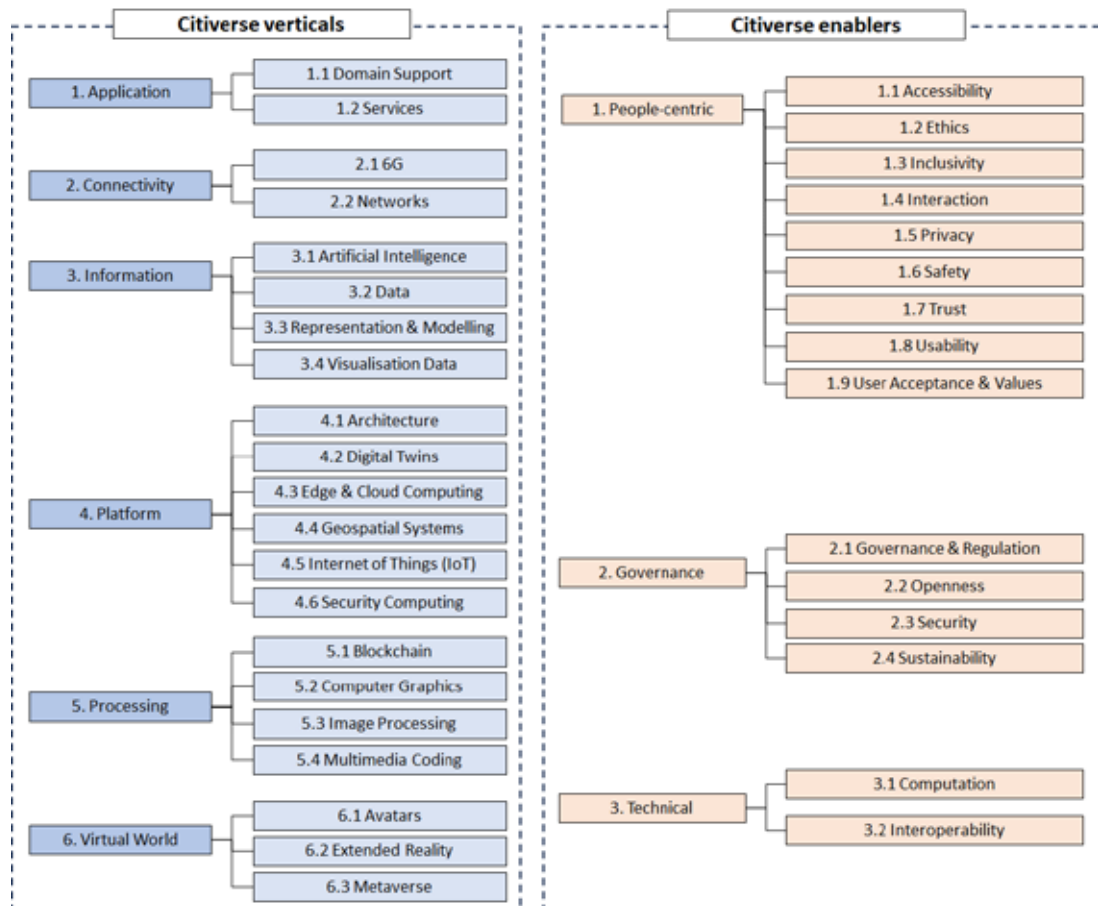


## ■ 3.12 Document structure

This Landscape Report consists of two main parts:

- ▶ Chapter 4: CitiVerse verticals, and
- ▶ Chapter 5: CitiVerse enablers.

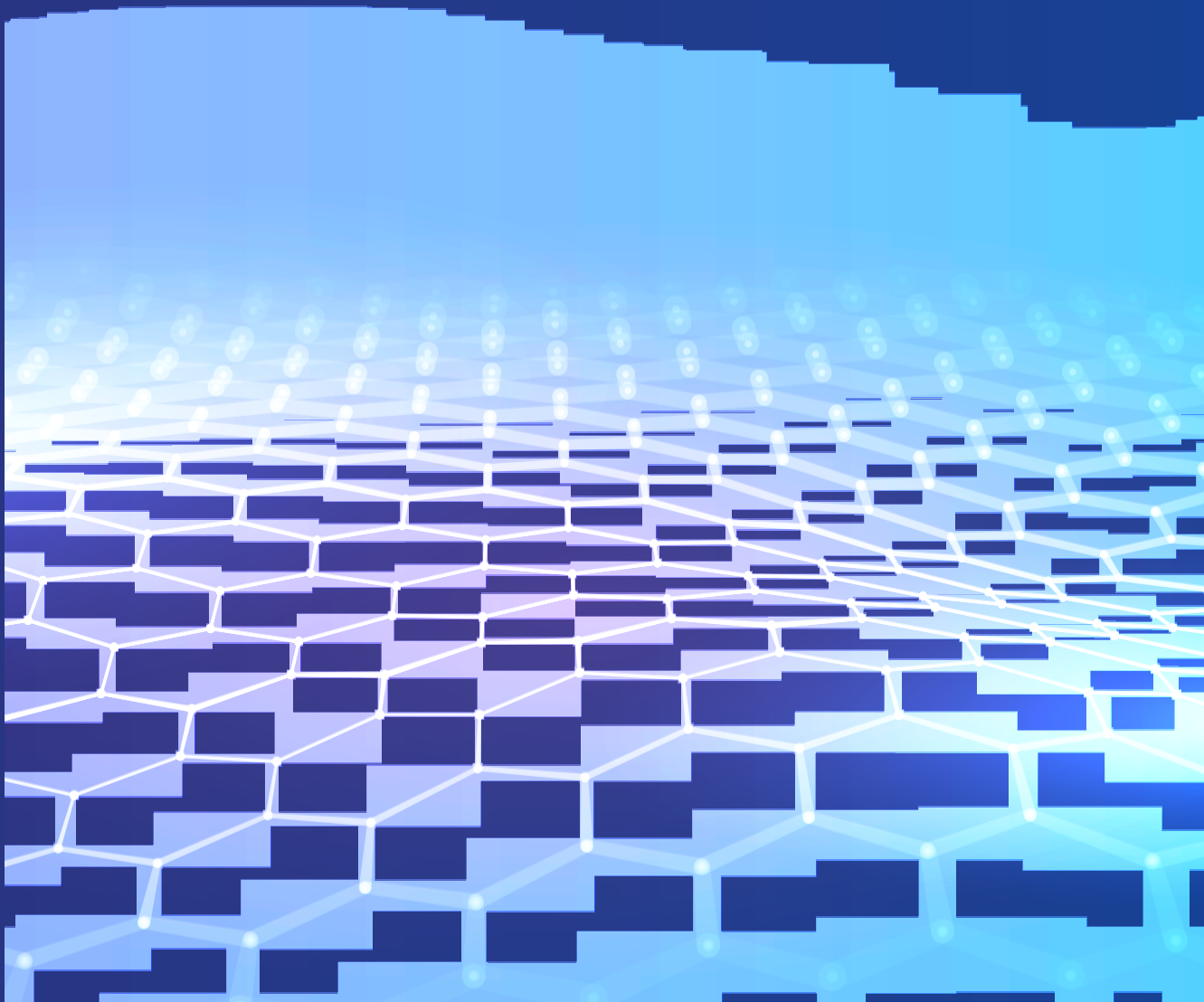
Since a standard can be allocated to several vertical / enabler entries, it has been decided to record only a single entry per standard with complete information. All other references to the same standard that follow in this document are summarised only, with hyperlinks taking you to the complete entry above.



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# 4 Landscape of Standards - Verticals



## ■ 4.1 Application

### 4.1.1 Domain Support

#### Standard | ISO/IEC 18025:2014 Information technology Environmental Data Coding Specification (EDCS)

ISO/IEC 18025:2014 provides mechanisms to specify unambiguously objects used to model environmental concepts. To accomplish this, a collection of nine EDCS dictionaries of environmental concepts are specified:

1. classifications: specify the type of environmental objects;
2. attributes: specify the state of environmental objects;
3. attribute value characteristics: specify information concerning the values of attributes;
4. attribute enumerates: specify the allowable values for the state of an enumerated attribute;
5. units: specify quantitative measures of the state of some environmental objects;
6. unit scales: allow a wide range of numerical values to be stated;
7. unit equivalence classes: specify sets of units that are mutually comparable;
8. organizational schemas: useful for locating classifications and attributes sharing a common context; and
9. groups: into which concepts sharing a common context are collected.

A functional interface is also specified.

📖 OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2014-02

🔗 URL: <https://www.iso.org/standard/60505.html>

### 4.1.2 Services

#### Technical report | ETSI TR 126 928 V16.1.0 Extended Reality (XR) in 5G (3GPP TR 26.928 version 16.1.0 Release 16)

The present document collects information on eXtended Reality (XR) in the context of 5G radio and network services. The primary scope of the present document is the documentation of the following aspects:

- ▷ introducing Extended Reality by providing definitions, core technology enablers, a summary of devices and form factors, as well as ongoing related work in 3GPP and elsewhere,
- ▷ collecting and documenting core use cases in the context of Extended Reality,
- ▷ identifying relevant client and network architectures, APIs and media processing functions that support XR use cases,
- ▷ analysing and identifying the media formats (including audio and video), metadata, accessibility features, interfaces and delivery procedures between client and network required to offer such an experience,
- ▷ collecting key performance indicators and Quality-of-Experience metrics for relevant XR services

and the applied technology components, and

▷ drawing conclusions on the potential needs for standardisation in 3GPP.

📖 OTHER VERTICALS: Extended Reality

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👥 COMMITTEE: 3GPP, ETSI

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📅 PUBLISHED: 2021-01

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🔗 URL: [https://www.etsi.org/deliver/etsi\\_tr/126900\\_126999/126928/16.01.00\\_60/tr\\_126928v160100p.pdf](https://www.etsi.org/deliver/etsi_tr/126900_126999/126928/16.01.00_60/tr_126928v160100p.pdf)

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## Standard | IEEE P3141 Standard for 3D Body Processing

This standard addresses the anthropometric and topo-physiological attributes that contribute to the quality of experience of 3D body processing, as well as identifying and analyzing metrics and other useful information, as well as data relating to these attributes. The standard defines a harmonized framework, suite of objective and subjective methods, tools, and workflows for assessing 3D body processing quality of experience attributes. The standard specifies and defines methods, metrics, and mechanisms to facilitate interoperability, communication, security and trusted operation of 3D body processing technologies. This includes quality of output of devices (such as sensors and/or scanners), digitization, simulation and modeling, analytics and animation, data transmission and visualization in the 3D body processing ecosystem, the ecosystem being in the near environment that interacts with the body.

📖 OTHER VERTICALS: Avatars

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👥 COMMITTEE: IEEE CTS/ETSC

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📅 PUBLISHED: 2022-02

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🔗 URL: <https://standards.ieee.org/ieee/3141/10825/>

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## Standard | ISO 18163:2016 Clothing Digital fittings Vocabulary and terminology used for the virtual garment

ISO 18133:2016 defines the terms that are commonly used for the digital fitting system. The digital fitting system includes virtual fabric, virtual fabric properties, virtual garment pattern, virtual garment pattern properties, virtual sewing line, virtual garment, and virtual garment simulation of a virtual garment on a virtual human body model for fit assessment.

📖 OTHER VERTICALS: Avatars

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👥 COMMITTEE: ISO TC 133

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📅 PUBLISHED: 2016-04

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🔗 URL: <https://www.iso.org/standard/61644.html>

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## Standard | ISO 18825-1:2016 Clothing Digital fittings Part 1: Vocabulary and terminology used for the virtual human body

This document is the first of a family of standards. ISO 18825-1:2016 covers vocabulary and terminology used for the virtual human body in the virtual garment system used as a main tool in various fields of clothing application. It is applicable to all stages of online clothing communication and business, including design, manufacture, order, sales, distribution and customer management.

📖 OTHER VERTICALS: Avatars

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👥 COMMITTEE: ISO TC 133

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📅 PUBLISHED: 2016-07

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🔗 URL: <https://www.iso.org/standard/61643.html>

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## Standard | ISO 18825-2:2016 Clothing Digital fittings Part 2: Vocabulary and terminology used for attributes of the virtual human body

ISO 18825-2:2016 defines the terms used to describe the virtual human body which is used in virtual garment systems. Specifically, virtual body landmarks and virtual body dimensions are described. It mainly deals with vocabulary and terminology of essential virtual body dimensions of the virtual torso, arm, leg, head, face, hands and bones and joints of virtual human body. Since there are many body landmarks on the head and hand, landmarks on these parts are defined separately from those on other parts of the body. It is intended for developers of virtual garment systems. Although ISO 18825-2:2016 does not aim at users of virtual human body in online communication, the improved reliability of virtual human body will benefit them.

OTHER VERTICALS: Avatars

COMMITTEE: ISO TC 133

PUBLISHED: 2016-07

URL: <https://www.iso.org/standard/63494.html>

## Standard | ISO 20947-1:2021 Performance evaluation protocol for digital fitting systems Part 1: Accuracy of virtual human body representation

This document is the first of a family of standards. This document focuses on the method of quantifying the differences in body dimensions and visualizing shape differences between the human body and a virtual human body model. This document provides a performance evaluation protocol for virtual human body representation systems, which create virtual human body (including virtual fit mannequin) models based on 3D body scan data and/or body dimensions data of a human body. The required accuracy of a virtual human body depends on the purpose and use of the digital fitting system.

OTHER VERTICALS: Avatars

COMMITTEE: ISO TC 133

PUBLISHED: 2021-07

URL: <https://www.iso.org/standard/73663.html>

## Standard | ISO/DIS 17097 3-D human body scan data Part 1: Terminologies and methodologies for processing of human scan data

This standard specifies terms, methods, and considerations related to the processing of scan data using software after acquiring human body scan data using a 3-D human body scanner. NOTE Knowledge and experience in the processing and analysis of 3-D point-cloud and mesh are required to improve the quality of human body scan data while maintaining its morphological characteristics for its application to the design of a particular product, workplace, and/or system. Custom software can be developed to support the processing of human body scan data by incorporating terms, methods, and considerations in this standard in a selective manner.

OTHER VERTICALS: Avatars

COMMITTEE: ISO TC 159 SC 3

PUBLISHED: under development

URL: <https://www.iso.org/standard/84848.html>

## Standard | ISO/IEC 39794-16:2021 Information technology Extensible biometric data interchange formats Part 16: Full body image data

This document is intended to provide a generic extensible full body image data format for biometric recognition applications requiring exchange of human full body image data. Typical applications are:

- a) automated body biometric verification and identification of an unknown individual or cadaver (one-to-one as well as one-to-many comparison);
- b) support for human verification of identity by comparison of individuals against full body images; and
- c) support for human examination of full body images with sufficient resolution to allow a human examiner to verify identity or identify a living individual or a cadaver.

This document ensures that full human body images and image sequence data generated by video surveillance and other similar systems are suitable for identification and verification. The structure of the data format in this document is compatible with ISO/IEC 39794-5. In addition to the data format, this document specifies application-specific profiles including scene constraints, photographic properties and digital image attributes like image spatial sampling rate, image size, etc. These application profiles are contained in a series of annexes. The 3D encoding types “3D point map” and “range image” are not supported by this document.

📖 OTHER VERTICALS: Avatars

👥 COMMITTEE: ISO/IEC JTC 1/SC 37

📅 PUBLISHED: 2021-06

🔗 URL: <https://www.iso.org/standard/78020.html>

## Standard | ISO/IEC 19777-1:2006 Information technology Computer graphics and image processing Extensible 3D (X3D) language bindings Part 1: ECMAScript

For integration into a programming language, the X3D abstract interfaces are embedded in a language-dependent layer obeying the particular conventions of that language. ISO/IEC 19777-1:2006 specifies such a language dependent layer for the ECMAScript language. ISO/IEC 19775-2 specifies a language-independent application programmer interface (API) to a set of services and functions.

📖 OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2006-05

🔗 URL: <https://www.iso.org/standard/33915.html>

## Standard | ISO/IEC 19777-2:2006 Information technology Computer graphics and image processing Extensible 3D (X3D) language bindings Part 2: Java

The Extensible 3D (X3D) specification, ISO/IEC 19775, specifies a language-independent application programmer interface (API) to a set of services and functions. For integration into a programming language, the X3D abstract interfaces are embedded in a language dependent layer obeying the particular conventions of that language. ISO/IEC 19777-2:2006 specifies such a language-dependent layer for the Java programming language.

📖 OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2006-05

🔗 URL: <https://www.iso.org/standard/38020.html>

## Technical report | ETSI GR ARF 002 V1.1.1 Augmented Reality Framework (ARF); Industrial use cases for AR applications and services

The present document presents and classifies industrial use cases for AR applications and services. It forms the basis for the requirements document to be drafted ETSI GS ARF 004: Augmented Reality Framework (ARF) Interoperability Requirements for AR components, systems and services.

📅 OTHER VERTICALS: Extended Reality

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👥 COMMITTEE: ETSI ISG ARF

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📅 PUBLISHED: 2019-07

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🔗 URL: [https://www.etsi.org/deliver/etsi\\_gr/ARF/001\\_099/002/01.01.01\\_60/gr\\_ARF002v010101p.pdf](https://www.etsi.org/deliver/etsi_gr/ARF/001_099/002/01.01.01_60/gr_ARF002v010101p.pdf)

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## Technical report | IEC TR 63478-1 ED1 User's Quality of Experience (QoE) on Multimedia Conferencing Services Part 1: General

This Technical Report describes general considerations to be taken for measurement of user's Quality of Experience (QoE) on multimedia conferencing services.

👥 COMMITTEE: IEC TC 100

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📅 PUBLISHED: under development

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🔗 URL: [https://www.iec.ch/dyn/www/f?p=103:38:17155273168177:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:1297,23,109492](https://www.iec.ch/dyn/www/f?p=103:38:17155273168177:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:1297,23,109492)

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## Standard | IEC SRD 63426 ED1 Reference standards portfolio (RSP) for active assisted living (AAL) in a connected home environment (CHE)

This document classifies elements suitable for AAL connected home environment based on AAL system components and defines instances, a specific example of elements, to be used in AAL connected home environment. An element defined in this document is a more specialized and subdivided classification on a connected home environment view. This document lists up existing standards applicable to elements/instances, with focus on interoperability and connectivity and identifies standardization needs and new standardization opportunities specific to the use of AAL CHE element.

👥 COMMITTEE: IEEE SyC AAL

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📅 PUBLISHED: under development

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🔗 URL: [https://www.iec.ch/ords/f?p=103:38:712598602956404:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:11827,23,105294](https://www.iec.ch/ords/f?p=103:38:712598602956404:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:11827,23,105294)

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## ■ 4.2 Connectivity

### 4.2.1 6G

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#### Technical report | ETSI TR 126 998 V17.1.0 Support of 5G glass-type Augmented Reality / Mixed Reality (AR/MR) devices (3GPP TR 26.998 version 17.1.0 Release 17)

The present document collects information on glass-type AR/MR devices in the context of 5G radio and network services. The primary scope of this Technical Report is the documentation of the following aspects:

- providing formal definitions for the functional structures of AR glasses, including their capabilities and constraints,
- documenting core use cases for AR services over 5G and defining relevant processing functions and reference architectures,
- identifying media exchange formats and profiles relevant to the core use cases,
- identifying necessary content delivery transport protocols and capability exchange mechanisms, as well as suitable 5G system functionalities (including device, edge, and network) and required QoS (including radio access and core network technologies),
- identifying key performance indicators and quality of experience factors,
- identifying relevant radio and system parameters (required bitrates, latencies, loss rates, range, etc.) to support the identified AR use cases and the required QoE, and
- providing a detailed overall power analysis for media AR related processing and communication.

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📖 OTHER VERTICALS: Extended Reality

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⚙️ ENABLERS: Computation, Interoperability

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👥 COMMITTEE: 3GPP, ETSI

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📅 PUBLISHED: 2022-10

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🔗 URL: [https://www.etsi.org/deliver/etsi\\_tr/126900\\_126999/126998/17.01.00\\_60/tr\\_126998v170100p.pdf](https://www.etsi.org/deliver/etsi_tr/126900_126999/126998/17.01.00_60/tr_126998v170100p.pdf)

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#### Technical report | ETSI TR 126 999 V17.0.0 5G; LTE; Virtual Reality (VR) streaming interoperability and characterization

The present document provides reference test material and test results for improved usability of technologies in 3GPP TS 26.118: Virtual Reality (VR) profiles for streaming applications. The specification 3GPP TS 26.118 includes several VR media profiles for video and a single media profile for audio with different configuration options. The specification focuses primarily on interoperability requirements for VR360 applications, but does not address performance characterization of the solutions. In order for content providers and the rest of the ecosystem to be able to select and configure the technologies defined in 3GPP TS 26.118 and to generate content for streaming applications, collecting such information would be most valuable.

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📖 OTHER VERTICALS: Extended Reality

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⚙️ ENABLERS: Interoperability, Usability

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👥 COMMITTEE: 3GPP, ETSI

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📅 PUBLISHED: 2022-05

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🔗 URL: [https://www.etsi.org/deliver/etsi\\_tr/126900\\_126999/126999/17.00.00\\_60/tr\\_126999v170000p.pdf](https://www.etsi.org/deliver/etsi_tr/126900_126999/126999/17.00.00_60/tr_126999v170000p.pdf)

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OTHER

Technical report | ETSI TR 126 928 V16.1.0 Extended Reality (XR) in 5G (3GPP TR 26.928 version 16.1.0 Release 16) | [\[see details\]](#)

4.2.2 Networks

Standard | ISO 23247-4:2021 Automation systems and integration Digital twin framework for manufacturing Part 4: Information exchange

This document identifies technical requirements for information exchange between entities within the reference architecture. The requirements for information exchange in the following networks are within the scope of this document:

- ▷ user network that connects the user entity and the digital twin entity;
- ▷ service network that connects sub-entities within the digital twin entity;
- ▷ access network that connects the device communication entity to the digital twin entity and to the user entity; and
- ▷ proximity network that connects the device communication entity to the observable manufacturing elements.

OTHER VERTICALS: Digital Twins

ENABLERS: Interoperability

COMMITTEE: ISO TC 184 SC 4

PUBLISHED: 2021-10

URL: <https://www.iso.org/standard/78745.html>

Standard | ISO/IEC 18038:2020 Information technology Computer graphics, image processing and environmental representation Sensor representation in mixed and augmented reality

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. This document specifies the following functionalities:

- a) representation of physical sensors in a 3D scene;
- b) definition of physical sensors in a 3D scene;
- c) representation of functionalities of each physical sensor in a 3D scene;
- d) representation of physical properties of each physical sensor in a 3D scene;
- e) management of physical sensors in a 3D scene; and
- f) interface with physical sensor information in a 3D scene.

This document defines a reference model for physical sensor-based mixed-reality applications to represent and to exchange functions of physical sensors in 3D scenes. It does not define specific physical interfaces necessary for manipulating physical devices, but rather defines common functional interfaces that can be used interchangeably between applications. This document does not define how specific applications are implemented with specific physical sensor devices. It does not include computer generated sensor information using computer input/output devices such as a mouse or a keyboard. The sensors in this document represent physical sensor devices in the real world.

OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2020-04

🔗 URL: <https://www.iso.org/standard/70720.html>

## ■ 4.3 Information

### 4.3.1 Artificial Intelligence (AI)

#### Guide | IEEE 1232.3-2014 Guide for the Use of Artificial Intelligence Exchange and Service Tie to All Test Environments

Guidance to developers of IEEE 1232 conformant applications is provided in this guide. A simple doorbell is used as an example system under test to illustrate how the static model constructs of Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE) are used to form a diagnostic reasoner knowledge base. Each of AI-ESTATE's knowledge base types is discussed in conceptual terms, and how those concepts are represented in exchange files is shown. Also, some of the nuanced aspects of diagnostic knowledge bases in AI-ESTATE are clarified. An example reasoner session is provided to illustrate the use of AI-ESTATE services.

📖 OTHER VERTICALS: Geospatial Systems

⚙️ ENABLERS: Ethics, Governance & Regulation

👥 COMMITTEE: IEEE SA BOG/SCC20

📅 PUBLISHED: 2014-10

🔗 URL: <https://standards.ieee.org/ieee/1232.3/4665/>

#### Framework | IEEE 2807-2022 Framework of Knowledge Graphs Series

A framework of knowledge graphs is proposed in this standard. The knowledge graph conceptual model, construction and integration process of knowledge graphs, main activities in the processes, and stakeholders of knowledge graphs are described in detail. This standard can be applied in various organizations that plan, design, develop, implement, and apply knowledge and in organizations that develop support technologies, tools, and services to knowledge graphs.

📖 OTHER VERTICALS: Geospatial Systems

⚙️ ENABLERS: Ethics, Governance & Regulation

👥 COMMITTEE: IEEE C/SAB

📅 PUBLISHED: 2023-01

🔗 URL: <https://standards.ieee.org/ieee/2807/7525/>

## Standard | IEEE 2937-2022 Standard for Performance Benchmarking for AI Server Systems

Artificial intelligence (AI) computing differs from generic computing in terms of device formation, operators, and usage. AI server systems, including AI server, cluster, and high-performance computing (HPC) infrastructures are designed specifically for this purpose. The performance of these infrastructures is important to users not only on generic models but also on the ones for specific domains. Formal methods for the performance benchmarking for AI server systems are provided in this standard, including approaches for test, metrics, and measure. In addition, the technical requirements for benchmarking tools are discussed.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/AISC

PUBLISHED: 2022-09

URL: <https://standards.ieee.org/ieee/2937/10376/>

## Standard | IEEE 2941-2021 Standard for Artificial Intelligence (AI) Model Representation, Compression, Distribution and Management

The AI development interface, AI model interoperable representation, coding format, and model encapsulated format for efficient AI model inference, storage, distribution, and management are discussed in this standard.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/DCSC

PUBLISHED: 2022-03

URL: <https://standards.ieee.org/ieee/2941/10363/>

## Guide | IEEE 3652.1-2020 Guide for Architectural Framework and Application of Federated Machine Learning

Federated machine learning defines a machine learning framework that allows a collective model to be constructed from data that is distributed across repositories owned by different organizations or devices. A blueprint for data usage and model building across organizations and devices while meeting applicable privacy, security and regulatory requirements is provided in this guide. It defines the architectural framework and application guidelines for federated machine learning, including description and definition of federated machine learning; the categories federated machine learning and the application scenarios to which each category applies; performance evaluation of federated machine learning; and associated regulatory requirements.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/AISC

PUBLISHED: 2021-03

URL: <https://standards.ieee.org/ieee/3652.1/7453/>



## Recommended Practice | IEEE P2247.4 Recommended Practice for Ethically Aligned Design of Artificial Intelligence (AI) in Adaptive Instructional Systems

This recommended practice describes ethical considerations and recommended best practices in the design of artificial intelligence as used by adaptive instructional systems. The ethical considerations derived from P2247.1, Standard for the Classification of Adaptive Instructional Systems, is directly related to: P2247.1 Standard for the Classification of Adaptive Instructional Systems, P2247.2 Interoperability Standards for Adaptive Instructional Systems (AISs), and P2247.3 Recommended Practices for Evaluation of Adaptive Instructional Systems.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/LTSC

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/2247.4/10368/>

## Recommended Practice | IEEE P2863 Recommended Practice for Organizational Governance of Artificial Intelligence

This recommended practice specifies governance criteria such as safety, transparency, accountability, responsibility and minimizing bias, and process steps for effective implementation, performance auditing, training and compliance in the development or use of artificial intelligence within organizations.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/AISC

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/2863/10142/>

## Standard | IEEE P2874 Standard for Spatial Web Protocol, Architecture and Governance

This standard describes a Hyperspace Transaction Protocol (HSTP) that enables interoperable, semantically compatible connections between connected hardware (e.g. autonomous drones, sensors, smart devices, robots) and software (e.g. services, platforms, applications, artificial intelligence systems). The Spatial Web socio-technical standards, Hyper-Spatial Modeling Language (HSML) and Hyper-Spatial Transaction Protocol (HSTP), enable world modeling by structuring spatial information and securing efficient transactions. This standard includes specifications for:

- 1) a spatial range query format and response language for requesting data about objects within a dimensional range (spatial, temperature, pressure, motion) and their content.
- 2) a semantic data ontology schema for describing objects, relations, and actions in a standardized way
- 3) a verifiable credentialing and certification method for permissioning create, retrieve, update, and delete (CRUD) access to devices, locations, users, and data; and
- 4) a human and machine-readable contracting language that enables the expression and automated execution of legal, financial and physical activities.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/AISC

PUBLISHED: under development

## Guide | IEEE P2894 Guide for an Architectural Framework for Explainable Artificial Intelligence

This guide provides a technological framework that facilitates the increase of trustworthiness of AI (Artificial Intelligence) systems, by using explainable artificial intelligence (XAI) technologies and methods including the following aspects:

- 1) the requirements of providing XAI systems in different application scenarios;
- 2) the categorization of a series of XAI tools that offer human-understandable explanations; and
- 3) a set of measurable solutions to evaluate XAI systems in terms of performances concerning the accuracy, privacy, and security.

📁 OTHER VERTICALS: Geospatial Systems

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⚙️ ENABLERS: Ethics, Governance & Regulation

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👥 COMMITTEE: IEEE C/AISC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/2894/10284/>

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## Standard | IEEE P2941.1 Standard for Operator Interfaces of Artificial Intelligence

A set of operator interfaces frequently used in artificial intelligence (AI) applications is defined in this standard, where the AI operators refer to the standard building blocks and primitives for performing basic AI operations. The functionality and the specific input and output operands of an AI operator are discussed, as well as both generality and efficiency. Various types of operators, such as those related to basic mathematics, neural network, and machine learning, are highlighted.

📁 OTHER VERTICALS: Geospatial Systems

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⚙️ ENABLERS: Ethics, Governance & Regulation

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👥 COMMITTEE: IEEE C/DCSC

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📅 PUBLISHED: 2023-03

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🔗 URL: <https://standards.ieee.org/ieee/2941.1/10567/>

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## Standard | IEEE P2975 Standard for Industrial Artificial Intelligence (AI) Data Attributes

This standard defines attributes related to industrial Artificial Intelligence (AI) data that facilitates the classification, association, and mapping towards value creation using data. The attributes include but are not limited to data source, type, ownership, sampling frequency, traceability, privacy attributes for modeling, sampling, shareability and its use in AI algorithms.

📁 OTHER VERTICALS: Geospatial Systems

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⚙️ ENABLERS: Ethics, Governance & Regulation

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👥 COMMITTEE: IEEE C/SM

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/2975/10558/>

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## Standard | IEEE P2976 Standard for XAI eXplainable Artificial Intelligence for Achieving Clarity and Interoperability of AI Systems Design

This standard defines mandatory and optional requirements and constraints that need to be satisfied for an AI method, algorithm, application or system to be recognized as explainable. Both partially explainable and fully or strongly explainable methods, algorithms and systems are defined. XML Schema are also defined.

📁 OTHER VERTICALS: Geospatial Systems

⚙️ ENABLERS: Ethics, Governance & Regulation

👥 COMMITTEE: IEEE CIS/SC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/2976/10522/>

## Standard | IEEE P3119 Standard for the Procurement of Artificial Intelligence and Automated Decision Systems

This standard establishes a uniform set of definitions and a process model for the procurement of Artificial Intelligence (AI) and Automated Decision Systems (ADS) by which government entities can address socio-technical and responsible innovation considerations to serve the public interest. The process requirements include a framing of procurement from an IEEE Ethically Aligned Design (EAD) foundation and a participatory approach that redefines traditional stages of procurement as: problem definition, planning, solicitation, critical evaluation of technology solutions (e.g. Impact assessments), and contract execution. The scope of the standard not only addresses the procurement of AI in general, but also government in-house development and hybrid public-private development of AI and ADS as an extension of internal government procurement practices.

📁 OTHER VERTICALS: Geospatial Systems

⚙️ ENABLERS: Ethics, Governance & Regulation

👥 COMMITTEE: IEEE SSIT/SC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/3119/10729/>

## Standard | IEEE P3123 Standard for Artificial Intelligence and Machine Learning Terminology and Data Formats

The standard defines specific terminology utilized in artificial intelligence and machine learning (AI/ML). The standard provides clear definition for relevant terms in AI/ML. Furthermore, the standard defines requirements for data formats.

📁 OTHER VERTICALS: Geospatial Systems

⚙️ ENABLERS: Ethics, Governance & Regulation

👥 COMMITTEE: IEEE C/AISC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/3123/10744/>

## Recommended Practice | IEEE P3128 Recommended Practice for The Evaluation of Artificial Intelligence (AI) Dialogue System Capabilities

This recommended practice establishes an evaluation framework for the capabilities of artificial intelligence dialogue systems such as chatbots, consulting terminals, or operation interfaces. The recommended practice defines and classifies the types and levels of the intelligence capabilities according to a checklist of criteria. The checklist tables describe the criteria used to determine the level that a dialogue system achieves based on the analysis of behavior and performance.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/AISC

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/3128/10746/>

## Standard | IEEE P3129 Standard for Robustness Testing and Evaluation of Artificial Intelligence (AI)-based Image Recognition Service

Test specifications with a set of indicators for common corruption and adversarial attacks, which can be used to evaluate the robustness of artificial intelligence-based image recognition services are provided in this standard. Robustness attack threats and establishes an assessment framework to evaluate the robustness of artificial intelligence-based image recognition service under various settings are also specified in this standard.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/AISC

PUBLISHED: 2023-06

URL: <https://standards.ieee.org/ieee/3129/10747/>

## Standard | IEEE P3152 Standard for the Description of the Natural or Artificial Character of Intelligent Communicators

This standard describes recognizable audio and visual marks to assist with the identification of communicating entities as human or machine intelligence to facilitate transparency, understanding, and trust during online, telephone, or other electronic interactions. Interventions to discern whether an interaction is with a machine or not (such as a Turing Test) are not within the scope of this standard. This standard is concerned only about the declaration of the nature of the agency influencing an interaction.

OTHER VERTICALS: Geospatial Systems

ENABLERS: Ethics, Governance & Regulation

COMMITTEE: IEEE C/AISC

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/3152/10833/>

## Standard | IEEE P7014 Standard for Ethical considerations in Emulated Empathy in Autonomous and Intelligent Systems

This standard defines a model for ethical considerations and practices in the design, creation and use of empathic technology, incorporating systems that have the capacity to identify, quantify, respond to, or simulate affective states, such as emotions and cognitive states. This includes coverage of 'affective computing', 'emotion Artificial Intelligence' and related fields.

📁 OTHER VERTICALS: Geospatial Systems

⚙️ ENABLERS: Ethics, Governance & Regulation

👥 COMMITTEE: IEEE SSIT/SC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/7014/7648/>

## Standard | IEEE P7015 Standard for Data and Artificial Intelligence (AI) Literacy, Skills, and Readiness

To coordinate global data and AI literacy building efforts, this standard establishes an operational framework and associated capabilities for designing policy interventions, tracking their progress, and empirically evaluating their outcomes. The standard includes a common set of definitions, language, and understanding of data and AI literacy, skills, and readiness.

📁 OTHER VERTICALS: Geospatial Systems

⚙️ ENABLERS: Ethics, Governance & Regulation

👥 COMMITTEE: IEEE C/AISC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/7015/10688/>

## Technical report | ISO/IEC CD TR 5259-6 Artificial intelligence Data quality for analytics and machine learning (ML) Part 6: Visualization framework for data quality

This document describes a visualization framework for data quality in analytics and machine learning. The aim is to enable stakeholders using visualization methods to assess the results of data quality measures. This visualization framework supports data quality goals.

📁 OTHER VERTICALS: Visualisation Data

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 42

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/86532.html>

## Standard | IEEE P7003 Algorithmic Bias Considerations

This standard describes specific methodologies to help users certify how they worked to address and eliminate issues of negative bias in the creation of their algorithms, where negative bias infers the usage of overly subjective or uniformed data sets or information known to be inconsistent with legislation concerning certain protected characteristics (such as race, gender, sexuality, etc); or with instances of bias against groups not necessarily protected explicitly by legislation, but otherwise diminishing stakeholder or user well being and for which there are good reasons to be considered inappropriate. Possible elements include (but are not limited to): benchmarking procedures and criteria for the selection of validation data sets for bias quality control; guidelines on establishing and

communicating the application boundaries for which the algorithm has been designed and validated to guard against unintended consequences arising from out-of-bound application of algorithms; suggestions for user expectation management to mitigate bias due to incorrect interpretation of systems outputs by users (e.g. correlation vs. causation).

⚙️ ENABLERS: Ethics, Inclusivity

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👥 COMMITTEE: IEEE C/S2ESC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/7003/6980/>

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## Standard | IEEE P7008 Standard for Ethically Driven Nudging for Robotic, Intelligent and Autonomous Systems

Nudge, as exhibited by robotic, intelligent or autonomous systems are defined as overt or hidden suggestions or manipulations designed to influence the behavior or emotions of a user. This standard establishes a delineation of typical nudges (currently in use or that could be created). It contains concepts, functions and benefits necessary to establish and ensure ethically driven methodologies for the design of the robotic, intelligent and autonomous systems that incorporate them.

⚙️ ENABLERS: Ethics

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👥 COMMITTEE: IEEE RAS/SC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/7008/7095/>

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## Standard | ISO/IEC 22989:2022 Information technology Artificial intelligence Artificial intelligence concepts and terminology

This document establishes terminology for AI and describes concepts in the field of AI. This document can be used in the development of other standards and in support of communications among diverse, interested parties or stakeholders. This document is applicable to all types of organizations (e.g. commercial enterprises, government agencies, not-for-profit organizations).

👥 COMMITTEE: ISO/IEC JTC 1/SC 42

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📅 PUBLISHED: 2022-07

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🔗 URL: <https://www.iso.org/standard/74296.html>

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## Standard | ISO/IEC 23894:2023 Information technology Artificial intelligence Guidance on risk management

This document provides guidance on how organizations that develop, produce, deploy or use products, systems and services that utilize artificial intelligence (AI) can manage risk specifically related to AI. The guidance also aims to assist organizations to integrate risk management into their AI-related activities and functions. It moreover describes processes for the effective implementation and integration of AI risk management. The application of this guidance can be customized to any organization and its context.

👥 COMMITTEE: ISO/IEC JTC 1/SC 42

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📅 PUBLISHED: 2023-02

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🔗 URL: <https://www.iso.org/standard/77304.html>

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## Standard | ISO/IEC 38507:2022 Information technology Governance of IT Governance implications of the use of artificial intelligence by organizations

This document provides guidance for members of the governing body of an organization to enable and govern the use of Artificial Intelligence (AI), in order to ensure its effective, efficient and acceptable use within the organization. This document also provides guidance to a wider community, including: executive managers; external businesses or technical specialists, such as legal or accounting specialists, retail or industrial associations, or professional bodies; public authorities and policymakers; internal and external service providers (including consultants); assessors and auditors. This document is applicable to the governance of current and future uses of AI as well as the implications of such use for the organization itself. This document is applicable to any organization, including public and private companies, government entities and not-for-profit organizations. This document is applicable to an organization of any size irrespective of their dependence on data or information technologies.

👥 COMMITTEE: ISO/IEC JTC 1/SC 42

📅 PUBLISHED: 2022-04

🔗 URL: <https://www.iso.org/standard/56641.html>

## Standard | ISO/IEC DIS 5392 Information technology Artificial intelligence Reference architecture of knowledge engineering

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 among themselves and other systems from systemic user and functional views. This document also provides a common KE vocabulary by defining KE terms.

👥 COMMITTEE: ISO/IEC JTC 1/SC 42

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/81228.html>

## Standard | ISO/IEC FDIS 5338 Information technology Artificial intelligence AI system life cycle processes

This document defines a set of processes and associated terminology for describing the life cycle of AI systems. This document forms the foundation of a detailed AI system life cycle specification. It is based on ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207 with substitutes for and additions of AI specific processes, whose foundation is based on ISO/IEC 22989 and ISO/IEC 23053. Selected sets of these processes can be applied throughout the life cycle for managing and performing the stages of an AI system's life cycle. This document provides processes that support the definition, control and improvement of the AI system life cycle processes used within an organization or a project. Organizations and projects can use these processes when developing or acquiring AI systems. When an element of an AI system is traditional software or a traditional system, the software life cycle processes in ISO/IEC/IEEE 12207 and the system life cycle processes in ISO/IEC/IEEE 15288 may be used to implement that element.

👥 COMMITTEE: ISO/IEC JTC 1/SC 42

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/81118.html>

## Standard | ISO/IEC FDIS 5339 Information technology Artificial intelligence Guidance for AI applications

This document provides 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.

👤 COMMITTEE: ISO/IEC JTC 1/SC 42

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/81120.html>

## Technical specification | MPAI-AIF V2 Artificial Intelligence Framework

Technical Specification: AI Framework (MPAI-AIF) specifies architecture, interfaces, protocols, and API of a secure environment specially designed for execution of AI-based applications implemented as AI workflows (AIW) of AI modules (AIM). Version 2 extends the capabilities of Version 1 making it easier for AI application developers to support security in their applications.

👤 COMMITTEE: MPAI Community

📅 PUBLISHED: 2023-09

🔗 URL: <https://mpai.community/standards/mpai-aif/>

## 4.3.2 Data

### Standard | 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)

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.

📖 OTHER VERTICALS: Image Processing, Avatars, Extended Reality

⚙️ ENABLERS: Computation

👤 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2019-01

🔗 URL: <https://www.iso.org/standard/66281.html>

### Technical report | ISO/TR 24464:2020 Automation systems and integration Industrial data Visualization elements of digital twins

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).

📖 OTHER VERTICALS: Visualisation Data, Digital Twins, Avatars

⚙️ ENABLERS: Computation, Interoperability

👤 COMMITTEE: ISO TC 184 SC 4

📅 PUBLISHED: 2020-11

🔗 URL: <https://www.iso.org/standard/78836.html>

## Standard | ISO 16757-2:2016 Data structures for electronic product catalogues for building services Part 2: Geometry

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

- (a) shapes for representing the product itself,
- (b) symbolic shapes for the visualization of the product's function in schematic diagrams,
- (c) spaces for functional requirements,
- (d) surfaces for visualization, and
- (e) 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.

📖 OTHER VERTICALS: Visualisation Data, Architecture

⚙️ ENABLERS: Computation, Interoperability

👥 COMMITTEE: ISO TC 59 SC 13

📅 PUBLISHED: 2016-11

🔗 URL: <https://www.iso.org/standard/62080.html>

## Technical report | ETSI TR 103 957 V0.0.3 Cyber Security (CYBER); Extended Reality Cyber Security Analysis

From the perspective of a use case driven risk analysis, including gaps, applicable to the virtual world (termed Metaverse), respecting environmental constraints, represented as an immersive and constant virtual 3D world where users (people) interact by means of an avatar to carry out a wide range of activities, analyse uniquely new cyber security requirements and technical standards. The scope includes a focus on EU/CEPT requirements and ETSI work.

📖 OTHER VERTICALS: Security Computing, Extended Reality

⚙️ COMMITTEE: ETSI TC CYBER

📅 PUBLISHED: under development

🔗 URL: [https://portal.etsi.org/webapp/WorkProgram/Report\\_WorkItem.asp?WKI\\_ID=67949&curlItemNr=1&totalNrItems=1&optDisplay=10&qSORT=HIGHVERSION&qETSI\\_ALL=&SearchPage=TRUE&qETSI\\_NUMBER=103+957&qINCLUDE\\_SUB\\_TB=True&qINCLUDE\\_MOVED\\_ON=&qSTOP\\_FLG=&qKEYWORD\\_BOOLEAN=&qCL](https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=67949&curlItemNr=1&totalNrItems=1&optDisplay=10&qSORT=HIGHVERSION&qETSI_ALL=&SearchPage=TRUE&qETSI_NUMBER=103+957&qINCLUDE_SUB_TB=True&qINCLUDE_MOVED_ON=&qSTOP_FLG=&qKEYWORD_BOOLEAN=&qCL)

## Standard | ISO/IEC DIS 5927 Augmented and Virtual Reality safety Guidance on safe immersion, setup and usage

The standard specifies how Augmented Reality and Virtual Reality (AR/VR) devices should be set up and used in the enterprise; in a manner that ensures Health and Safety (H&S) is maintained, H&S consequences are understood, and additional risks are not introduced. Within this concept of safe usage, there is particular focus on guidance around safe immersion (time) and safety in the workplace. This ISO/IEC standard:

- (a) defines the concepts of AR, VR, the virtuality continuum and other associated terms such as Augmented Virtuality and Mixed Reality;
- (b) provides guidance on setting up AR systems;
- (c) provides guidance on setting up VR systems;
- (d) provides guidance on safe usage and immersion in AR systems both in the consumer and enterprise domains; and
- (e) provides guidance on safe usage and immersion in VR systems both in the consumer and enterprise domains.

This standard focuses on visual aspects of AR and VR. Other modes such as haptics and olfactory are not addressed within this standard. The standard covers both the hardware (the physical VR/AR head mounted displays) and areas of visual stimulus (the environments and graphics displayed in those headsets). The standard does not cover all possible visual stimulus scenarios; focus is directed toward those areas that are known to have implications on safe use. This specifically includes the source vection (visual illusion of self-motion in physically stationary VR/AR users) and/or motion (physical movement of VR/AR users) and associated safe use considerations. It should be noted that AR/VR have some shared safety concerns, but many are distinct to AR or VR and a consumer or enterprise environment. As such all of these are in scope, and the standard is structured to account for these differences.

OTHER VERTICALS: Security Computing, Extended Reality

ENABLERS: Interaction, Security

COMMITTEE: ISO/IEC JTC 1/SC 24

PUBLISHED: under development

URL: <https://www.iso.org/standard/81847.html>

## Standard | ISO 10303-21:2016 Industrial automation systems and integration Product data representation and exchange Part 21: Implementation methods: Clear text encoding of the exchange structure

ISO 10303-21:2016 specifies an exchange format that allows product data described in the EXPRESS language to be transferred from one computer system to another. ISO 10303-21:2016 adds anchor, reference and signature sections to support external references, support for compressed exchange structures in an archive, digital signatures and UTF-8 character encoding.

OTHER VERTICALS: Multimedia Coding

ENABLERS: Interoperability

COMMITTEE: ISO TC 184 SC 4

PUBLISHED: 2016-03

URL: <https://www.iso.org/standard/63141.html>

## Standard | ISO/IEC 14496-16:2011 Information technology Coding of audio-visual objects Part 16: Animation Framework eXtension (AFX)

ISO/IEC 14496-16:2011 specifies MPEG-4 Animation Framework eXtension (AFX) model for representing and encoding 3D graphics assets to be used standalone or integrated in interactive multimedia presentations (the latter when combined with other parts of MPEG-4). Within this model, MPEG-4 is extended with higher-level synthetic objects for geometry, texture, and animation as well as dedicated compressed representations.

OTHER VERTICALS: Multimedia Coding

ENABLERS: Interoperability

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: 2011-11

URL: <https://www.iso.org/standard/57367.html>

## Standard | ISO/IEC 14496-27:2009 Information technology Coding of audio-visual objects Part 27: 3D Graphics conformance

ISO/IEC 14496-27:2009 specifies how tests can be designed to verify whether compressed data (i.e. bitstreams) and decoders meet the requirements for the synthetic 3D graphics tools specified in ISO/IEC 14496-11:2005, ISO/IEC 14496-16:2006, ISO/IEC 14496-21:2006, and ISO/IEC 14496-25:2009. ISO/IEC 14496-27:2009 does not specifically address encoders. As far as synthetic 3D graphics are concerned, an encoder can be said to be an ISO/IEC 14496 encoder if it generates compressed data compliant with the syntactic and semantic bitstream payload requirements specified in ISO/IEC 14496-11, ISO/IEC 14496-16, ISO/IEC 14496-21, and ISO/IEC 14496-25. Characteristics of coded bitstreams and decoders are defined for ISO/IEC 14496-11, ISO/IEC 14496-16, ISO/IEC 14496-21, and ISO/IEC 14496-25. The characteristics of a bitstream define the subset of the standard that is exploited in the bitstream. Examples are the applied values or range of the bitrate. Decoder characteristics define the properties and capabilities of the applied decoding process. An example of a property is the applied arithmetic accuracy. The capabilities of a decoder specify which coded bitstreams the decoder can decode and reconstruct, by defining the subset of the standard that may be exploited in decodable bitstreams. A bitstream can be decoded by a decoder if the characteristics of the coded bitstream are within the subset of the normative references. ISO/IEC 14496-27:2009 describes procedures for testing conformance of compressed data and decoders to the requirements defined in ISO/IEC 14496-11, ISO/IEC 14496-16, ISO/IEC 14496-21, and ISO/IEC 14496-25; given the set of characteristics claimed, the requirements that shall be met are fully determined by these parts. ISO/IEC 14496-27:2009 summarizes the requirements, cross references them to characteristics, and defines how conformance with them can be tested. Guidelines are given on constructing tests to verify decoder conformance.

OTHER VERTICALS: Multimedia Coding

ENABLERS: Interoperability

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: 2009-12

URL: <https://www.iso.org/standard/53751.html>

## Standard | ISO/IEC 15938-3:2002 Information technology Multimedia content description interface Part 3: Visual

The structure of this document is as follows. Clauses 2-4 specify the terms, abbreviations, symbols and conventions used throughout the document. Clauses 5-11 contain definitions of the description tools standardized by 15938-3 grouped by the visual features they are associated with, starting with basic structures and containers in Clause 5, through color, texture, shape, motion, localization in Clause 10. Clause 11 contains the remaining, unclassified items. Each description tool is described by the following subclauses:

- ▷ Syntax: Normative DDL specification of the Ds or DSs;
- ▷ Binary Syntax: Normative binary representation of the Ds or DSs; and

▷ Semantic: Normative definition of the semantics of all the components of the corresponding D or DS.

☰ OTHER VERTICALS: Multimedia Coding

👤 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2002-05

🔗 URL: <https://www.iso.org/standard/34230.html>

## Standard | ISO/IEC 15938-5:2003 Information technology Multimedia content description interface Part 5: Multimedia description schemes

ISO/IEC 15938-5:2003 specifies a metadata system for describing multimedia content. ISO/IEC 15938-5:2003 specifies the Multimedia Description Schemes (MDS) description tools (Description Schemes, Descriptors, and datatypes) that comprise ISO/IEC 15938-5:2003 by specifying the normative syntax of each description tool using Description Definition Language (DDL) (see ISO/IEC 15938-2) and the normative semantics including semantics of each component of each description tool (attributes and elements). ISO/IEC 15938-5:2003 also provides informative examples that illustrate the instantiation of description tools in creating descriptions conforming to ISO/IEC 15938-5:2003.

ISO/IEC 15938-5:2003 defines the following basic elements: schema tools (the root element, top-level types, description metadata, and packages), basic datatypes (integers, reals, vectors, matrices), linking and media localization tools (spatial and temporal localization), basic description tools (language, text, classification schemes). ISO/IEC 15938-5:2003 defines the following content description tools, which describe the features of the multimedia content and the immutable metadata related to the multimedia content: structure description tools (spatio-temporal segments of multimedia content) and semantic description tools ("real-world" semantics related to or captured by the multimedia content, including objects, events, concepts, and so forth). ISO/IEC 15938-5:2003 defines additionally the following description tools for content metadata: media description (storage format, encoding), creation and production (title, creator, classification, purpose), and usage (access rights, publication). The content description and metadata tools are related in the sense that the content description tools use the content metadata tools. For example, a description of creation and production or media information can be attached to an individual video or video segment in order to describe the structure and creation and production of the multimedia content. ISO/IEC 15938-5:2003 also defines description tools for navigation and access (browsing, summarization), content organization (collections and models), and user interaction (user preferences pertaining to consumption of multimedia and usage history). Finally, ISO/IEC 15938-5:2003 defines classification schemes, which organize terms that are used by the description tools.

☰ OTHER VERTICALS: Multimedia Coding

⚙️ ENABLERS: Interoperability

👤 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2003-05

🔗 URL: <https://www.iso.org/standard/34232.html>

## Standard | ISO/IEC 23090-14:2023 Information technology Coded representation of immersive media Part 14: Scene description

This document specifies extensions to existing scene description formats in order to support MPEG media, in particular immersive media. MPEG media includes but is not limited to media encoded with MPEG codecs, media stored in MPEG containers, MPEG media and application formats as well as media provided through MPEG delivery mechanisms. Extensions include scene description format syntax and semantics and the processing model when using these extensions by a Presentation Engine. It also defines a Media Access Function (MAF) API for communication between the Presentation Engine and the Media Access Function for these extensions. While the extensions defined in this document can be applicable to other scene description formats, they are provided for ISO/IEC 12113.

☰ OTHER VERTICALS: Multimedia Coding

⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO/IEC JTC 1/SC 29

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📅 PUBLISHED: 2023-06

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🔗 URL: <https://www.iso.org/standard/80900.html>

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## Technical report | ISO/IEC TR 15938-8:2002 Information technology Multimedia content description interface Part 8: Extraction and use of MPEG-7 descriptions

ISO/IEC TR 15938-8:2002 forms an informative part of ISO/IEC 15938 on extraction and use of metadata descriptions for multimedia content. ISO/IEC TR 15938-8:2002 provides two types of information: informative examples that illustrate the instantiation of description tools in creating descriptions conforming to ISO/IEC 15938; and detailed technical information on extracting descriptions automatically from multimedia content and using them in multimedia applications. ISO/IEC TR 15938-8:2002 is a companion for ISO/IEC 15938-3 (Visual) and ISO/IEC 15938-5 (Multimedia Description Schemes), which provide normative definitions of the description tools. Effort has been made in this Technical Report to preserve the subclause numbering of ISO/IEC 15938-3 and ISO/IEC 15938-5 to allow easy mapping of the information on extraction and use with those technical specifications.

📖 OTHER VERTICALS: Multimedia Coding

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO/IEC JTC 1/SC 29

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📅 PUBLISHED: 2002-12

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🔗 URL: <https://www.iso.org/standard/37778.html>

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## Standard | ISO 17506:2022 Industrial automation systems and integration COLLADA (TM) digital asset schema specification for 3D visualization of industrial data

This document describes the COLLADA schema. COLLADA is a Collaborative Design Activity that defines an XML-based schema to enable 3D authoring applications to freely exchange digital assets without loss of information, enabling multiple software packages to be combined into extremely powerful tool chains. The purpose of this document is to provide a specification for the COLLADA schema in sufficient detail to enable software developers to create tools to process COLLADA resources. In particular, it is relevant to those who import to or export from digital content creation (DCC) applications, 3D interactive applications and tool chains, prototyping tools, real-time visualization applications such as those used in the video game and movie industries, and CAD tools. This document covers the initial design and specifications of the COLLADA schema, as well as a minimal set of requirements for COLLADA exporters. This document covers the following information:

- (a) initial design and specifications of the COLLADA schema;
- (b) requirements of COLLADA tools and a minimal set of requirements for COLLADA exporters;
- (c) detailed explanations for COLLADA programming;
- (d) core elements that describe geometry, animation, skinning, assets, and scenes;
- (e) physics model, visual effects (FX), boundary representation (B-rep) of animation, kinematics.

The document does not specify the implementation of, or definition of a run-time architecture for viewing or processing of COLLADA data.

📖 OTHER VERTICALS: Visualisation Data

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⚙️ ENABLERS: Computation, Interoperability

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👥 COMMITTEE: ISO TC 184 SC 4

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📅 PUBLISHED: 2022-03

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🔗 URL: <https://www.iso.org/standard/78834.html>

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## Technical report | ETSI TR 102 794 V1.1.1 Media Content Distribution (MCD); 3D Gaming Graphics Delivery Overview

The present document provides an overview of delivery of 3D graphics of games that are running on a high-performance server to client devices that would otherwise not have the resources to run these games natively. The present document describes the use cases, high level requirements and different solution approaches, and identifies the main area(s) where standardization work would be needed. Exploring the nature and content of what is going to be exchanged between servers and clients constitutes the main topic of the present document. The primary aim for this technology is to enable casual gaming scenarios, and it is not the primary aim to try to satisfy hardcore gamers, since we have to be realistic about what can be achieved with the current state of networking and server technology. Because of the nature of the content and in order to focus on feasible solutions, we may exclude certain type of network connections to be used, such as using “unreliable” or high-latency wireless connections such as 802.11b/g. We expect to have a broadband connection between the client and the server, without too many intermediate hops. In the present document we do not address deployment issues, such as integration into a Content on demand infrastructure (e.g. user registration, pricing, purchasing), or integration into a QoS framework (e.g. prioritization of gaming streams compared to other types of streams). Also, use cases and synchronization issues related to multi-player gaming, whereby different connection speeds/types could result in different response times, are out of scope of the present document.

OTHER VERTICALS: Computer Graphics

ENABLERS: Computation

COMMITTEE: ETSI

PUBLISHED: 2010-12

URL: [https://www.etsi.org/deliver/etsi\\_tr/102700\\_102799/102794/01.01.01\\_60/tr\\_102794v010101p.pdf](https://www.etsi.org/deliver/etsi_tr/102700_102799/102794/01.01.01_60/tr_102794v010101p.pdf)

## Standard | ISO/IEC 30178 ED1 Internet of Things (IoT) Data format, value and coding

Defines:

- ▶ common formats,
- ▶ values, and
- ▶ coding for Internet of things (IoT).

OTHER VERTICALS: Digital Twins

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,104965](https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,104965)

## Standard | PWI JTC1-SC41-16 Digital Twin Extraction and transactions of data components

This document specifies technical aspects related to the extraction, decoupling, trading, and benefits of data components throughout the digital twin life cycle.

OTHER VERTICALS: Digital Twins

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,118814](https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,118814)



## Technical report | PWI TR JTC1-SC41-11 Digital Twin Correspondence measure of DTw twinning

Definition of DTw correspondence measure; Components of the measure such as similarity, resolution, latency, LoD (level of detail); Quantification of the measure, Relation with other DTw projects including maturity level; and Unique features of DTw including twinning.

OTHER VERTICALS: Digital Twins

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,111474](https://www.iec.ch/dyn/www/?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,111474)

## Standard | ISO/AWI 8000-220 Data quality Part 220: Sensor data: Quality measurement

This deliverable specifies quality measures for quantitatively measuring quality characteristics of sensor data, where these characteristics are specified by ISO 8000-210. The following are within the scope of this deliverable:

- (1) fundamental principles and assumptions for measuring the quality of sensor data; and
- (2) quality measures for sensor data, with respect to applicable quality characteristics and corresponding data anomalies.

The following are outside the scope of this deliverable:

- (3) specific values for each measure, where the value indicates a distinction between, for example, good quality and poor quality; and
- (4) methods to improve the quality of sensor data.

OTHER VERTICALS: Internet of Things (IoT)

ENABLERS: Computation

COMMITTEE: ISO TC 184 SC 4

PUBLISHED: under development

URL: <https://www.iso.org/standard/86062.html>

## Standard | ISO/CD 8000-210 Data quality Part 210: Sensor data: Data quality characteristics

This deliverable specifies quality characteristics of data that is recorded by sensors as a stream of single, discrete digital values by sensors. The following are within the scope of this deliverable:

- (1) application of quality characteristics of sensor data that is a stream of single, discrete digital values;
- (2) types of anomalies in sensor data;
- (3) quality characteristics of sensor data; and
- (4) relationship with other ISO standards.

The following are outside the scope of this deliverable:

- (1) analogue, image, video and sound data produced by sensors; and
- (2) methods to measure data quality characteristics.

OTHER VERTICALS: Internet of Things (IoT)

ENABLERS: Computation

COMMITTEE: ISO TC 184 SC 4

PUBLISHED: under development

## Standard | IEEE 2813-2020 Standard for Big Data Business Security Risk Assessment

This standard can be applied to internet-based business scenarios, and can also be served serve as a practical guide to achieve help assess business security risk control through the big data technology. This standard can be applied in other types of organization, including public or privately-owned or state-owned enterprises, associations, or organizations, or by individuals, to improve assessment of their protection capability against business security risks based on big data technology.

📖 OTHER VERTICALS: Security Computing

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⚙️ ENABLERS: Security

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👥 COMMITTEE: IEEE CTS/ETSC

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📅 PUBLISHED: 2021-02

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🔗 URL: <https://standards.ieee.org/ieee/2813/7535/>

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## Recommended Practice | IEEE P7004.1 Recommended Practices for Virtual Classroom Security, Privacy and Data Governance

This recommended practice produces best practices for meeting the requirements of IEEE P7004: Standard for Child and Student Data Governance, when designing, provisioning, configuring, operating, and maintaining an online virtual classroom experience for synchronous online learning, education, and training. The recommended practice includes language that can be referenced in requests for proposals (RFPs) for online (also known as virtual) classroom solutions, the operational runbook(s) for such solutions, and the assessment and certification guideline(s) for compliance process of such solutions.

📖 OTHER VERTICALS: Security Computing

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⚙️ ENABLERS: Governance & Regulation, Privacy, Security

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👥 COMMITTEE: IEEE C/LTSC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/7004.1/10285/>

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## Standard | ISO 31700-1:2023 Consumer protection Privacy by design for consumer goods and services Part 1: High-level requirements

This document establishes high-level requirements for privacy by design to protect privacy throughout the lifecycle of a consumer product, including data processed by the consumer. This document does not contain specific requirements for the privacy assurances and commitments that organizations can offer consumers nor does it specify particular methodologies that an organization can adopt to design and-implement privacy controls, nor the technology that can be used to operate such controls.

📖 OTHER VERTICALS: Security Computing

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⚙️ ENABLERS: Privacy

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👥 COMMITTEE: ISO PC 317

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📅 PUBLISHED: 2023-01

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🔗 URL: <https://www.iso.org/standard/84977.html>

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## Standard | ISO/IEC 20889:2018 Privacy enhancing data de-identification terminology and classification of techniques

This document provides a description of privacy-enhancing data de-identification techniques, to be used to describe and design de-identification measures in accordance with the privacy principles in ISO/IEC 29100.

In particular, this document specifies terminology, a classification of de-identification techniques according to their characteristics, and their applicability for reducing the risk of re-identification.

This document is applicable to all types and sizes of organizations, including public and private companies, government entities, and not-for-profit organizations, that are PII controllers or PII processors acting on a controller's behalf, implementing data de-identification processes for privacy enhancing purposes.

📖 OTHER VERTICALS: Security Computing

⚙️ ENABLERS: Privacy

👥 COMMITTEE: ISO/IEC JTC 1/SC 27

📅 PUBLISHED: 2018-11

🔗 URL: <https://www.iso.org/standard/69373.html>

## Standard | ISO/IEC 24760-1:2019 IT Security and Privacy A framework for identity management Part 1: Terminology and concepts

This document defines terms for identity management, and specifies core concepts of identity and identity management and their relationships. It is applicable to any information system that processes identity information.

📖 OTHER VERTICALS: Security Computing

⚙️ ENABLERS: Security

👥 COMMITTEE: ISO/IEC JTC 1/SC 27

📅 PUBLISHED: 2019-05

🔗 URL: <https://www.iso.org/standard/77582.html>

## Standard | ISO/IEC 24760-2:2015 Information technology Security techniques A framework for identity management

ISO/IEC 24760-2:2015:

- ▶ provides guidelines for the implementation of systems for the management of identity information, and
- ▶ specifies requirements for the implementation and operation of a framework for identity management.

ISO/IEC 24760-2:2015 is applicable to any information system where information relating to identity is processed or stored.

📖 OTHER VERTICALS: Security Computing

⚙️ ENABLERS: Security

👥 COMMITTEE: ISO/IEC JTC 1/SC 27

📅 PUBLISHED: 2015-06

🔗 URL: <https://www.iso.org/standard/57915.html>

Standard | ISO/IEC 27551:2021 Information security, cybersecurity and privacy protection Requirements for attribute-based unlinkable entity authentication

This document provides a framework and establishes requirements for attribute-based unlinkable entity authentication (ABUEA).

OTHER VERTICALS: Security Computing

ENABLERS: Privacy

COMMITTEE: ISO/IEC JTC 1/SC 27

PUBLISHED: 2021-09

URL: <https://www.iso.org/standard/72018.html>

Standard | ISO/IEC 27556:2022 Information security, cybersecurity and privacy protection User-centric privacy preferences management framework

This document provides a user-centric framework for handling personally identifiable information (PII), based on privacy preferences.

OTHER VERTICALS: Security Computing

ENABLERS: Privacy

COMMITTEE: ISO/IEC JTC 1/SC 27

PUBLISHED: 2022-10

URL: <https://www.iso.org/standard/71674.html>

Standard | ISO/IEC 27559:2022 Information security, cybersecurity and privacy protection Privacy enhancing data de-identification framework

This document provides a framework for identifying and mitigating re-identification risks and risks associated with the lifecycle of de-identified data.

This document is applicable to all types and sizes of organizations, including public and private companies, government entities, and not-for-profit organizations, that are PII controllers or PII processors acting on a controller’s behalf, implementing data de-identification processes for privacy enhancing purposes.

OTHER VERTICALS: Security Computing

ENABLERS: Privacy

COMMITTEE: ISO/IEC JTC 1/SC 27

PUBLISHED: 2022-11

URL: <https://www.iso.org/standard/71677.html>

Standard | ISO/IEC 29100:2011 Information technology Security techniques Privacy framework

ISO/IEC 29100:2011 provides a privacy framework which

- specifies a common privacy terminology;
- defines the actors and their roles in processing personally identifiable information (PII);
- describes privacy safeguarding considerations; and
- provides references to known privacy principles for information technology.

ISO/IEC 29100:2011 is applicable to natural persons and organizations involved in specifying, procuring, architecting, designing, developing, testing, maintaining, administering, and operating information

and communication technology systems or services where privacy controls are required for the processing of PII.

📖 OTHER VERTICALS: Security Computing

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⚙️ ENABLERS: Privacy

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👥 COMMITTEE: ISO/IEC JTC 1/SC 27

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📅 PUBLISHED: 2011-12

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🔗 URL: <https://www.iso.org/standard/45123.html>

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## Standard | ISO/IEC 29115:2013 Information technology Security techniques Entity authentication assurance framework

ISO/IEC 29115:2013 provides a framework for managing entity authentication assurance in a given context. In particular, it:

- ▷ specifies four levels of entity authentication assurance;
- ▷ specifies criteria and guidelines for achieving each of the four levels of entity authentication assurance;
- ▷ provides guidance for mapping other authentication assurance schemes to the four LoAs;
- ▷ provides guidance for exchanging the results of authentication that are based on the four LoAs; and
- ▷ provides guidance concerning controls that should be used to mitigate authentication threats.

📖 OTHER VERTICALS: Security Computing

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⚙️ ENABLERS: Security

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👥 COMMITTEE: ISO/IEC JTC 1/SC 27

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📅 PUBLISHED: 2013-04

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🔗 URL: <https://www.iso.org/standard/45138.html>

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## Standard | ISO/IEC 29134:2023 Information technology Security techniques Guidelines for privacy impact assessment

This document gives guidelines for:

- ▷ a process on privacy impact assessments, and
- ▷ a structure and content of a PIA report.

It is applicable to all types and sizes of organizations, including public companies, private companies, government entities and not-for-profit organizations. This document is relevant to those involved in designing or implementing projects, including the parties operating data processing systems and services that process PII.

📖 OTHER VERTICALS: Security Computing

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⚙️ ENABLERS: Privacy

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👥 COMMITTEE: ISO/IEC JTC 1/SC 27

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📅 PUBLISHED: 2023-05

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🔗 URL: <https://www.iso.org/standard/86012.html>

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## Standard | ISO/IEC 29146:2016 Information technology Security techniques A framework for access management

ISO/IEC 29146:2016 defines and establishes a framework for access management (AM) and the secure management of the process to access information and Information and Communications


Technologies (ICT) resources, associated with the accountability of a subject within some context.

This International Standard provides concepts, terms and definitions applicable to distributed access management techniques in network environments.

This International Standard also provides explanations about related architecture, components and management functions.


The subjects involved in access management might be uniquely recognized to access information systems, as defined in ISO/IEC 24760.

The nature and qualities of physical access control involved in access management systems are outside the scope of this International Standard.

 OTHER VERTICALS: Security Computing

 ENABLERS: Security

 COMMITTEE: ISO/IEC JTC 1/SC 27


 PUBLISHED: 2016-06

 URL: <https://www.iso.org/standard/45169.html>

## Standard | ISO/IEC 29184:2020 Information technology Online privacy notices and consent

This document specifies controls which shape the content and the structure of online privacy notices as well as the process of asking for consent to collect and process personally identifiable information (PII) from PII principals.

This document is applicable in any online context where a PII controller or any other entity processing PII informs PII principals of processing.

 OTHER VERTICALS: Security Computing

 ENABLERS: Privacy

 COMMITTEE: ISO/IEC JTC 1/SC 27

 PUBLISHED: 2020-06


 URL: <https://www.iso.org/standard/70331.html>

## Technical report | ISO/IEC TR 27550:2019 Information technology Security techniques Privacy engineering for system life cycle processes

This document provides privacy engineering guidelines that are intended to help organizations integrate recent advances in privacy engineering into system life cycle processes. It describes:


- (1) the relationship between privacy engineering and other engineering viewpoints (system engineering, security engineering, risk management); and
- (2) privacy engineering activities in key engineering processes such as knowledge management, risk management, requirement analysis, and architecture design.

The intended audience includes engineers and practitioners who are involved in the development, implementation or operation of systems that need privacy consideration, as well as managers in organizations responsible for privacy, development, product management, marketing, and operations.

 OTHER VERTICALS: Security Computing

 ENABLERS: Privacy

 COMMITTEE: ISO/IEC JTC 1/SC 27

 PUBLISHED: 2019-09

 URL: <https://www.iso.org/standard/72024.html>

## Technical specification | ISO/IEC TS 27110:2021 Information technology, cybersecurity and privacy protection Cybersecurity framework development guidelines

This document specifies guidelines for developing a cybersecurity framework. It is applicable to cybersecurity framework creators regardless of their organizations' type, size or nature.

📖 OTHER VERTICALS: Security Computing

⚙️ ENABLERS: Security

👥 COMMITTEE: ISO/IEC JTC 1/SC 27

📅 PUBLISHED: 2021-02

🔗 URL: <https://www.iso.org/standard/72435.html>

## Technical specification | ISO/IEC TS 27560:2023 Privacy technologies Consent record information structure

This document specifies an interoperable, open and extensible information structure for recording PII principals' consent to PII processing. This document provides requirements and recommendations on the use of consent receipts and consent records associated with a PII principal's PII processing consent, aiming to support the:

- ▷ provision of a record of the consent to the PII principal;
- ▷ exchange of consent information between information systems;
- ▷ management of the life cycle of the recorded consent.

📖 OTHER VERTICALS: Security Computing

⚙️ ENABLERS: Privacy

👥 COMMITTEE: ISO/IEC JTC 1/SC 27

📅 PUBLISHED: 2023-08

🔗 URL: <https://www.iso.org/standard/80392.html>

## Technical specification | ISO/IEC TS 27570:2021 Privacy protection Privacy guidelines for smart cities

The document takes a multiple agency as well as a citizen-centric viewpoint. It provides guidance on:

- ▷ smart city ecosystem privacy protection;
- ▷ how standards can be used at a global level and at an organizational level for the benefit of citizens; and
- ▷ processes for smart city ecosystem privacy protection.

This document is applicable to all types and sizes of organizations, including public and private companies, government entities, and not-for-profit organizations that provide services in smart city environments.

📖 OTHER VERTICALS: Security Computing

⚙️ ENABLERS: Privacy

👥 COMMITTEE: ISO/IEC JTC 1/SC 27

📅 PUBLISHED: 2021-01

🔗 URL: <https://www.iso.org/standard/71678.html>

## Technical specification | ISO/IEC TS 29003:2018 Information technology Security techniques Identity proofing

The ISO/IEC TS 29003:2018 standard:

- ▷ gives guidelines for the identity proofing of a person;
- ▷ specifies levels of identity proofing, and requirements to achieve these levels.

ISO/IEC TS 29003:2018 is applicable to identity management systems.

OTHER VERTICALS: Security Computing

ENABLERS: Security

COMMITTEE: ISO/IEC JTC 1/SC 27

PUBLISHED: 2018-03

URL: <https://www.iso.org/standard/62290.html>

## Technical report | ISO/TR 31700-2:2023 Consumer protection Privacy by design for consumer goods and services Part 2: Use cases

This document provides illustrative use cases, with associated analysis, chosen to assist in understanding the requirements of 31700-1. The intended audience includes engineers and practitioners who are involved in the development, implementation or operation of digitally enabled consumer goods and services.

OTHER VERTICALS: Security Computing

ENABLERS: Privacy

COMMITTEE: ISO PC 317

PUBLISHED: 2023-01

URL: <https://www.iso.org/standard/84978.html>

## Standard | ISO 10303-1:2021 Industrial automation systems and integration Product data representation and exchange Part 1: Overview and fundamental principles

This document is the first of a family of standards. This document provides an overview of ISO 10303. ISO 10303 provides a representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged. The exchange is among different computer systems and environments associated with the complete product lifecycle, including product design, manufacture, use, maintenance, and final disposition of the product. This document defines the basic principles of product information representation and exchange used in ISO 10303. It specifies the characteristics of the various series of parts of ISO 10303 and the relationships among them.

The following are within the scope of this document:

- (1) scope statement for ISO 10303 as a whole;
- (2) overview of ISO 10303;
- (3) architectures of ISO 10303;
- (4) structure of ISO 10303;
- (5) terms and definitions used throughout ISO 10303;
- (6) overview of data specification methods used in ISO 10303; NOTE: This includes the EXPRESS data specification language and graphical presentation of product information models.
- (7) introduction to the series of parts of ISO 10303: (a) integrated resources; (b) application interpreted constructs; (c) application modules; (d) business object models; (e) application protocols; (f) implementation methods; (g) usage guides; (h) conformance testing methodology and framework; (i) abstract test suites; (j) scheme for identification of schemas and other information objects defined within parts of ISO 10303.



OTHER VERTICALS: Visualisation Data

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ENABLERS: Computation, Interoperability

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COMMITTEE: ISO TC 184 SC 4

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PUBLISHED: 2021-03

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URL: <https://www.iso.org/standard/72237.html>

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## Standard | ISO 10303-225:1999 Industrial automation systems and integration Product data representation and exchange Part 225: Application protocol: Building elements using explicit shape representation

This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for the exchange of building element shape, property, and spatial configuration information between application systems with explicit shape representations. Building elements are those physical things of which a building is composed, such as structural elements, enclosing and separating elements, service elements, fixtures and equipment, and spaces. Building element shape, property, and spatial configuration information requirements can be used at all stages of the life cycle of a building, including the design process, construction, and maintenance. Building element shape, property, and spatial configuration information requirements specified in this part of ISO 10303 support the following activities:

- (a) concurrent design processes or building design iterations;
- (b) integration of building structure designs with building systems designs to enable design analysis;
- (c) building design visualization;
- (d) specifications for construction and maintenance;
- (e) analysis and review.

The following are within the scope of this part of ISO 10303:

- (1) explicit representation of the three-dimensional shape of building elements using boundary representation (B-rep) solid models, swept solid models, or constructive solid geometry (CSG) models.
- (2) the spatial configuration of building elements that comprise the assembled building;
- (3) building structures that represent physically distinct buildings that are part of a single building complex;
- (4) non-structural elements that enclose a building or separate areas within a building;
- (5) the shape and arrangement of equipment and service elements that provide services to a building;
- (6) the shape and arrangement of fixtures in a building;
- (7) specification of spaces and levels;
- (8) the shape of the site on which the building will be erected;
- (9) specification of properties of building elements, including material composition;
- (10) specification of classification information;
- (11) association of properties and classification information to building elements;
- (12) changes to building element shape, property, and spatial configuration information;
- (13) association of approvals with building element shape, property, and spatial configuration information; and
- (14) as-built record of the building.

OTHER VERTICALS: Visualisation Data

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ENABLERS: Computation, Interoperability

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COMMITTEE: ISO TC 184 SC 4

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PUBLISHED: 1999-12

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URL: <https://www.iso.org/standard/25091.html>

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Standard | ISO 10303-46:2022 Industrial automation systems and integration  
Product data representation and exchange Part 46: Integrated generic resource:  
Visual presentation

ISO 10303-46 specifies the integrated resource constructs for Visual presentation. ISO 10303-46 specifies the integrated resources for the visualization of displayable product information. Presentation data as described in ISO 10303-46 are combined with product data and are exchanged together between systems with the aim that the receiving system can construct one or several pictures of the product information suitable for human perception. Product information can be visualized in two ways: either by realistic, life-like images according to the rules of projective geometry and light propagation and reflection, or by symbolic presentations that conform with draughting standards and conventions. ISO 10303-46 supports both types of presentations. The two types of visualization processes require different kinds of graphical transformations and these can be combined in the same picture. The actual generation of the picture from the product information and its presentation data is left to the receiving system. The rendered depiction can deviate from an ideal target because of limitations in the capabilities of graphics systems.

OTHER VERTICALS:	Visualisation Data
ENABLERS:	Computation, Interoperability
COMMITTEE:	ISO TC 184 SC 4
PUBLISHED:	2022-12
URL:	<a href="https://www.iso.org/standard/84676.html">https://www.iso.org/standard/84676.html</a>

Standard | IEEE 7001 Standard for Transparency of Autonomous Systems

Measurable, testable levels of transparency, so that autonomous systems can be objectively assessed, and levels of compliance determined, are described in this standard.

COMMITTEE:	IEEE VT/ITS
PUBLISHED:	2022-03
URL:	<a href="https://standards.ieee.org/ieee/7001/6929/">https://standards.ieee.org/ieee/7001/6929/</a>

Standard | IEEE 7005 Standard for Transparent Employer Data Governance

Specific methodologies to help employers in accessing, collecting, storing, utilizing, sharing, and destroying employee data are described in this standard. Specific metrics and conformance criteria regarding these types of uses from trusted global partners and how third parties and employers can meet them are provided in this standard. Certification processes, success criteria, and execution procedures are not within the scope of this standard.

ENABLERS:	Governance & Regulation
COMMITTEE:	IEEE C/S2ESC
PUBLISHED:	2021-11
URL:	<a href="https://standards.ieee.org/ieee/7005/7014/">https://standards.ieee.org/ieee/7005/7014/</a>

Standard | IEEE P1926.1 Standard for a Functional Architecture of Distributed  
Energy Efficient Big Data Processing

This standard specifies a functional architecture that supports the energy-efficient transmission and processing of large volumes of data, starting at processing nodes close to the data source, with significant processing resources provided at centralized data centers.

COMMITTEE:	IEEE COM/GreenICT-SC
PUBLISHED:	under development

## Standard | IEEE P2673 Standard for Patient Digital Biomedical Data Files with 3D Topological Mapping of Macroanatomy and Microanatomy for Use in Big Data and Augmented Intelligence Systems

This standard provides a framework for organization and use of new patient biomedical files containing medical imaging and imaging biomarker information for use in big data cloud-based augmented intelligence systems. In addition, this standard defines 3D digital topological mapping of information and data to human macroanatomy and microanatomy. Included in this standard are requirements to assure compliance with ethical design and value-based design standards to assure (1) patient data security with full access, sharing, and user control of their personal data; and (2) protection of the professional fiduciary relationships between physicians and patients.

👥 COMMITTEE: IEEE EMB/SC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/2673/7234/>

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## Standard | IEEE P2957 Standard for a Reference Architecture for Big Data Governance and Metadata Management

This standard defines a big data governance, metadata management and machine-readable reference architecture to enable scalability, findability, accessibility, interoperability and reusability of datasets among corporate heterogeneous and cross-domain repositories. The standard focuses on achieving data interoperability by utilizing persistent identifiers (PIDs) to enable:

- (1) a standard metadata registry for data discovery using a machine-readable format,
- (2) a standard data type registry for data consumption using a machine-actionable format, and
- (3) standard end-point services to convert data values between different types.

👥 COMMITTEE: IEEE C/SAB

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/2957/10381/>

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## Standard | IEEE P7004 Standard for Child and Student Data Governance

This standard provides stakeholders with certifiable and responsible child and student data governance methodologies.

⚙️ ENABLERS: Governance & Regulation

👥 COMMITTEE: IEEE C/LTSC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/7004/10270/>

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## Standard | ISO 8000-1:2022 Data quality Part 1: Overview

This document is the first of a family of standards. This document provides an overview of the ISO 8000 series. The following are within the scope of this document:

- (1) stating the scope of the ISO 8000 series as a whole;
- (2) establishing the principles of information and data quality;
- (3) describing the path to data quality;
- (4) describing the structure of the ISO 8000 series;
- (5) providing a summary of the content of each part in the ISO 8000 series; and
- (6) establishing the relationship of the ISO 8000 series to other international standards.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO TC 184 SC 4

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📅 PUBLISHED: 2022-04

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🔗 URL: <https://www.iso.org/standard/81745.html>

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## Standard | ISO/IEC 14496-25:2011 Information technology Coding of audio-visual objects Part 25: 3D Graphics Compression Model

ISO/IEC 14496-25:2011 describes a model for connecting 3D graphics compression tools defined in ISO/IEC 14496 to graphics primitives defined in any other standard, specification or recommendation.

The goal of ISO/IEC 14496-25:2011 is to specify an architectural model able to accommodate third-party XML based descriptions of scene graph and graphics primitives with (potential) binarization tools and with MPEG-4 3D graphics compression tools specified in ISO/IEC 14496-2, ISO/IEC 14496-11 and ISO/IEC 14496-16.

📖 OTHER VERTICALS: Representation & Modelling, Multimedia Coding

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO/IEC JTC 1/SC 29

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📅 PUBLISHED: 2011-05

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🔗 URL: <https://www.iso.org/standard/57755.html>

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## Guide | ISO/AWI 23143-1 Information exchange between BIM and GIS Part 1: Core principles and specifications

The scope of this project is to provide guidelines for information exchange between BIM and GIS. As part of a series of proposed international standards for BIM-GIS information exchange, Part 01: core principles and specifications will provide guidance on how to use existing standards adequately so that each domain can provide and request information properly. This work needs to be sufficiently broad by integrating ISO Standards and the latest developments from OGC and buildingSMART. The work will also cover the core principles of working with BIM and GIS, namely ensuring the Georeferencing of BIM models.

📖 OTHER VERTICALS: Representation & Modelling, Geospatial Systems

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👥 COMMITTEE: ISO TC 59 SC 13

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📅 PUBLISHED: under development

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🔗 URL: <https://www.iso.org/standard/87373.html?browse=tc>

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## Guide | ISO/AWI 23143-2 Information exchange between BIM and GIS Part 2: Facilitating data exchange through metadata

The scope of this project is to provide guidelines for information exchange between BIM and GIS. As part of a series of proposed international standards for BIM-GIS information exchange, Part 02: Facilitating data exchange through metadata will aim to solve metadata issues to support bidirectional GIS/BIM information exchange and suggest technical requirements based on use case scenarios. Metadata give great opportunities to find, evaluate and manage relevant information for the bidirectional information exchange. To ensure the interoperability between GIS and BIM information models, it is critical for one domain experts to understand the metadata generated from the other domain and vice versa. The work will review existing methodologies and research with regard to bidirectional GIS/BIM information exchange, especially in terms of metadata and item registration. It will provide a use case scenario to give a certain context of bidirectional exchange of metadata. The use case will also provide the context within which the interaction that needs to be taken place between GIS and BIM

model experts. With the use of the use case scenario, the process of properly generating metadata for each domain to ensure the bidirectional exchange can be identified. It will then list the technical requirements to support the process and provide a guideline to follow.

OTHER VERTICALS: Representation & Modelling, Geospatial Systems

COMMITTEE: ISO TC 59 SC 13

PUBLISHED: under development

URL: <https://www.iso.org/standard/87376.html?browse=tc>

## Standard | ISO 12911:2023 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Framework for specification of BIM implementation

This document establishes a framework for providing specifications for the internal commissioning and implementation of building information modelling (BIM) during both delivery and operational phases. It identifies a structured approach so as to encourage clarity during development, management and checking processes for use by organizations that develop and apply these specifications.

This document does not provide specific content but it does provide examples.

It is applicable to buildings, infrastructure, facilities and managed landscapes, of any size or complexity.

OTHER VERTICALS: Representation & Modelling

COMMITTEE: ISO TC 59 SC 13

PUBLISHED: 2023-02

URL: <https://www.iso.org/standard/79692.html?browse=tc>

## Standard | 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

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.

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.

OTHER VERTICALS: Representation & Modelling

COMMITTEE: ISO TC 59 SC 13

PUBLISHED: 2018-12

URL: <https://www.iso.org/standard/68078.html?browse=tc>

## Standard | ISO 23386:2020 Building information modelling and other digital processes used in construction Methodology to describe, author and maintain properties in interconnected data dictionaries

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.

📖 OTHER VERTICALS: Representation & Modelling

👥 COMMITTEE: ISO TC 59 SC 13

📅 PUBLISHED: 2020-03

🔗 URL: <https://www.iso.org/standard/75401.html?browse=tc>

## Standard | ISO 29481-3:2022 Building information models Information delivery manual Part 3: Data schema

This document is the technical addition to the methodology set out in ISO 29481-1. It defines a specification to store, exchange and read information delivery manual (IDM) specifications in a standardized and machine-readable way.

📖 OTHER VERTICALS: Representation & Modelling

👥 COMMITTEE: ISO TC 59 SC 13

📅 PUBLISHED: 2022-09

🔗 URL: <https://www.iso.org/standard/81261.html?browse=tc>

## Standard | ISO/CD TR 16214 Geospatial and BIM review of vocabularies

📖 OTHER VERTICALS: Representation & Modelling

👥 COMMITTEE: ISO TC 59 SC 13

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/84517.html?browse=tc>

## Standard | ISO/DIS 7817.2 Building information modelling Level of information need Concepts and principles

📖 OTHER VERTICALS: Representation & Modelling

👥 COMMITTEE: ISO TC 59 SC 13

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/82914.html?browse=tc>

## Standard | IEC SRD 63273-1:2023 Smart city use case collection and analysis City information modelling Part 1: High-level analysis

IEC SRD 63273-1:2023 series aims to scope out the requirements of city information modelling standards by collecting and analysing its use cases. Specifically, the IEC SRD 63273 series achieves the objectives of identifying the key application areas and stakeholders, developing user stories and clarifying the relationship among these stakeholders, collecting and analysing use cases of city information modelling, scoping out the requirements for city information modelling standards and providing recommendations to IEC regarding urban planning and management.

The IEC SRD 63273 part 1 explains how the work of city information modelling use case collection and analysis address sustainable development goals, provides a brief overview of city information modelling, and identifies the key application areas and stakeholders of city information modelling, identifies the key application areas of city information modelling, and determines the stakeholders and the relationships among them in these application areas.

📖 OTHER VERTICALS: Representation & Modelling, Digital Twins

👥 COMMITTEE: IEC SyC Smart Cities

📅 PUBLISHED: 2023-08

🔗 URL: <https://webstore.iec.ch/publication/74173>

## Standard | IEC SRD 63273-2 Systems Reference Deliverable (SRD) Use Case Collection and Analysis: City Information Modelling Part 2

📖 OTHER VERTICALS: Representation & Modelling

👥 COMMITTEE: IEC SyC Smart Cities

📅 PUBLISHED: under development

🔗 URL: [https://www.iec.ch/dyn/www/?p=103:38:213710033121054:::FSP\\_ORG\\_ID.FSP\\_APEX\\_PAGE.FSP\\_PROJECT\\_ID:13073.23.103401](https://www.iec.ch/dyn/www/?p=103:38:213710033121054:::FSP_ORG_ID.FSP_APEX_PAGE.FSP_PROJECT_ID:13073.23.103401)

## Technical report | IEC Technology Report City information modelling:2021 City information modelling and urban digital twins

The development and delivery of smart cities involves many different systems, types of data, and sets of information. This complexity, and the dynamic interaction between the large numbers of stakeholders and city systems, makes planning and managing cities a great challenge. Without a tangible operational model to combine cross-sector data and information, the holistic, cross-boundary planning of cities, districts and neighbourhoods remains constrained. Therefore, new and effective tools are needed to enable the delivery of better city services and to make the urban environment more liveable, inclusive, safe, resilient and sustainable.

City information modelling (CIM) and urban digital twins (UDT) are two emerging technologies for smart cities that aim to provide such tools. Both offer solutions for data processing, urban analysis, design, simulation and modelling. They connect all involved stakeholders and actors to collaboratively deliver the vision of a smart city: a sustainable, inclusive, healthy, prosperous and participative city.

They provide solutions for smart cities based on open standards and a multiscale and multitemporal database that integrates a wide variety of data sources presenting the full range of smart urban features, systems and processes.

OTHER VERTICALS: Representation & Modelling, Digital Twins

COMMITTEE: IEC SyC Smart Cities

PUBLISHED: 2021-12

URL: <https://webstore.iec.ch/publication/72587>

## OTHER

Standard | ISO 23247-4:2021 Automation systems and integration Digital twin framework for manufacturing Part 4: Information exchange | [see details]

### 4.3.3 Representation & Modelling

Standard | ISO/IEC 23005-4:2018 Information technology Media context and control Part 4: Virtual world object characteristics

The technologies of this document specified are description languages and vocabularies to describe virtual world objects. The adaptation engine is not within the scope of this document. This document specifies syntax and semantics of the tools used to characterize a virtual world object related metadata: Virtual World Object Characteristics (VWOC) as an XML Schema-based language which enables one to describe a basic structure of avatars and virtual world objects in virtual environments.

OTHER VERTICALS: Avatars, Extended Reality, Metaverse

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: 2018-09

URL: <https://www.iso.org/standard/73579.html>

Standard | ISO 16792:2021 Technical product documentation Digital product definition data practices

This document specifies requirements for the preparation, revision and presentation of digital product definition data, hereafter referred to as data sets, complementing existing standards. It supports two methods of application: 3D model-only and 3D model with 2D drawing in digital format. The structure of this document presents requirements common to both methods followed by clauses providing for any essential, differing requirements for each method. Additionally, its use in conjunction with computer-aided design (CAD) systems can assist in the progression towards improved modelling and annotation practices for CAD and engineering disciplines, as well as serving as a guideline for CAX software developers.

OTHER VERTICALS: Avatars, Extended Reality

COMMITTEE: ISO TC 10

PUBLISHED: 2021-04

URL: <https://www.iso.org/standard/73871.html>



## Standard | ISO/IEC 23488:2022 Information technology Computer graphics, image processing and environment data representation Object/environmental representation for image-based rendering in virtual/mixed and augmented reality (VR/MAR)

This document specifies an image-based representation model that represents target objects/environments using a set of images and optionally the underlying 3D model for accurate and efficient objects/environments representation at an arbitrary viewpoint. It is applicable to a wide range of graphic, virtual reality and mixed reality applications which require the method of representing a scene with various objects and environments. This document:

- (1) defines terms for image-based representation and 3D reconstruction techniques;
- (2) specifies the required elements for image-based representation;
- (3) specifies a method of representing the real world in the virtual space based on image-based representation;
- (4) specifies how visible image patches can be integrated with the underlying 3D model for more accurate and rich objects/environments representation from arbitrary viewpoints;
- (5) specifies how the proposed model allows multi-object representation; and
- (6) provides an XML based specification of the proposed representation model and an actual implementation example (see Annex A).

📖 OTHER VERTICALS: Avatars, Extended Reality

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 2022-05

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🔗 URL: <https://www.iso.org/standard/75718.html>

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## Technical specification | ISO/IEC TS 23884:2021 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)

This document specifies:

- ▷ physical and material parameters of virtual or real objects expressed to support comprehensive haptic rendering methods, such as stiffness, friction and micro-textures; and
- ▷ a flexible specification of the haptic rendering algorithm itself.

It supplements other standards that describe scene or content description and information models for virtual and mixed reality, such as ISO/IEC 19775 and ISO/IEC 3721-1.

📖 OTHER VERTICALS: Avatars, Extended Reality

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 2021-12

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🔗 URL: <https://www.iso.org/standard/77278.html>

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## Standard | ISO/IEC 23093-3:2022 Information technology Internet of media things Part 3: Media data formats and APIs

This document specifies the syntax and semantics of description schemes to represent data exchanged by media things (e.g., media sensors, media actuators, media analysers, media storages). Moreover, it specifies the APIs to exchange these data between media things. This document does not specify how sensing and analysing is carried out but defines the interfaces between the media things.

📖 OTHER VERTICALS: Internet of Things (IoT), Multimedia Coding

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO/IEC JTC 1/SC 29

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📅 PUBLISHED: 2022-06

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🔗 URL: <https://www.iso.org/standard/81589.html>

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## Standard | ISO 14306:2017 Industrial automation systems and integration JT file format specification for 3D visualization

ISO 14306:2017 defines the syntax and semantics of a file format for the 3D visualization and interrogation of lightweight geometry and product manufacturing information derived from CAD systems, using visualization software tools that do not need the full capability of a CAD system. ISO 14306:2017 has been adopted as a 3D visualization capability in addition to the ISO 10303 series. The file format supports the following information:

- (1) facet information (triangles), stored with geometry compression techniques
- (2) visual attributes such as lights, textures and materials
- (3) product manufacturing information, such as dimensions, tolerances and other attributes
- (4) boundary representation (b-rep) solid model shape representations. Several alternatives are available, including a representation based on the geometry standard defined in ISO 10303
- (5) configuration representations
- (6) delivery methods such as asynchronous streaming of content

ISO 14306:2017 does not specify the implementation of, or definition of a run-time architecture for viewing or processing of the file format.

📖 OTHER VERTICALS: Computer Graphics

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⚙️ ENABLERS: Computation, Interoperability

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👥 COMMITTEE: ISO TC 184 SC 4

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📅 PUBLISHED: 2017-11

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🔗 URL: <https://www.iso.org/standard/62770.html>

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## Standard | ISO 32000-1:2008 Document management Portable document format Part 1: PDF 1.7

ISO 32000-1:2008 specifies a digital form for representing electronic documents to enable users to exchange and view electronic documents independent of the environment in which they were created or the environment in which they are viewed or printed. It is intended for the developer of software that creates PDF files (conforming writers), software that reads existing PDF files and interprets their contents for display and interaction (conforming readers) and PDF products that read and/or write PDF files for a variety of other purposes (conforming products).

📖 OTHER VERTICALS: Extended Reality

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👥 COMMITTEE: ISO TC 171 SC 2

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📅 PUBLISHED: 2008-07

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🔗 URL: <https://www.iso.org/standard/51502.html>

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## Standard | ISO/IEC 12113:2022 Information technology Runtime 3D asset delivery format Khronos glTF™ 2.0

This document describes the glTF file format. glTF is an API-neutral runtime asset delivery format. glTF bridges the gap between 3D content creation tools and modern graphics applications by providing an efficient, extensible, interoperable format for the transmission and loading of 3D content.

📖 OTHER VERTICALS: Extended Reality

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO/IEC JTC 1

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📅 PUBLISHED: 2022-07

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🔗 URL: <https://www.iso.org/standard/83990.html>

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## Standard | ISO/IEC 14772-1:1997 Information technology Computer graphics and image processing The Virtual Reality Modeling Language Part 1: Functional specification and UTF-8 encoding

ISO/IEC 14772, the Virtual Reality Modeling Language (VRML), defines a file format that integrates 3D graphics and multimedia. Conceptually, each VRML file is a 3D time-based space that contains graphic and aural objects that can be dynamically modified through a variety of mechanisms. This part of ISO/IEC 14772 defines a primary set of objects and mechanisms that encourage composition, encapsulation, and extension. The semantics of VRML describe an abstract functional behaviour of time-based, interactive 3D, multimedia information. ISO/IEC 14772 does not define physical devices or any other implementation-dependent concepts (e.g., screen resolution and input devices). ISO/IEC 14772 is intended for a wide variety of devices and applications, and provides wide latitude in interpretation and implementation of the functionality. For example, ISO/IEC 14772 does not assume the existence of a mouse or 2D display device. Each VRML file:

- a. implicitly establishes a world coordinate space for all objects defined in the file, as well as all objects included by the file;
- b. explicitly defines and composes a set of 3D and multimedia objects;
- c. can specify hyperlinks to other files and applications; and
- d. can define object behaviours.

An important characteristic of VRML files is the ability to compose files together through inclusion and to relate files together through hyperlinking. For example, consider the file `earth.wrl` which specifies a world that contains a sphere representing the earth. This file may also contain references to a variety of other VRML files representing cities on the earth (e.g., `fileparis.wrl`). The enclosing file, `earth.wrl`, defines the coordinate system that all the cities reside in. Each city file defines the world coordinate system that the city resides in but that becomes a local coordinate system when contained by the earth file. Hierarchical file inclusion enables the creation of arbitrarily large, dynamic worlds. Therefore, VRML ensures that each file is completely described by the objects contained within it. Another essential characteristic of VRML is that it is intended to be used in a distributed environment such as the World Wide Web. There are various objects and mechanisms built into the language that support multiple distributed files, including:

- a. in-lining of other VRML files;
- b. hyperlinking to other files;
- c. using established Internet and ISO standards for other file formats; and
- d. defining a compact syntax.

📖 OTHER VERTICALS: Extended Reality

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 1997-12

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🔗 URL: <https://www.iso.org/standard/25508.html>

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## Standard | ISO/IEC DIS 3721-1 Information model for MAR (Mixed and Augmented Reality) contents

The objective of this document is to propose an extension to the existing standard for the information model for representing the mixed and augmented reality scene/contents description, namely:

- 1) Extending the existing and conventional constructs for representing the virtual reality scene graph

and structure such that a comprehensive range of mixed and augmented reality contents can also be represented.

2) As part of the extension, representing physical objects in the mixed and augmented reality scene targeted for augmentation.

3) As part of the extension, representing physical objects as augmentation to other (virtual or physical) objects in the mixed and augmented reality scene.

4) Providing ways to spatially associate aforementioned physical objects with the corresponding target objects (virtual or physical) in the mixed and augmented reality scene.

5) Other necessary functionalities and abstractions that will support the dynamic MAR scene description such as event/data mapping, and dynamic augmentation behaviours.

6) Describing the association between these constructs and the MAR system which is responsible for taking and interpreting this information model and rendering/presenting it out through the MAR display device.

The document also provides definitions for terms as related to these MAR content informational components and their attributes. The target audience of this document are mainly MAR system developers and contents designers interested in specifying MAR contents to be played by an MAR system or browser. The standard will provide a basis for further application standards or file formats for any virtual and mixed reality applications and content representation. The extension will be self-contained in the sense that it is independent from the existing virtual reality information constructs, focusing only on the mixed and augmented reality aspects. However, this document only proposes the information model, and neither promotes nor proposes to use a specific language, file format, algorithm, device, implementation method, and standard. The proposed model is to be considered as the minimal basic model that can be extended for other purposed in actual implementation.

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📖 OTHER VERTICALS: Extended Reality

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: under development

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🔗 URL: <https://www.iso.org/obp/ui/#iso:std:iso-iec:3721:-1:dis:ed-1:vl:en>

## Standard | ISO 128-3:2022 Technical product documentation (TPD) General principles of representation Part 3: Views, sections and cuts

This document specifies the general principles for presenting views, sections and cuts applicable to various kinds of technical drawings (e.g. mechanical, electrical, architectural, civil engineering), following the orthographic projection methods specified in ISO 5456-2. Views and sections for shipbuilding technical drawings are discussed in ISO 128-15. Views and sections for 3D models are discussed in ISO 16792. Attention has also been given in this document to the requirements of reproduction, including microcopying in accordance with ISO 6428.

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👥 COMMITTEE: ISO TC 10

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📅 PUBLISHED: 2022-08

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🔗 URL: <https://www.iso.org/standard/83356.html>

## Standard | ISO 14739-1:2014 Document management 3D use of Product Representation Compact (PRC) format Part 1: PRC 10001

ISO 14739-1:2014 describes PRC 10001 of a product representation compact (PRC) file format for three dimensional (3D) content data. This format is designed to be included in PDF (ISO 32000) and other similar document formats for the purpose of 3D visualization and exchange. It can be used for creating, viewing, and distributing 3D data in document exchange workflows. It is optimized to store, load, and display various kinds of 3D data, especially that coming from computer aided design (CAD) systems.

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👥 COMMITTEE: ISO TC 171 SC 2

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📅 PUBLISHED: 2014-12

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🔗 URL: <https://www.iso.org/standard/54948.html>

## Standard | ISO 19444-1:2019 Document management XML Forms Data Format Part 1: Use of ISO 32000-2 (XFDf 3.0)

This document specifies an XML format for representing forms data and annotations in the Portable Document Format, ISO 32000-2 (PDF 2.0).

🔗 ENABLERS: Interoperability

👥 COMMITTEE: ISO TC 171 SC 2

📅 PUBLISHED: 2019-08

🔗 URL: <https://www.iso.org/standard/74272.html>

## Standard | ISO 32000-2:2020 Document management Portable document format Part 2: PDF 2.0

This document specifies a digital form for representing electronic documents to enable users to exchange and view electronic documents independent of the environment in which they were created or the environment in which they are viewed or printed. It is intended for developers of software that creates PDF files (PDF writers), software that reads existing PDF files and (usually) interprets their contents for display (PDF readers), software that reads and displays PDF content and interacts with the computer users to possibly modify and save the PDF file (interactive PDF processors) and PDF products that read and/or write PDF files for a variety of other purposes (PDF processors). (PDF writers and PDF readers are more specialised classifications of interactive PDF processors and all are PDF processors).

👥 COMMITTEE: ISO TC 171 SC 2

📅 PUBLISHED: 2020-12

🔗 URL: <https://www.iso.org/standard/75839.html>

## Standard | ISO/IEC AWI 20538 Human information data model for 3D virtual smart cities

The human information data model for VR-based smart cities is defined to represent human-related information in 3D virtual environments. It defines concepts, a data model, and how to integrate 3D virtual worlds and information related to sensors that people carry with them. It defines an exchangeable information data model necessary for transferring and storing human information in 3D virtual smart cities. This document will specify:

- ▷ Representation of human information in a 3D virtual smart city.
- ▷ Representation of human information with sensors in a 3D virtual smart city.
- ▷ Representation of human semantic and physiological information for a 3D virtual smart city.
- ▷ Definition of an interchangeable data model for human information for a VR smart city.

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/86311.html>

## Technical report | ISO/IEC/IEEE 24641:2023 Systems and Software engineering Methods and tools for model-based systems and software engineering

This document deals with the tool capabilities and methods for model-based systems and software engineering (MBSSE). This document:

- (1) specifies a reference model for the overall structure and processes of MBSSE-specific processes, and describes how the components of the reference model fit together;
- (2) specifies interrelationships between the components of the reference model;
- (3) specifies MBSSE-specific processes for model-based systems and software engineering; the

processes are described in terms of purpose, inputs, outcomes and tasks;

(4) specifies methods to support the defined tasks of each process; and

(5) specifies tool capabilities to automate or semi-automate tasks or methods.

This document does not bring any additional life cycle processes for system and software but specifies an MBSSE reference model considered as activities, not only from the life cycle perspectives of systems engineering problem solving and the system-of-interest evolution, but also from the cognitive perspectives of modelling and model management, which can sustain and facilitate the system and software life cycle processes during digital transformation and in the digital age. The processes defined in this document are applicable for a single project, as well as for an organization performing multiple projects or an enterprise. These processes are applicable for managing and performing the systems and software engineering activities based on models within any stage in the life cycle of a system-of-interest.

👥 COMMITTEE: ISO/IEC JTC 1/SC 7

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📅 PUBLISHED: 2023-05

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🔗 URL: <https://www.iso.org/standard/79111.html>

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## Technical specification | ISO/TS 23301:2021 STEP geometry visualization services

This document defines a set of metadata to support the audit trail of the transformation of a geometry definition, while it is distributed and shared in supply-chains, to ensure the traceability of geometric model data. It also defines a set of web services based on the utilisation of these metadata. The following are within the scope of this document:

- (1) metadata definitions for geometry transformation audit trail;
- (2) syntax for storing these metadata in geometry data sets in various formats;
- (3) conformance level for implementers and business processes; and
- (4) definitions of web services to query the geometric model data set and its associated metadata.

The following are outside the scope of this document:

- (1) service specifications for CAD operations;
- (2) specifications of a cybersecurity infrastructure to enable web services;
- (3) the technical implementation of a STEP geometry services client or server;
- (4) any geometric model definition;
- (5) any product and manufacturing information (PMI) definition; and
- (6) archiving.

⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO TC 184 SC 4

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📅 PUBLISHED: 2021-12

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🔗 URL: <https://www.iso.org/standard/75189.html>

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## Technical specification | ISO/TS 24064:2023 Document management Portable document format RichMedia annotations conforming to the ISO 10303-242 (STEP AP 242) specification

This document specifies how to extend the ISO 32000-2 specification by adding the ISO 10303-242 (STEP AP 242) format as a valid format for 3D assets contained in a RichMedia annotation. It is intended for:

- ▶ developers of software that creates PDF files (PDF writers);
- ▶ software that reads existing PDF files and usually interprets their contents for display (PDF readers);
- ▶ software that reads and displays PDF content and interacts with the computer users to possibly modify and save the PDF file (PDF processors);
- ▶ PDF products that read and/or write PDF files for a variety of other purposes (PDF processors).

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ISO TC 171 SC 2

📅 PUBLISHED: 2023-03

🔗 URL: <https://www.iso.org/standard/77686.html>

## OTHER

Standard | ISO 10303-21:2016 Industrial automation systems and integration Product data representation and exchange Part 21: Implementation methods: Clear text encoding of the exchange structure [see details]

Standard | ISO/IEC 14496-16:2011-Information technology Coding of audio-visual objects Part 16: Animation Framework eXtension (AFX) [see details]

Standard | ISO/IEC 14496-27:2009-Information technology Coding of audio-visual objects Part 27: 3D Graphics conformance [see details]

Standard | ISO/IEC 15938-3:2002-Information technology Multimedia content description interface Part 3: Visual [see details]

Standard | ISO/IEC 15938-5:2003-Information technology Multimedia content description interface Part 5: Multimedia description schemes [see details]

Standard | ISO/IEC 23090-14:2023-Information technology Coded representation of immersive media Part 14: Scene description [see details]

Technical report | ISO/IEC TR 15938-8:2002-Information technology Multimedia content description interface Part 8: Extraction and use of MPEG-7 descriptions [see details]

Standard | ISO 17506:2022-Industrial automation systems and integration COLLADA (TM) digital asset schema specification for 3D visualization of industrial data [see details]

Standard | IEEE P3141-Standard for 3D Body Processing [see details]

Standard | ISO 18163:2016-Clothing Digital fittings Vocabulary and terminology used for the virtual garment [see details]

Standard | ISO 18825-1:2016-Clothing Digital fittings Part 1: Vocabulary and terminology used for the virtual human body [see details]

Standard | ISO 18825-2:2016-Clothing Digital fittings Part 2: Vocabulary and terminology used for attributes of the virtual human body [see details]

Standard | ISO 20947-1:2021-Performance evaluation protocol for digital fitting systems Part 1: Accuracy of virtual human body representation [see details]

Standard | ISO/DIS 17097-3-D human body scan data Part 1: Terminologies and methodologies for processing of human scan data [see details]

Standard | ISO/IEC 39794-16:2021-Information technology Extensible biometric data interchange formats Part 16: Full body image data [see details]

Standard | ISO/IEC 19777-1:2006-Information technology Computer graphics and



image processing Extensible 3D (X3D) language bindings Part 1: ECMAScript [see details]

Standard | ISO/IEC 19777-2:2006-Information technology Computer graphics and image processing Extensible 3D (X3D) language bindings Part 2: Java [see details]

Standard | ISO/IEC 14496-25:2011 Information technology Coding of audio-visual objects Part 25: 3D Graphics Compression Model [see details]

Guide | ISO/AWI 23143-1 Information exchange between BIM and GIS Part 1: Core principles and specifications [see details]

Guide | ISO/AWI 23143-2 Information exchange between BIM and GIS Part 2: Facilitating data exchange through metadata [see details]

Standard | ISO 12911:2023 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) Framework for specification of BIM implementation [see details]

Standard | 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 [see details]

Standard | ISO 23386:2020 Building information modelling and other digital processes used in construction Methodology to describe, author and maintain properties in interconnected data dictionaries [see details]

Standard | ISO 29481-3:2022 Building information models Information delivery manual Part 3: Data schema [see details]

Standard | ISO/CD TR 16214 Geospatial and BIM review of vocabularies [see details]

Standard | ISO/DIS 7817.2 Building information modelling Level of information need Concepts and principles [see details]

Standard | IEC SRD 63273-1:2023 Smart city use case collection and analysis City information modelling Part 1: High-level analysis [see details]

Standard | IEC SRD 63273-2 Systems Reference Deliverable (SRD) Use Case Collection and Analysis: City Information Modelling Part 2 [see details]

Technical report | IEC Technology Report City information modelling:2021 City information modelling and urban digital twins [see details]



## 4.3.4 Visualisation Data

### Standard | ISO 9241-125:2017 Ergonomics of human-system interaction Part 125: Guidance on visual presentation of information

ISO 9241-125:2017 provides guidance for the visual 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. Those of its provisions 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. ISO 9241-125:2017 can be utilized throughout the design process (e.g. as specification and guidance for designers during design or as a basis for heuristic evaluation). Its provisions for the presentation of information depend upon the visual design approach, the task, the user, the environment and the single or multiple technologies that might be used for presenting the information. Consequently, this document cannot be applied without knowledge of the context of use. It is not intended to be used as a prescriptive set of rules to be applied in its entirety but rather assumes that the designer has proper information available concerning task and user requirements and understands the use of available technology. Some of the provisions of this document are based on Latin-based language usage and might not apply, or might need to be modified, for use with languages that use other alphabets. In applying those that assume a specific language base (e.g. alphabetic ordering of coding information, items in a list), it is important that care is taken to follow its intent of the standard when translation is required to a different language. ISO 9241-125:2017 does not address auditory or tactile/haptic presentation of information or modality shifting for the presentation of visual information in other modalities. NOTE ISO 9241-112 provides high-level ergonomic guidance that applies to all modalities.

COMMITTEE: ISO TC 159 SC 4

PUBLISHED: 2017-09

URL: <https://www.iso.org/standard/64839.html>

### Standard | ISO 9241-161:2016 Ergonomics of human-system interaction Part 161: Guidance on visual user-interface elements

ISO 9241-161:2016 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. ISO 9241-161:2016 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 derivatives, 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. It does not provide detailed coverage of the methods and techniques required for design of user-interface elements. This part of ISO 9241 does not address implementation (e.g. graphical design of elements) and interaction details for specific input methods or technologies. It does not cover decorative user-interface elements that are intended to address solely aesthetic (hedonic) qualities in the user interface, e.g. background images. The information in this part of ISO 9241 is intended for use by those responsible for the selection and implementation of visual user-interface elements in interactive systems and for evaluating user interfaces. It is intended for use by those planning and managing platform specific aspects of user interface screen design. It also provides guidance for human factors/ergonomics and usability professionals involved in human-centred design. It addresses technical issues only to the extent necessary to allow users of this part of ISO 9241 to understand the relevance and importance of a consistent interface element usage and selection in the design process as a whole. Annex A provides a guide to selection of different visual user interface elements depending of their appropriate application.

COMMITTEE: ISO TC 159 SC 4

## OTHER

Technical report | ISO/IEC CD TR 5259-6 Artificial intelligence Data quality for analytics and machine learning (ML) Part 6: Visualization framework for data quality [see details]

Technical report | ISO/TR 24464:2020 Automation systems and integration Industrial data Visualization elements of digital twins [see details]

Standard | ISO 16757-2:2016 Data structures for electronic product catalogues for building services Part 2: Geometry [see details]

Standard | ISO 17506:2022 Industrial automation systems and integration COLLADA (TM) digital asset schema specification for 3D visualization of industrial data[see details]

Standard | ISO 10303-1:2021 Industrial automation systems and integration Product data representation and exchange Part 1: Overview and fundamental principles [see details]

Standard | ISO 10303-225:1999 Industrial automation systems and integration Product data representation and exchange Part 225: Application protocol: Building elements using explicit shape representation [see details]

Standard | ISO 10303-46:2022 Industrial automation systems and integration Product data representation and exchange Part 46: Integrated generic resource: Visual presentation [see details]

## ■ 4.4 Platform

### 4.4.1 Architecture

#### Technical specification | ETSI GS ARF 003 V1.1.1 Augmented Reality Framework (ARF); AR framework architecture

The present document specifies a functional reference architecture for AR components, systems and services. The structure of this architecture and the functionalities of its components have been derived from a collection of use cases, ETSI GR ARF 002 (V1.1.1): Augmented Reality Framework (ARF) Industrial use cases for AR applications and services, and an overview of the current landscape of AR standards, ETSI GR ARF 001 (V1.1.1): Augmented Reality Framework (ARF); AR standards landscape. The present document introduces the characteristics of an AR system and describes the functional building blocks of the AR reference architecture and their mutual relationships. The generic nature of the architecture is validated by mapping the workflow of several use cases to the components of this framework architecture.

📖 OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ETSI ISG ARF

📅 PUBLISHED: 2020-03

🔗 URL: [https://www.etsi.org/deliver/etsi\\_gs/ARF/001\\_099/003/01.01.01\\_60/gs\\_ARF003v010101p.pdf](https://www.etsi.org/deliver/etsi_gs/ARF/001_099/003/01.01.01_60/gs_ARF003v010101p.pdf)

#### Technical specification | ETSI GS ARF 004-5 V1.1.1 Augmented Reality Framework (ARF); Interoperability Requirements for AR components, systems and services; Part 5: External Communications

The present document reviews the high level Reference Point requirements between the Scene Management and External Application Support functions as they are described in ETSI GS ARF 003 (V1.1.1): Augmented Reality Framework (ARF) AR framework architecture.

📖 OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ETSI ISG ARF

📅 PUBLISHED: 2022-12

🔗 URL: [https://www.etsi.org/deliver/etsi\\_gs/ARF/001\\_099/00405/01.01.01\\_60/gs\\_ARF00405v010101p.pdf](https://www.etsi.org/deliver/etsi_gs/ARF/001_099/00405/01.01.01_60/gs_ARF00405v010101p.pdf)

#### Technical specification | ETSI GS ARF 005 V1.1.1 Augmented Reality Framework (ARF); Open APIs for the Creation and Management of the World Representation

The present document provides an overview and an introduction to the interface specification for the reference points “AR 16 World Anchors” and “AR 17 Reference Objects” of the AR framework architecture, ETSI GS ARF 003 (V1.1.1): Augmented Reality Framework (ARF) AR framework architecture, developed by the ETSI Industry Specification Group (ISG) for an Augmented Reality Framework (ARF). The actual interface specification is provided as OpenAPI™ specification, ARF005 World Storage API, revision 1.0.0, and forms the baseline for the present document.

📖 OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ETSI ISG ARF

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📅 PUBLISHED: 2022-09

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🔗 URL: [https://www.etsi.org/deliver/etsi\\_gs/ARF/001\\_099/005/01.01.01\\_60/gs\\_ARF005v010101p.pdf](https://www.etsi.org/deliver/etsi_gs/ARF/001_099/005/01.01.01_60/gs_ARF005v010101p.pdf)

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## Standard | ISO/IEC 18039:2019 Information technology Computer graphics, image processing and environmental data representation Mixed and augmented reality (MAR) reference model

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) 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. The reference model is intended for use by current and future developers of MAR applications, components, systems, services or specifications to describe, compare, contrast and communicate their architectural design and implementation. The MAR reference model is designed to apply to MAR systems independent of specific algorithms, implementation methods, computational platforms, display systems and sensors or devices used. This document does not specify how a particular MAR application, component, system, service or specification is designed, developed or implemented. It does not specify the bindings of those designs and concepts to programming languages or the encoding of MAR information through any coding technique or interchange format. This document contains a list of representative system classes and use cases with respect to the reference model.

📁 OTHER VERTICALS: Extended Reality

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 2019-02

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🔗 URL: <https://www.iso.org/standard/30824.html>

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## Technical report | ISO/TR 23262:2021 GIS (geospatial) / BIM interoperability

This document investigates barriers and proposes measures to improve interoperability between geospatial and BIM domains, namely, to align GIS standards developed by ISO/TC 211 and BIM standards developed by ISO/TC 59/SC 13. Where relevant this document takes into account work and documents from other organizations and committees, such as buildingSMART, International (bSI), Open Geospatial Consortium (OGC) and Comité Européen de Normalisation (CEN). The focus is to identify future topics for standardization and possible revision needs of existing standards. This document investigates conceptual and technological barriers between GIS and BIM domains at the data, service and process levels, as defined by ISO 11354 (all parts).

📁 OTHER VERTICALS: Geospatial Systems

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO TC 59 SC 13

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📅 PUBLISHED: 2021-05

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🔗 URL: <https://www.iso.org/standard/75105.html>

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## Standard | ISO/IEC 30141 ED2 Internet of Things (IoT) Reference architecture

This document specifies an Internet of Things (IoT) reference architecture (IoT RA). The IoT RA is a generalization of existing practice including the distinguishing characteristics of IoT systems and other 195 fundamental characteristics exhibited by IoT systems. The IoT RA addresses stakeholder concerns related to 196 the business value of IoT systems. The IoT RA also addresses the interactions between the IoT system, the 197 users, and the physical environment. Implementation of IoT systems is also addressed in this IoT RA. Among 198 the characteristics specified in the IoT RA are abstract functions within IoT systems and a variety of structures 199 that are used to construct IoT systems.

📖 OTHER VERTICALS: Internet of Things (IoT)

👥 COMMITTEE: ISO/IEC JTC 1/SC 41

📅 PUBLISHED: under development

🔗 URL: [https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,104064](https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,104064)

## Technical specification | ISO/IEC TS 30149 ED1 Internet of Things (IoT) Trustworthiness Principles

This document provides elements of IoT trustworthiness based on ISO/IEC 30141 IoT Reference Architecture.

📖 OTHER VERTICALS: Internet of Things (IoT)

⚙️ ENABLERS: Trust

👥 COMMITTEE: ISO/IEC JTC 1/SC 41

📅 PUBLISHED: under development

🔗 URL: [https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,104432](https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,104432)

## Standard | ISO/IEC 23093-1:2022 Information technology Internet of media things Part 1: Architecture

This document describes the architecture of systems for the internet of media things.

📖 OTHER VERTICALS: Multimedia Coding

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2022-03

🔗 URL: <https://www.iso.org/standard/81586.html>

## Standard | ISO 29481-1:2016 Building information models Information delivery manual Part 1: Methodology and format

This part of ISO 29481 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.

This part of ISO 29481 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.

📁 OTHER VERTICALS: Architecture

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO TC 59 SC 13

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📅 PUBLISHED: 2016-05

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🔗 URL: <https://www.iso.org/standard/60553.html>

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## Standard | ISO 29481-2:2012 Building information models Information delivery manual Part 2: Interaction framework

ISO 29481-2:2012 specifies a methodology and format for describing coordination 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. ISO 29481-2:2012 is intended to facilitate interoperability between software applications used in the construction process, to promote digital collaboration between actors in the building construction process, and to provide a basis for accurate, reliable, repeatable, and high-quality information exchange.

⚙️ ENABLERS: Interaction

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👥 COMMITTEE: ISO TC 59 SC 13

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📅 PUBLISHED: 2012-12

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🔗 URL: <https://www.iso.org/standard/55691.html>

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## Recommendation | ITU-T F.746.12 Requirements for a real-time interactive multimedia service under poor network conditions

This recommendation describes the scenarios, general framework, and requirements for a real-time interactive multimedia service (RIMS) under poor network conditions. The RIMS system plays an important role in many scenarios and situations, e.g., emergency relief, remote education and emergency communication. The RIMS requires providing measures for adjustment of coding parameters, including video and audio coding parameters, dynamically, and it requires setting maximal priority of audio communication under low-speed network conditions and configuring usage priority attributes to ensure that high-priority uses have priority of service over low-priority uses.

⚙️ ENABLERS: Computation, Interaction

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👥 COMMITTEE: ITU-T SG 16

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📅 PUBLISHED: under development

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🔗 URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=17515](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17515)

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## Recommendation | ITU-T F.746.14 Requirements and reference framework for cloud virtual reality systems

Cloud virtual reality based on cloud capabilities, can effectively shield terminal differences, reduce the difficulty of application development, lower some specific industry entry barriers, and promote the industry business chain cooperation. This recommendation focuses on the overall requirements of cloud virtual reality systems and the related requirements of each layer including content requirements, network requirements, control requirements, resource requirements and terminal requirements, as well as the reference framework for related high-level functions. Cloud virtual reality based on cloud capabilities, can effectively shield terminal differences, reduce the difficulty of application development, lower some specific industry entry barriers, and promote the industry business chain cooperation. This recommendation focuses on the overall requirements of cloud virtual reality systems and the related requirements of each layer including content requirements, network requirements, control requirements, resource requirements and terminal requirements, as well as the reference framework for related high-level functions.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ITU-T SG 16

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📅 PUBLISHED: under development

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🔗 URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=17594](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17594)

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## Recommendation | ITU-T F.746.17 Requirements for media processing services

This recommendation identifies the functional requirements for the media processing services. In particular, the scope of this Recommendation includes functional requirements and application scenarios. Media processing services utilize a set of techniques including cloud computing, computing resource virtualization, and job queue processing to dynamically control and manage computing resources, which improves scalability, flexibility, and availability. This Recommendation specifies the functional requirements of general requirements, service provision requirements, service management requirements, security considerations, etc.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ITU-T SG 16

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📅 PUBLISHED: under development

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🔗 URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=17497](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17497)

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## Technical specification | MPAA-CAV V1 Connected Autonomous Vehicles

Technical Specification: Connected Autonomous Vehicles (MPAA-CAV) – Architecture V1 is the first of the planned series of standards. MPAA-CAV – Architecture partitions a CAV into Subsystems that are further partitioned into Components. Both Subsystems and Components are specified by their functions and interfaces. Subsystems are additionally specified by their Component topology.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: MPAA Community

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📅 PUBLISHED: 2023-09

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🔗 URL: <https://mpaa.community/standards/mpaa-cav/>

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## OTHER

Standard | ISO 16757-2:2016 Data structures for electronic product catalogues for building services Part 2: Geometry [see details]

Technical report | ETSI TR 126 928 V16.1.0 Extended Reality (XR) in 5G (3GPP TR 26.928 version 16.1.0 Release 16) [see details]

Technical report | ETSI TR 126 998 V17.1.0 Support of 5G glass-type Augmented Reality / Mixed Reality (AR/MR) devices (3GPP TR 26.998 version 17.1.0 Release 17) [see details]

## 4.4.2 Digital Twins

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Technical report | ISO/IEC TR 30194 ED1 Internet of Things (IoT) and Digital Twin Best practices for use case projects

This document describes best practices for use case projects in terms of characterization, template,

plan and maintenance. It is intended to developers of use case projects, including in the context of standardisation. The document can be used to complement existing methodology standards such as IEC 62559 or IEC Guide 125.

OTHER VERTICALS: Internet of Things (IoT)

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/ords/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,20,104897](https://www.iec.ch/ords/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,20,104897)

### Standard | PWI JTC1-SC41-17 Guidance on the integration of IoT and digital twins in data spaces

This document provides guidance on the integration of IoT systems and digital twins in data spaces.

OTHER VERTICALS: Internet of Things (IoT)

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,118815](https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,118815)

### Standard | PWI JTC1-SC41-8 Internet of Things (IoT) Behavioral and policy interoperability

Based on ISO/IEC 21823-1, this document provides the basic concepts for IoT systems and digital twin systems behavioral and policy interoperability. This includes requirements guidance on how to identify points of interoperability guidance on how to express behavioral and policy information on capabilities guidance on how to achieve trustworthiness interoperability, and use cases and examples.

OTHER VERTICALS: Internet of Things (IoT)

ENABLERS: Interoperability

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,108353](https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,108353)

### Standard | IEEE P3144 Standard for Digital Twin Maturity Model and Assessment Methodology in Industry

This standard defines a digital twin maturity model for industry, including digital twin capability domains and corresponding subdomains. This standard also defines assessment methodologies, including assessment content, assessment processes, and assessment maturity levels.

COMMITTEE: IEEE C/SM

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/3144/10837/>

### Standard | ISO/IEC 30173 ED1 Digital twin Concepts and terminology

This document establishes terminology for Digital Twin (DT) 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).

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/ords/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,20,104883](https://www.iec.ch/ords/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,20,104883)

## Standard | ISO/IEC 30186 ED1 Digital twin Maturity model and guidance for a maturity assessment

This document provides a generic digital twin maturity model, definition of assessment indicators, and guidance for a maturity assessment.

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,23,111892](https://www.iec.ch/dyn/www/f?p=103:38:9406018951756:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,23,111892)

## Standard | ISO/IEC 30188 ED1 Digital Twin Reference architecture

This document specifies a general Digital Twin Reference Architecture in terms of defining system characteristics, a Reference Model and architecture views for Digital Twins.

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/f?p=103:38:2868118221034:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,20,104896](https://www.iec.ch/dyn/www/f?p=103:38:2868118221034:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,20,104896)

## Technical report | ISO/IEC TR 30172 ED1 Digital Twin Use cases

This document provides a collection of representative use cases of DT applications in a variety of domains.

COMMITTEE: ISO/IEC JTC 1/SC 41

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/f?p=103:38:2868118221034:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:20486,20,104881](https://www.iec.ch/dyn/www/f?p=103:38:2868118221034:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:20486,20,104881)

## Recommendation | Y.4600 Requirements and capabilities of a digital twin system for smart cities

This recommendation identifies requirements and capabilities of a smart city digital twin system which may be used to analyse use cases and case studies, develop strategies and identify optimal parameters to achieve a specific goal of a city by conducting simulations on a digital replica of the city (virtual cities).

COMMITTEE: ITU-T SG 20

PUBLISHED: 2022-08

URL: <https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15073>

## Recommendation | Y.dt-ITS Requirements and capability framework of digital

## twin for intelligent transport system

By applying kinds of emerging technologies, digital twin for intelligent transport system which provides real digital representation of physical transportation world could be constructed. With the profound and full-scale understanding of historical, real-time and statistical traffic related data in digital twin for intelligent transport system, the awareness of physical transportation is significantly enhanced, problems of transportation system could be discovered earlier, various traffic situations could be simulated, different long term, medium, short term strategies could be properly decided, and a lot of applications supported by intelligent transport system, such as transportation planning and traffic optimization, could be provided better and more intelligent. This Recommendation specifies the requirements and capability framework of digital twin for intelligent transport system.

COMMITTEE: ITU-T SG 20

PUBLISHED: under development

URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=17116](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=17116)

## Recommendation | Y.scdt-reqts Requirements and capabilities of a digital twin system for smart cities

A digital twin is the digital representation of an observable object with data connections that enable convergence between the physical and digital states at an appropriate rate of synchronization. Also, a digital twin has the capabilities of connection, integration, analysis, simulation, visualization, optimization and provides an integrated view throughout the life-cycle of the observable objects. The digital twin can provide real-time monitoring and proactive control, predictive maintenance by data analytics, cost and downtime reduction, and so on. Due to these benefits, various industries have adopted the digital twin technology. The smart cities and communities may have many kinds of cross domain problems, such as manufacturing, transportation, energy and safety, and it is difficult to resolve these problems by individual digital twin. To solve them, the digital twins in various domains can be federated. The federated digital twins collect and analyse the information from various domains, provide the solution for the problems, and simulate the effects. For this, some components and functions are needed to support for digital twin federation. First, registration of information for each digital twin is performed. And the discovery, connection, and utilization for the adequate digital twins are carried out for digital twin federation. This Recommendation defines the requirements for digital twin federation.

COMMITTEE: ITU-T SG 20

PUBLISHED: under development

URL: [https://www.itu.int/itu-t/workprog/wp\\_item.aspx?isn=17951](https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=17951)

## OTHER

Technical report | ISO/TR 24464:2020 Automation systems and integration  
Industrial data Visualization elements of digital twins [see details]

Standard | ISO/IEC 30178 ED1 Internet of Things (IoT) Data format, value and coding [see details]

Standard | PWI JTC1-SC41-16 Digital Twin Extraction and transactions of data components [see details]

Technical report | PWI TR JTC1-SC41-11 Digital Twin Correspondence measure of DTw twinning [see details]

Standard | ISO 23247-4:2021 Automation systems and integration Digital twin framework for manufacturing Part 4: Information exchange [see details]

Standard | IEC SRD 63273-1:2023 Smart city use case collection and analysis City information modelling Part 1: High-level analysis [see details]

Technical report | IEC Technology Report City information modelling:2021 City information modelling and urban digital twins [see details]

### 4.4.3 Edge & Cloud Computing

#### Guide | IEEE 2301-2020 Guide for Cloud Portability and Interoperability Profiles

Advice is given for cloud computing ecosystem participants (cloud vendors, service providers, and users) of standards-based choices in areas such as application interfaces, portability interfaces, management interfaces, interoperability interfaces, file formats, and operation conventions. These choices are grouped into multiple logical profiles, which are organized to address different cloud roles.

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: IEEE C/CCSC

📅 PUBLISHED: 2020-08

🔗 URL: <https://standards.ieee.org/ieee/2301/5077/>

#### Standard | IEEE 2302-2021 Standard for Intercloud Interoperability and Federation

A functional model for federation based on the NIST Cloud Federation Reference Architecture is defined in this standard. This model allows a range of deployment topologies and governance. As a general federation model, it can be applied to many application domains using different implementation approaches. As such, it includes cloud-to-cloud federation and interoperability.

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: IEEE C/CCSC

📅 PUBLISHED: 2022-03

🔗 URL: <https://standards.ieee.org/ieee/2302/7056/>

#### Standard | IEEE P2304 Standard for Cloud Computing Shared Function Model

This standard provides a general shared function model for cloud computing, in order to normalize how functions are shared between cloud service providers (CSPs) and cloud service customers (CSCs). The standard specifies functions ownership from seven aspects for three main cloud service delivery models, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). The seven aspects of function are as follows:

- 1) The physical infrastructure function.
- 2) The virtualization infrastructure function.
- 3) The operating system function.
- 4) The network control function.
- 5) The application function.
- 6) The data function.
- 7) The identity and access management function.

Each of the seven aspects considers many factors including security, management, etc. In this standard, levels 1 to 4, which are clearly the service provider's function for IaaS, PaaS, and SaaS, are briefly mentioned for the integrity of the model. This standard focuses on levels 5, 6, and 7.

⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: IEEE C/CCSC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/2304/10690/>

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## 4.4.4 Geospatial Systems

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### Standard | ISO/IEC 18026:2009 Information technology Spatial Reference Model (SRM)

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. The SRM addresses the needs of a broad community of users, who have a range of accuracy and performance requirements in computationally intensive applications. Aspects of ISO/IEC 18026:2009 apply to, but are not limited to:

- (1) mapping, charting, geodesy, and imagery;
- (2) topography;
- (3) location-based services;
- (4) oceanography;
- (5) meteorology and climatology;
- (6) interplanetary and planetary sciences;
- (7) embedded systems; and
- (8) modelling and simulation.

The application program interface supports more than 30 forms of position representation. To ensure that spatial operations are performed consistently, the application program interface specifies conversion operations with functionality defined to ensure high precision transformation between alternative representations of geometric properties. ISO/IEC 18026:2009 is not intended to replace the standards and specifications developed by ISO/TC 211, ISO/TC 184, the International Astronomical Union (IAU), and the International Association of Geodesy (IAG). It is applicable to applications whose spatial information requirements overlap two or more of the application areas that are the scope of the work of ISO/TC 211, ISO/TC 184, the IAU, and the IAG.

📁 OTHER VERTICALS: Computer Graphics

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⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 2009-07

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🔗 URL: <https://www.iso.org/standard/54166.html>

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### Standard | ISO 19101-1:2014 Geographic information Reference model Part 1: Fundamentals

This document is the first of a family of standards. ISO 19101-1:2014 defines the reference model for standardization in the field of geographic information. This reference model describes the notion of interoperability and sets forth the fundamentals by which this standardization takes place. Although structured in the context of information technology and information technology standards, ISO 19101-1:2014 is independent of any application development method or technology implementation approach.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2014-11

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🔗 URL: <https://www.iso.org/standard/59164.html>

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## Standard | ISO 19103:2015 Geographic information Conceptual schema language

ISO 19103:2015 provides rules and guidelines for the use of a conceptual schema language within the context of geographic information. The chosen conceptual schema language is the Unified Modeling Language (UML). ISO 19103:2015 provides a profile of the Unified Modelling Language (UML). The standardization target type of this standard is UML schemas describing geographic information.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2015-12

🔗 URL: <https://www.iso.org/standard/56734.html>

## Standard | ISO 19104:2016 Geographic information Terminology

ISO 19104:2016 specifies requirements for the collection, management and publication of terminology in the field of geographic information. The scope of this document includes:

- ▷ selection of concepts, harmonization of concepts and development of concept systems,
- ▷ structure and content of terminological entries,
- ▷ term selection,
- ▷ definition preparation,
- ▷ cultural and linguistic adaptation,
- ▷ layout and formatting requirements in rendered documents, and
- ▷ establishment and management of terminology registers.

ISO 19104:2016 is applicable to International Standards and Technical Specifications in the field of geographic information.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2016-10

🔗 URL: <https://www.iso.org/standard/63541.html>

## Standard | ISO 19105:2000 Geographic information Conformance and testing

This International Standard specifies the framework, concepts and methodology for testing and criteria to be achieved to claim conformance to the family of ISO geographic information standards. It provides a framework for specifying abstract test suites (ATS) and for defining the procedures to be followed during conformance testing. Conformance may be claimed for data or software products or services or by specifications including any profile or functional standard. Standardization of test methods and criteria for conformance to geographic information standards will allow verification of conformance to those standards. Verifiable conformance is important to geographic information users, in order to achieve data transfer and sharing.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2022-07

🔗 URL: <https://www.iso.org/standard/76457.html>

## Standard | ISO 19106:2004 Geographic information Profiles

ISO 19106:2004 is intended to define the concept of a profile of the ISO geographic information standards developed by ISO/TC 211 and to provide guidance for the creation of such profiles. Only those components of specifications that meet the definition of a profile contained herein can be established and managed through the mechanisms described in this International Standard. These profiles can be standardized internationally using the ISO standardization process. This document also provides guidance for establishing, managing, and standardizing at the national level (or in some other forum).

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2004-07

## Standard | ISO 19107:2019 Geographic information Spatial schema

This document specifies conceptual schemas for describing the spatial characteristics of geographic entities, and a set of spatial operations consistent with these schemas. It treats \_vector\_ geometry and topology. It defines standard spatial operations for use in access, query, management, processing and data exchange of geographic information for spatial (geometric and topological) objects. Because of the nature of geographic information, these geometric coordinate spaces will normally have up to three spatial dimensions, one temporal dimension and any number of other spatially dependent parameters as needed by the applications. In general, the topological dimension of the spatial projections of the geometric objects will be at most three.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2019-12

🔗 URL: <https://www.iso.org/standard/66175.html>

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## Standard | ISO 19108:2002 Geographic information Temporal schema, with technical corrigendum

ISO 19108:2002 defines concepts for describing temporal characteristics of geographic information. It depends upon existing information technology standards for the interchange of temporal information. It provides a basis for defining temporal feature attributes, feature operations, and feature associations, and for defining the temporal aspects of metadata about geographic information. Since this International Standard is concerned with the temporal characteristics of geographic information as they are abstracted from the real world, it emphasizes valid time rather than transaction time.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2002-09

🔗 URL: <https://www.iso.org/standard/26013.html>

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## Standard | ISO 19109:2015 Geographic information Rules for application schema

ISO 19109:2015 defines rules for creating and documenting application schemas, including principles for the definition of features.

The scope of this International Standard includes the following:

- (1) conceptual modelling of features and their properties from a universe of discourse;
- (2) definition of application schemas;
- (3) use of the conceptual schema language for application schemas;
- (4) transition from the concepts in the conceptual model to the data types in the application schema; and
- (5) integration of standardized schemas from other ISO geographic information standards with the application schema.

The following are outside the scope:

- (a) choice of one particular conceptual schema language for application schemas;
- (b) definition of any particular application schema;
- (c) representation of feature types and their properties in a feature catalogue;
- (d) representation of metadata;
- (e) rules for mapping one application schema to another;
- (f) implementation of the application schema in a computer environment;
- (g) computer system and application software design; and
- (h) programming.

👥 COMMITTEE: ISO TC 211

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## Standard | ISO 19110:2016 Geographic information Methodology for feature cataloguing

ISO 19110:2016 defines the methodology for cataloguing feature types. This document specifies how feature types can be organized into a feature catalogue and presented to the users of a set of geographic data. This document is applicable to creating catalogues of feature types in previously uncatalogued domains and to revising existing feature catalogues to comply with standard practice. This document applies to the cataloguing of feature types that are represented in digital form. Its principles can be extended to the cataloguing of other forms of geographic data. Feature catalogues are independent of feature concept dictionaries defined in ISO 19126 and can be specified without having to use or create a Feature Concept Dictionary. ISO 19110:2016 is applicable to the definition of geographic features at the type level. This document is not applicable to the representation of individual instances of each type. This document excludes portrayal schemas as specified in ISO 19117. ISO 19110:2016 may be used as a basis for defining the universe of discourse being modelled in a particular application, or to standardize general aspects of real world features being modelled in more than one application.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2016-12

🔗 URL: <https://www.iso.org/standard/57303.html>

## Standard | ISO 19111:2019 Geographic information Referencing by coordinates

This document defines the conceptual schema for the description of referencing by coordinates. It describes the minimum data required to define coordinate reference systems. This document supports the definition of:

(1) spatial coordinate reference systems where coordinate values do not change with time. The system may:

be geodetic and apply on a national or regional basis, or  
apply locally such as for a building or construction site, or  
apply locally to an image or image sensor; or

be referenced to a moving platform such as a car, a ship, an aircraft or a spacecraft. Such a coordinate reference system can be related to a second coordinate reference system which is referenced to the Earth through a transformation that includes a time element;

(2) spatial coordinate reference systems in which coordinate values of points on or near the surface of the earth change with time due to tectonic plate motion or other crustal deformation. Such dynamic systems include time evolution, however they remain spatial in nature;

(3) parametric coordinate reference systems which use a non-spatial parameter that varies monotonically with height or depth;

(4) temporal coordinate reference systems which use dateTime, temporal count or temporal measure quantities that vary monotonically with time; and

(5) mixed spatial, parametric or temporal coordinate reference systems.

The definition of a coordinate reference system does not change with time, although in some cases some of the defining parameters can include a rate of change of the parameter. The coordinate values within a dynamic and in a temporal coordinate reference system can change with time. This document also describes the conceptual schema for defining the information required to describe operations that change coordinate values. In addition to the minimum data required for the definition of the coordinate reference system or coordinate operation, the conceptual schema allows additional descriptive information coordinate reference system metadata to be provided. This document is applicable to producers and users of geographic information. Although it is applicable to digital geographic data, the principles described in this document can be extended to many other forms of spatial data such as maps, charts and text documents.

COMMITTEE: ISO TC 211

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PUBLISHED: 2019-01

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URL: <https://www.iso.org/standard/74039.html>

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## Standard | ISO 19112:2019 Geographic information Spatial referencing by geographic identifiers

This document defines the conceptual schema for spatial references based on geographic identifiers. It establishes a general model for spatial referencing using geographic identifiers and defines the components of a spatial reference system. It also specifies a conceptual scheme for a gazetteer. Spatial referencing by coordinates is addressed in ISO 19111. However, a mechanism for recording complementary coordinate references is included in this document. This document enables producers of data to define spatial reference systems using geographic identifiers and assists users in understanding the spatial references used in datasets. It enables gazetteers to be constructed in a consistent manner and supports the development of other standards in the field of geographic information. This document is applicable to digital geographic data, and its principles may be extended to other forms of geographic data such as maps, charts and textual documents.

COMMITTEE: ISO TC 211

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PUBLISHED: 2019-02

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URL: <https://www.iso.org/standard/70742.html>

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## Standard | ISO 19115-1:2014 Geographic information Metadata Part 1: Fundamentals

This document is the first of a family of standards. ISO 19115-1:2014 defines the schema required for describing geographic information and services by means of metadata. It provides information about the identification, the extent, the quality, the spatial and temporal aspects, the content, the spatial reference, the portrayal, distribution, and other properties of digital geographic data and services.

ISO 19115-1:2014 is applicable to:

- (1) the cataloguing of all types of resources, clearinghouse activities, and the full description of datasets and services; and
- (2) geographic services, geographic datasets, dataset series, and individual geographic features and feature properties.

ISO 19115-1:2014 defines:

- (a) mandatory and conditional metadata sections, metadata entities, and metadata elements;
- (b) the minimum set of metadata required to serve most metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data and services);
- (c) optional metadata elements to allow for a more extensive standard description of resources, if required; and
- (d) a method for extending metadata to fit specialized needs.

Though ISO 19115-1:2014 is applicable to digital data and services, its principles can be extended to many other types of resources such as maps, charts, and textual documents as well as non-geographic data. Certain conditional metadata elements might not apply to these other forms of data.

COMMITTEE: ISO TC 211

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PUBLISHED: 2014-04

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URL: <https://www.iso.org/standard/53798.html>

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## Standard | ISO 19116:2019 Geographic information Positioning services

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. A standardized interface for positioning allows the integration of reliable position information obtained from non-specific positioning technologies and is useful in various location-focused information applications, such as surveying, navigation, intelligent transportation systems (ITS), and location-based services (LBS).

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2019-12

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🔗 URL: <https://www.iso.org/standard/70882.html>

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## Standard | ISO 19117:2012 Geographic information Portrayal

ISO 19117:2012 specifies a conceptual schema for describing symbols, portrayal functions that map geospatial features to symbols, and the collection of symbols and portrayal functions into portrayal catalogues. This conceptual schema can be used in the design of portrayal systems. It allows feature data to be separate from portrayal data, permitting data to be portrayed in a dataset independent manner.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2012-12

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🔗 URL: <https://www.iso.org/standard/46226.html>

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## Standard | ISO 19118:2011 Geographic information Encoding

ISO 19118:2011 specifies the requirements for defining encoding rules for use for the interchange of data that conform to the geographic information in the set of International Standards known as the ISO 19100 series. ISO 19118:2011 specifies requirements for creating encoding rules based on UML schemas, requirements for creating encoding services, and requirements for XML-based encoding rules for neutral interchange of data. ISO 19118:2011 does not specify any digital media, does not define any transfer services or transfer protocols, nor does it specify how to encode inline large images.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2011-10

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🔗 URL: <https://www.iso.org/standard/44212.html>

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## Standard | ISO 19119:2016 Geographic information Services

ISO 19119:2016 defines requirements for how platform neutral and platform specific specification of services shall be created, in order to allow for one service to be specified independently of one or more underlying distributed computing platforms. ISO 19119:2016 defines requirements for a further mapping from platform neutral to platform specific service specifications, in order to enable conformant and interoperable service implementations. ISO 19119:2016 addresses the Meta:Service foundation of the ISO geographic information reference model described in ISO 19101-1:2014, Clause 6 and Clause 8, respectively. ISO 19119:2016 defines how geographic services shall be categorised according to a service taxonomy based on architectural areas and allows also for services to be categorised according to a usage life cycle perspective, as well as according to domain specific and user defined service taxonomies, providing support for easier publication and discovery of services.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2016-01

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🔗 URL: <https://www.iso.org/standard/59221.html>

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## Standard | ISO 19123-1:2023 Geographic information Schema for coverage geometry and functions Part 1: Fundamentals

This document is the first of a family of standards. This document defines a conceptual schema for coverages. A coverage is a mapping from a spatial, temporal or spatiotemporal domain to attribute

values sharing the same attribute type. A coverage domain consists of a collection of direct positions in a coordinate space that can be defined in terms of spatial and/or temporal dimensions, as well as non-spatiotemporal (in ISO 19111:2019, “parametric”) dimensions. Examples of coverages include point clouds, grids, meshes, triangulated irregular networks, and polygon sets. Coverages are the prevailing data structures in a number of application areas, such as remote sensing, meteorology and mapping of depth, elevation, soil and vegetation. This document defines the coverage concept including the relationship between the domain of a coverage and its associated attribute range. This document defines the characteristics of the domain. The characteristics of the attribute range are not defined in this document, but are defined in implementation standards. Consequently, the standardization target of this document consists of implementation standards, not concrete implementations themselves.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2023-06

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🔗 URL: <https://www.iso.org/standard/70743.html>

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## Standard | ISO 19125-1:2004 Geographic information Simple feature access Part 1: Common architecture

This document is the first of a family of standards. ISO 19125-1:2004 establishes a common architecture for geographic information and defines terms to use within the architecture. It also standardizes names and geometric definitions for Types for Geometry. ISO 19125-1:2004 does not place any requirements on how to define the Geometry Types in the internal schema nor does it place any requirements on when or how or who defines the Geometry Types. ISO 19125-1:2004 does not attempt to standardize and does not depend upon any part of the mechanism by which Types are added and maintained.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2004-11

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🔗 URL: <https://www.iso.org/standard/40114.html>

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## Standard | ISO 19126:2021 Geographic information Feature concept dictionaries and registers

This document specifies a schema for feature concept dictionaries to be established and managed as registers. It does not specify schemas for feature catalogues or for the management of feature catalogues as registers. However, as feature catalogues are often derived from feature concept dictionaries, this document does specify a schema for a hierarchical register of feature concept dictionaries and feature catalogues. These registers are in accordance with ISO 19135-1.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2021-05

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🔗 URL: <https://www.iso.org/standard/78898.html>

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## Standard | ISO 19127:2019 Geographic information Geodetic register

This document defines the management and operations of the ISO geodetic register and identifies the data elements, in accordance with ISO 19111:2007 and the core schema within ISO 19135-1:2015, required within the geodetic register.

👥 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2019-02

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🔗 URL: <https://www.iso.org/standard/67252.html>

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## Standard | ISO 19128:2005 Geographic information Web map server interface

ISO 19128:2005 specifies the behaviour of a service that produces spatially referenced maps dynamically from geographic information. It specifies operations to retrieve a description of the maps offered by a server, to retrieve a map, and to query a server about features displayed on a map. ISO 19128:2005 is applicable to pictorial renderings of maps in a graphical format; it is not applicable to retrieval of actual feature data or coverage data values.

👤 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2005-12

🔗 URL: <https://www.iso.org/standard/32546.html>

## Standard | ISO 19130-1:2018 Geographic information Imagery sensor models for geopositioning Part 1: Fundamentals

This document is the first of a family of standards. 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. This document specifies several ways in which information in support of geopositioning can be provided.

a) It may be provided as a sensor description with the associated physical and geometric information necessary to rigorously construct a PSM. For the case where precise geoposition information is needed, this document identifies the mathematical equations for rigorously constructing PSMs that relate 2D image space to 3D ground space and the calculation of the associated propagated errors. This document provides detailed information for three types of passive electro-optical/ IR sensors (frame, pushbroom and whiskbroom) and for an active microwave sensing system SAR. It provides a framework by which these sensor models can be extended to other sensor types.

b) It can be provided as a TRM, using functions whose coefficients are based on a PSM so that they provide information for precise geopositioning, including the calculation of errors, as precisely as the PSM they replace.

c) It can be provided as a CM that provides a functional fitting based on observed relationships between the geopositions of a set of GCPs and their image coordinates.

d) It can be provided as a set of GCPs that can be used to develop a CM or to refine a PSM or TRM.

This document does not specify either how users derive geoposition data or the format or content of the data the users generate.

👤 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2018-09

🔗 URL: <https://www.iso.org/standard/66847.html>

## Standard | ISO 19131:2022 Geographic information Data product specifications

This document describes requirements for the specification of geographic data products, based upon the concepts of other International Standards in the ISO 19100 family of standards. It also provides guidance in the creation of data product specifications, so that they can be easily understood and fit for their intended purpose. This document specifies XML encoding of data product specifications. This document provides OWL representation of the underlying UML model. See Annex F. This document is intended for use by data producers, data providers, service providers and potential users of data products.

👤 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2022-11

🔗 URL: <https://www.iso.org/standard/85092.html>

## Standard | ISO 19132:2007 Geographic information Location-based services Reference model

ISO 19132:2007 defines a reference model and a conceptual framework for location-based services (LBS), and describes the basic principles by which LBS applications may interoperate. This framework references or contains an ontology, a taxonomy, a set of design patterns and a core set of LBS service abstract specifications in UML. ISO 19132:2007 further specifies the framework's relationship to other frameworks, applications and services for geographic information and to client applications. ISO 19132:2007 addresses, for an LBS system, the first three basic viewpoints as defined in the Reference Model for Open Distributed Processing (RM-ODP, see ISO/IEC 10746-1). These viewpoints are the Enterprise Viewpoint (detailing the purpose, scope, and policies of the system); Information Viewpoint (detailing the semantics of information and processing within the system); Computational Viewpoint (detailing the functional decomposition of the system). The fourth and fifth viewpoints are addressed only in requirements or examples. These are the Engineering Viewpoint (detailing the infrastructure for distribution); Technology Viewpoint (detailing the technology for implementation); Reference models and frameworks can be defined at a variety of levels, from conceptual design to software documentation. ISO 19132:2007 defines the conceptual framework for and the type of applications included within LBS, establishes general principles for LBS for both mobile and fixed clients, specifies the interface for data access while roaming, defines the architectural relationship with other ISO geographic information standards, and identifies areas in which further standards for LBS are required. ISO 19132:2007 does not address rules by which LBS are developed, nor general principles for roaming agreements for mobile clients and tracking targets.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2007-10

🔗 URL: <https://www.iso.org/standard/40601.html>

## Standard | ISO 19133:2005 Geographic information Location-based services Tracking and navigation

ISO 19133:2005 describes the data types, and operations associated with those types, for the implementation of tracking and navigation services. It is designed to specify web services that can be made available to wireless devices through web-resident proxy applications, but is not restricted to that environment.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2005-10

🔗 URL: <https://www.iso.org/standard/32551.html>

## Standard | ISO 19134:2007 Geographic information Location-based services Multimodal routing and navigation

ISO 19134:2006 specifies the data types and their associated operations for the implementation of multimodal location-based services for routing and navigation. It is designed to specify web services that may be made available to wireless devices through web-resident proxy applications, but is not limited to that environment.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2007-02

🔗 URL: <https://www.iso.org/standard/32552.html>

## Standard | ISO 19135-1:2015 Geographic information Procedures for item registration Part 1: Fundamentals, with amendment

This document is the first of a family of standards. ISO 19135-1:2015 specifies procedures to be followed in establishing, maintaining, and publishing registers of unique, unambiguous, and permanent identifiers and meanings that are assigned to items of geographic information. In order to accomplish

this purpose, ISO 19135-1:2015 specifies elements that are necessary to manage the registration of these items.

COMMITTEE: ISO TC 211

PUBLISHED: 2015-10

URL: <https://www.iso.org/standard/54721.html>

## Standard | ISO 19136-1:2020 Geographic information Geography Markup Language (GML) Part 1: Fundamentals

This document is the first of a family of standards. The Geography Markup Language (GML) is an XML encoding in accordance with ISO 19118 for the transport and storage of geographic information modelled in accordance with the conceptual modelling framework used in the ISO 19100 series of International Standards and including both the spatial and non-spatial properties of geographic features. This document defines the XML Schema syntax, mechanisms and conventions that:

- (1) provide an open, vendor-neutral framework for the description of geospatial application schemas for the transport and storage of geographic information in XML;
- (2) allow profiles that support proper subsets of GML framework descriptive capabilities;
- (3) support the description of geospatial application schemas for specialized domains and information communities;
- (4) enable the creation and maintenance of linked geographic application schemas and datasets;
- (5) support the storage and transport of application schemas and datasets; and
- (6) increase the ability of organizations to share geographic application schemas and the information they describe.

Implementers can decide to store geographic application schemas and information in GML, or they can decide to convert from some other storage format on demand and use GML only for schema and data transport.

NOTE: If an ISO 19109 conformant application schema described in UML is used as the basis for the storage and transportation of geographic information, this document provides normative rules for the mapping of such an application schema to a GML application schema in XML Schema and, as such, to an XML encoding for data with a logical structure in accordance with the ISO 19109 conformant application schema.

COMMITTEE: ISO TC 211

PUBLISHED: 2020-01

URL: <https://www.iso.org/standard/75676.html>

## Standard | ISO 19137:2007 Geographic information Core profile of the spatial schema

ISO 19137:2007 defines a core profile of the spatial schema specified in ISO 19107 that specifies, in accordance with ISO 19106, a minimal set of geometric elements necessary for the efficient creation of application schemata. It supports many of the spatial data formats and description languages already developed and in broad use within several nations or liaison organizations.

COMMITTEE: ISO TC 211

PUBLISHED: 2007-05

URL: <https://www.iso.org/standard/32555.html>

## Standard | ISO 19141:2008 Geographic information Schema for moving features

ISO 19141:2008 defines a method to describe the geometry of a feature that moves as a rigid body. Such movement has the following characteristics.

- (a) The feature moves within any domain composed of spatial objects as specified in ISO 19107.

(b) The feature may move along a planned route, but it may deviate from the planned route.

(c) Motion may be influenced by physical forces, such as orbital, gravitational, or inertial forces.

(d) Motion of a feature may influence or be influenced by other features, for example:

▷ The moving feature might follow a predefined route (e.g. road), perhaps part of a network, and might change routes at known points (e.g. bus stops, waypoints).

▷ Two or more moving features may be pulled together or pushed apart (e.g. an airplane will be refuelled during flight, a predator detects and tracks a prey, refugee groups join forces).

▷ Two or more moving features may be constrained to maintain a given spatial relationship for some period (e.g. tractor and trailer, convoy).

ISO 19141:2008 does not address other types of change to the feature. Examples of changes that are not addressed include the following:

(a) The deformation of features.

(b) The succession of either features or their associations.

(c) The change of non-spatial attributes of features.

The feature's geometric representation cannot be embedded in a geometric complex that contains the geometric representations of other features, since this would require the other features' representations to be updated as the feature moves. Because ISO 19141:2008 is concerned with the geometric description of feature movement, it does not specify a mechanism for describing feature motion in terms of geographic identifiers. This is done, in part, in ISO 19133.

🏢 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2008-06

🔗 URL: <https://www.iso.org/standard/41445.html>

## Standard | ISO 19142:2010 Geographic information Web Feature Service

ISO 19142:2010 specifies the behaviour of a web feature service that provides transactions on and access to geographic features in a manner independent of the underlying data store. It specifies discovery operations, query operations, locking operations, transaction operations and operations to manage stored parameterized query expressions.

🏢 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2010-12

🔗 URL: <https://www.iso.org/standard/42136.html>

## Standard | ISO 19143:2010 Geographic information Filter encoding

ISO 19143:2010 describes an XML and KVP encoding of a system neutral syntax for expressing projections, selection and sorting clauses collectively called a query expression. These components are modular and intended to be used together or individually by other International Standards which reference ISO 19143:2010.

🏢 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2010-10

🔗 URL: <https://www.iso.org/standard/42137.html>

## Standard | ISO 19144-1:2009 Geographic information Classification systems Part 1: Classification system structure, with technical corrigendum

This document is the first of a family of standards. ISO 19144-1:2009 establishes the structure of a geographic information classification system, together with the mechanism for defining and registering the classifiers for such a system. It specifies the use of discrete coverages to represent the result of applying the classification system to a particular area and defines the technical structure of a register of classifiers in accordance with ISO 19135.

COMMITTEE: ISO TC 211

PUBLISHED: 2009-08

URL: <https://www.iso.org/standard/32562.html>

## Standard | ISO 19145:2013 Geographic information Registry of representations of geographic point location

ISO 19145:2013 specifies the process for establishing, maintaining and publishing registers of representation of geographic point location in compliance with ISO 19135. It identifies and describes the information elements and the structure of a register of representations of geographic point location including the elements for the conversion of one representation to another. ISO 19145:2013 also specifies the XML implementation of the required XML extension to ISO/TS 19135-2, for the implementation of a register of geographic point location representations.

COMMITTEE: ISO TC 211

PUBLISHED: 2013-02

URL: <https://www.iso.org/standard/32563.html>

## Standard | ISO 19146:2018 Geographic information Cross-domain vocabularies

This document establishes a methodology for cross-mapping vocabularies. It also specifies an implementation of ISO 19135-1:2015 for the purpose of registering cross-mapped vocabulary entries. Methodologies for the development of ontologies and taxonomies that relate to geographic information and geomatics are not within the scope of this document.

COMMITTEE: ISO TC 211

PUBLISHED: 2018-06

URL: <https://www.iso.org/standard/72217.html>

## Standard | ISO 19147:2015 Geographic information Transfer Nodes

ISO 19147:2015 specifies the data types and code lists associated with those types for the implementation of transfer nodes and their services in transport modelling and location based services. It includes the following:

- (1) defines transfer nodes in a multimodal way so that the definition is general and valid for all types of transport means and modes;
- (2) links transfer nodes to a location;
- (3) focuses on the attributes defining the transfer node in relation to nodes in mode-specific networks;
- (4) defines the attributes of transfer nodes that are relevant for travel planning and modelling of interoperable transport systems by transport planners; and
- (5) defines a set of services and facilities that may be related to transfer nodes and a way to provide information on accessibility, deviations and restrictions related to these services and facilities.

ISO 19147:2015 is applicable for transport infrastructure owners and operators when defining and/or describing their transport infrastructure and for transport-related Service Providers when providing information to travellers and others. It is limited to the transport of persons and is also limited to the static getting-on and getting-off points. The main focus is on transfer nodes being part of public transport networks, that are located in road networks, but this International Standard is also applicable for transfer nodes in rail networks and in air and sea transport networks.

COMMITTEE: ISO TC 211

PUBLISHED: 2015-06

URL: <https://www.iso.org/standard/44874.html>



## Standard | ISO 19148:2021 Geographic information Linear referencing

This document specifies a conceptual schema for locations relative to a one-dimensional object as measurement along (and optionally offset from) that object. It defines a description of the data and operations required to use and support linear referencing. This document is applicable to transportation, utilities, environmental protection, location-based services and other applications which define locations relative to linear objects. For ease of reading, most examples discussed in this document come from the transportation domain.

COMMITTEE: ISO TC 211

PUBLISHED: 2021-04

URL: <https://www.iso.org/standard/75150.html>

## Standard | ISO 19149:2011 Geographic information Rights expression language for geographic information GeoREL

ISO 19149:2011 defines an XML-based vocabulary or language to express rights for geographic information in order that digital licenses can be created for such information and related services. This language, GeoREL, is an extension of the rights expression language in ISO/IEC 21000-5 and is to be used to compose digital licenses. Each digital license will unambiguously express those particular rights that the owners (or their agent) of a digital geographic resource extend to the holders of that license. The digital rights management system in which these licenses are used can then offer ex ante (before the fact) protection for all such resources. The proper use of a GeoREL includes the preservation of rights access by formula expressed in usage licenses. Thus, data in the public or private domain, when protected, remain in their respective domains if the usage rights granted so state. These rights are not always covered by copyright law, and are often the result of contracts between individuals that specify the proper and allowed uses of resources, as opposed to the threat of copyright litigations which is an ex post facto (after the fact) remediation measure, not an ex ante protection measure. ISO 19149:2011 is not a reflection of, or extension of, copyright law. Mechanisms for the enforcement and preservation of those contract rights are specified in ISO/IEC 21000, and it is not the intention of ISO 19149:2011 to replace nor redefine those mechanisms, but to use them as previously standardized.

COMMITTEE: ISO TC 211

PUBLISHED: 2011-11

URL: <https://www.iso.org/standard/32567.html>

## Standard | ISO 19152:2012 Geographic information Land Administration Domain Model (LADM)

The ISO 19152:2012 standard:

- (a) defines a reference Land Administration Domain Model (LADM) covering basic information-related components of land administration (including those over water and land, and elements above and below the surface of the earth);
- (b) provides an abstract, conceptual model with four packages related to parties (people and organizations); basic administrative units, rights, responsibilities, and restrictions (ownership rights); spatial units (parcels, and the legal space of buildings and utility networks); spatial sources (surveying), and spatial representations (geometry and topology);
- (c) provides terminology for land administration, based on various national and international systems, that is as simple as possible in order to be useful in practice. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions;
- (d) provides a basis for national and regional profiles; and
- (e) enables the combining of land administration information from different sources in a coherent manner.

COMMITTEE: ISO TC 211

PUBLISHED: 2012-12

URL: <https://www.iso.org/standard/51206.html>



## Standard | ISO 19154:2014 Geographic information Ubiquitous public access Reference model

ISO 19154:2014 defines a reference model for ubiquitous public access (UPA) to geographic information. This reference model uses standard concepts from both the Open distributed processing ? Reference model (RM-ODP) in ISO/IEC 10746-1 and ISO 19101. The reference model specified in ISO 19154:2014 defines the following:

- (1) conceptual models for ubiquitous public access (UPA) to geographic information;
- (2) a reference model and framework to support current and future specification development in this area;
- (3) the semantics of information and processing within systems and services for the UPA of geographic information; and
- (4) the architectural relationship between this International Standard and other ISO geographic information standards.

ISO 19154 is applicable to location-based services (LBS), ubiquitous computing environments, linked open data, and other domains that require a seamless public access to geographic information. Although structured in the context of information technology and information technology standards, ISO 19154:2014 is independent of any application development method or technology implementation approach.

COMMITTEE: ISO TC 211

PUBLISHED: 2014-11

URL: <https://www.iso.org/standard/32572.html>

## Standard | ISO 19155:2012 Geographic information Place Identifier (PI) architecture

This document is the first of a family of standards. ISO 19155:2012 specifies an architecture that defines a reference model with an encoding method for an identifier of a place. The concept of \_place\_ within ISO 19155:2012 includes \_places\_ not only in the real world but also those in the virtual world. These \_places\_ are identified using either coordinate identifiers, geographic identifiers, or virtual world identifiers such as URI. In ISO 19155:2012, an identifier of a place is referred to as a Place Identifier (PI). The reference model defines a mechanism to match multiple Place Identifiers to the same place. In addition, a data structure and set of service interfaces are also defined in this reference model. ISO 19155:2012 is applicable to location based services, emergency management services and other application domains that require a common architecture, across specific domains, for the representation of place descriptions using coordinate, geographic, or virtual world identifiers.

COMMITTEE: ISO TC 211

PUBLISHED: 2012-11

URL: <https://www.iso.org/standard/32573.html>

## Standard | ISO 19156:2023 Geographic information Observations and measurements

This document defines a conceptual schema for observations, for features involved in the observation process, and for features involved in sampling when making observations. These provide models for the exchange of information describing observation acts and their results, both within and between different scientific and technical communities. Observations commonly involve sampling of an ultimate feature-of-interest. This document defines a common set of sample types according to their spatial, material (for ex situ observations) or statistical nature. The schema includes relationships between sample features (sub-sampling, derived samples). This document concerns only externally visible interfaces and places no restriction on the underlying implementations other than what is needed to satisfy the interface specifications in the actual situation.

COMMITTEE: ISO TC 211

PUBLISHED: 2023-04

URL: <https://www.iso.org/standard/82463.html>

## Standard | ISO 19157-1:2023 Geographic information Data quality Part 1: General requirements

This document is the first of a family of standards. This document establishes the principles for describing the quality of geographic data. It:

- (a) defines a well-considered system of components for describing data quality;
- (b) defines the process for defining additional, domain-specific components for describing data quality;
- (c) specifies components and the content structure of data quality measures;
- (d) describes general procedures for evaluating the quality of geographic data; and
- (e) establishes principles for reporting data quality.

This document is applicable to data producers providing quality information to describe and assess how well a dataset conforms to its product specification and to data users attempting to determine whether or not specific geographic data are of sufficient quality for their particular application. This document does not attempt to define minimum acceptable levels of quality for geographic data. Such information is usually present as a requirement in a data product specification, defined in accordance with ISO 19131, for example.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2023-04

🔗 URL: <https://www.iso.org/standard/78900.html>

## Standard | ISO 19160-1:2015 Addressing Part 1: Conceptual model

This document is the first of a family of standards. ISO 19160-1:2015 defines a conceptual model for address information (address model), together with the terms and definitions that describe the concepts in the model. Lifecycle, metadata, and address aliases are included in the conceptual model. The model is presented in the Unified Modeling Language (UML). The model provides a common representation of address information, independent of actual addressing implementations. It is not intended to replace conceptual models proposed in other specifications, but provides a means to cross-map between different conceptual models for address information and enables the conversion of address information between specifications. The model provides a basis for developing address specifications by individual countries or communities.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2015-12

🔗 URL: <https://www.iso.org/standard/61710.html>

## Standard | ISO 19161-1:2020 Geographic information Geodetic references Part 1: International terrestrial reference system (ITRS)

This document is the first of a family of standards. This document provides the basic information and the requirements related to the International Terrestrial Reference System (ITRS), its definition, its realizations and how to access and use these realizations. This document:

- (1) describes ITRS following the definitions and terminology adopted by the International Union of Geodesy and Geophysics (IUGG), the International Association of Geodesy (IAG) and the International Astronomical Union (IAU);
- (2) describes different categories of ITRS realizations: its primary realization, labelled the International Terrestrial Reference Frame (ITRF), other existing realizations of reference systems that are mathematically derived from the ITRS, and realizations that are aligned to the ITRF, such as GNSS-specific reference frames; and
- (3) categorizes procedures for realizing the ITRS.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2020-01

🔗 URL: <https://www.iso.org/standard/70655.html>

## Standard | ISO 19162:2019 Geographic information Well-known text representation of coordinate reference systems

This document defines the structure and content of a text string implementation of the abstract model for coordinate reference systems described in ISO 19111. The string defines frequently needed types of coordinate reference systems and coordinate operations in a self-contained form that is easily readable by machines and by humans. The essence is its simplicity; as a consequence there are some constraints upon the more open content allowed in ISO 19111. To retain simplicity in the well-known text (WKT) description of coordinate reference systems and coordinate operations, the scope of this document excludes parameter grouping and pass-through coordinate operations. The text string provides a means for humans and machines to correctly and unambiguously interpret and utilise a coordinate reference system definition with look-ups or cross references only to define coordinate operation mathematics. A WKT string is not suitable for the storage of definitions of coordinate reference systems or coordinate operations because it omits metadata about the source of the data and may omit metadata about the applicability of the information.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2019-07

🔗 URL: <https://www.iso.org/standard/76496.html>

## Standard | ISO 19165-1:2018 Geographic information Preservation of digital data and metadata Part 1: Fundamentals

This document is the first of a family of standards. 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. Geospatial data are preserved as a geospatial information package (IP). This document defines the requirements of the geospatial archival IP and details of the geospatial submission and the dissemination IPs. A geospatial archival IP is fully self-describing and allows a future reconstruction of the dataset without external documentation. The functional requirements for a preservation archive are defined in Annex D. ISO 19165-1:2018 complements standards developed by ISO/TC 211 as well as other ISO standards such as ISO 14721.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2018-05

🔗 URL: <https://www.iso.org/standard/67325.html>

## Standard | ISO 19168-1:2020 Geographic information Geospatial API for features Part 1: Core

This document is the first of a family of standards. This document specifies the behaviour of Web APIs that provide access to features in a dataset in a manner independent of the underlying data store. This document defines discovery and query operations. Discovery operations enable clients to interrogate the API, including the API definition and metadata about the feature collections provided by the API, to determine the capabilities of the API and retrieve information about available distributions of the dataset. Query operations enable clients to retrieve features from the underlying data store based upon simple selection criteria, defined by the client.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2020-09

🔗 URL: <https://www.iso.org/standard/32586.html>

## Standard | ISO 19170-1:2021 Geographic information Discrete Global Grid Systems Specifications Part 1: Core Reference System and Operations, and Equal Area Earth Reference System

This document is the first of a family of standards. This document supports the definition of:

- (1) Discrete Global Grid Systems (DGGS) core comprising: an RS using zonal identifiers with structured geometry, and functions providing import, export and topological query,
- (2) Common spatio-temporal classes for geometry, topology, RS using zonal identifiers, zonal identifiers and zones, based on ISO 19111 CRS. The spatio-temporal scope is constrained to: spatial elements that are invariant through all time, and temporal elements that are invariant across all space.
- (3) Equal-Area Earth Reference Systems (EAERSs) for Equal-Area Earth DGGS.

👤 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2021-05

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🔗 URL: <https://www.iso.org/standard/32588.html>

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## Standard | ISO 6709:2022 Standard representation of geographic point location by coordinates

This document specifies the representation of latitude and longitude and optionally height or depth compatible with previous editions of ISO 6709. This document also supports the representations of other coordinate types and time that can be associated with those coordinates as defined through one or more coordinate reference systems (CRS). This document describes a text string of coordinates, suitable for electronic data exchange, for one point, including reference system identification to ensure that the coordinates unambiguously represent the position of that point. Files containing multiple points with a single common reference system identification are out of scope. This document also describes a simpler text string structure for coordinate representation of a point location that is more suitable for human readability.

👤 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2022-09

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🔗 URL: <https://www.iso.org/standard/75147.html>

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## Standard | ISO/IEC 18305:2016 Information technology Real time locating systems Test and evaluation of localization and tracking systems

ISO/IEC 18305:2016 identifies appropriate performance metrics and test & evaluation scenarios for localization and tracking systems, and it provides guidance on how best to present and visualize the T&E results. It focuses primarily on indoor environments.

⚙️ ENABLERS: Computation

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👤 COMMITTEE: ISO/IEC JTC 1/SC 31

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📅 PUBLISHED: 2016-11

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🔗 URL: <https://www.iso.org/standard/62090.html>

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## Technical report | ISO/TR 19121:2000 Geographic information Imagery and gridded data

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.

👤 COMMITTEE: ISO TC 211

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### Technical report | ISO/TR 19167:2019 Application of ubiquitous public access to-geographic information to an air quality information service

This document facilitates an understanding of the Ubiquitous Public Access (UPA) context information model, as defined in ISO 19154, to establish a UPA-to-Geographic Information (GI) environment. In addition, this document illustrates how the UPA context information model is designed and implemented to provide an air quality information service from a geographic information system (GIS)-based air quality information system. The UPA context information model for air quality information is only a sample of all possible examples to realize the UPA-to-GI that could satisfy the requirements of ISO 19154.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2019-12

🔗 URL: <https://www.iso.org/standard/75148.html>

### Technical report | ISO/TR 19169:2021 Geographic Information Gap-analysis: mapping and describing the differences between the current GDF and ISO/TC 211 conceptual models to suggest ways to harmonize and resolve conflicting issues

This document maps and describes the differences between GDF (ISO 20524 series), from ISO/TC 204, and conceptual models from the ISO 19100 family, from ISO/TC 211, and suggests ways to harmonize and resolve issues of conflict. Throughout this document, reference to GDF refers to GDF v5.1, ISO 20524-1 and ISO 20524-2, unless expressly identified otherwise. Where necessary, reference will be made to Part 1 or Part 2.

👥 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2021-06

🔗 URL: <https://www.iso.org/standard/32587.html>

### Technical specification | ISO/TS 19115-1:2014 Geographic information Metadata Part 1: Fundamentals

This document is the first of a family of standards. ISO 19115-1:2014 defines the schema required for describing geographic information and services by means of metadata. It provides information about the identification, the extent, the quality, the spatial and temporal aspects, the content, the spatial reference, the portrayal, distribution, and other properties of digital geographic data and services. ISO 19115-1:2014 is applicable to:

- (a) the cataloguing of all types of resources, clearinghouse activities, and the full description of datasets and services; and
- (b) geographic services, geographic datasets, dataset series, and individual geographic features and feature properties.

ISO 19115-1:2014 defines:

- (1) mandatory and conditional metadata sections, metadata entities, and metadata elements;
- (2) the minimum set of metadata required to serve most metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data and services);
- (3) optional metadata elements to allow for a more extensive standard description of resources, if required; and
- (4) a method for extending metadata to fit specialized needs.

Though ISO 19115-1:2014 is applicable to digital data and services, its principles can be extended to many other types of resources such as maps, charts, and textual documents as well as non-geographic

data. Certain conditional metadata elements might not apply to these other forms of data.

COMMITTEE: ISO TC 211

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PUBLISHED: 2014-04

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URL: <https://www.iso.org/standard/53798.html>

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### Technical specification | ISO/TS 19129:2009 Geographic information Imagery, gridded and coverage data framework

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.

COMMITTEE: ISO TC 211

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PUBLISHED: 2009-04

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URL: <https://www.iso.org/standard/43041.html>

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### Technical specification | ISO/TS 19139-1:2019 Geographic information XML schema implementation Part 1: Encoding rules

This document is the first of a family of standards. This document defines XML based encoding rules for conceptual schemas specifying types that describe geographic resources. The encoding rules support the UML profile as used in the UML models commonly used in the standards developed by ISO/TC 211. The encoding rules use XML schema for the output data structure schema. The encoding rules described in this document are not applicable for encoding UML application schema for geographic features (see ISO 19136 for those rules).

COMMITTEE: ISO TC 211

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PUBLISHED: 2019-03

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URL: <https://www.iso.org/standard/67253.html>

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### Technical specification | ISO/TS 19150-1:2012 Geographic information Ontology Part 1: Framework

This document is the first of a family of standards. ISO/TS 19150-1:2012 defines the framework for semantic interoperability of geographic information. This framework defines a high level model of the components required to handle semantics in the ISO geographic information standards with the use of ontologies.

COMMITTEE: ISO TC 211

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PUBLISHED: 2012-11

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URL: <https://www.iso.org/standard/57465.html>

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### Technical specification | ISO/TS 19158:2012 Geographic information Quality assurance of data supply

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. The framework defined in ISO/TS 19158:2012 enables a customer to satisfy itself that its suppliers, both internal and external, are capable of delivering geographic information to the required quality. Fundamental to the framework is the assurance of the supplier's ability to understand and meet the quality requirements. Through the quality assurance framework both the customer and the supplier are able to consider the quality required at the earliest opportunity in the production/update

process. Principles and responsibilities of the relationship between the customer and the supplier that facilitate the framework are provided. The responsibility for the quality assessment procedure is shared between the customer and the supplier. ISO/TS 19158:2012 is applicable to customers and suppliers of all geographic information where the quality of the product may be impacted upon by the supplier's processes in any of the following scenarios:

- 1) there is an agreement or legislation for the supply of data acquisition services,
- 2) data acquisition services are being tendered for, and
- 3) one or more suppliers exist in the supply chain.

ISO/TS 19158:2012 is not applicable for the supply of legacy datasets or 'off the shelf' products where there is no further data production or update activity to manage.

🏢 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2012-10

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🔗 URL: <https://www.iso.org/standard/32576.html>

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### Technical specification | ISO/TS 19159-1:2014 Geographic information Calibration and validation of remote sensing imagery sensors and data Part 1: Optical sensors

This document is the first of a family of standards. 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.

🏢 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2014-07

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🔗 URL: <https://www.iso.org/standard/60080.html>

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### Technical specification | ISO/TS 19163-1:2016 Geographic information Content components and encoding rules for imagery and gridded data Part 1: Content model

This document is the first of a family of standards. 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. The binding between the content and a specific encoding format will be defined in the subsequent parts of ISO 19163. ISO/TS 19163-1:2016 does not address LiDAR, SONAR data and ungeoreferenced gridded data. The logical data structures and the rules for encoding the content components will be addressed in the subsequent parts of ISO 19163.

🏢 COMMITTEE: ISO TC 211

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📅 PUBLISHED: 2016-01

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🔗 URL: <https://www.iso.org/standard/32581.html>

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### Technical specification | ISO/TS 19166:2021 Geographic information BIM to GIS conceptual mapping (B2GM)

This document defines the conceptual framework and mechanisms for mapping information elements from Building Information Modelling (BIM) to Geographic Information Systems (GIS) to access the required information based on specific user requirements. The conceptual framework for mapping BIM information to GIS is defined with the following three mapping mechanisms: (1) BIM to GIS Perspective Definition (B2G PD); (2) BIM to GIS Element Mapping (B2G EM); (3) BIM to GIS LOD Mapping (B2G LM). This document does not describe physical schema integration or mapping



between BIM and GIS models because the physical schema integration or mapping between two heterogeneous models is very complex and can cause a variety of ambiguity problems. Developing a unified information model between BIM and GIS is a desirable goal, but it is out of the scope of this document. The scope of this document includes the following:

- (1) definition for BIM to GIS conceptual mapping requirement description;
- (2) definition of BIM to GIS conceptual mapping framework and component; and
- (3) definition of mapping for export from one schema into another.

The following concepts are outside the scope:

- (1) definition of any particular mapping application requirement and mechanism;
- (2) bi-directional mapping method between BIM and GIS;
- (3) definition of physical schema mapping between BIM and GIS; and
- (4) definition of coordinate system mapping between BIM and GIS.

NOTE: For cases involving requirements related to Geo-referencing for providing the position and orientation of the BIM model based on GIS, there exist other standards such as ISO 19111 and the Information Delivery Manual (IDM) from buildingSMART on Geo-referencing BIM.

🏢 COMMITTEE: ISO TC 211

📅 PUBLISHED: 2021-05

🔗 URL: <https://www.iso.org/standard/78899.html>

## OTHER

Technical report | ISO/TR 23262:2021 GIS (geospatial) / BIM interoperability [see details]

Guide | IEEE 1232.3-2014 Guide for the Use of Artificial Intelligence Exchange and Service Tie to All Test Environments [see details]

Framework | IEEE 2807-2022 Framework of Knowledge Graphs Series [see details]

Standard | IEEE 2937-2022 Standard for Performance Benchmarking for AI Server Systems [see details]

Standard | IEEE 2941-2021 Standard for Artificial Intelligence (AI) Model Representation, Compression, Distribution and Management [see details]

Guide | IEEE 3652.1-2020 Guide for Architectural Framework and Application of Federated Machine Learning [see details]

Recommended Practice | IEEE P2247.4 Recommended Practice for Ethically Aligned Design of Artificial Intelligence (AI) in Adaptive Instructional Systems [see details]

Recommended Practice | IEEE P2863 Recommended Practice for Organizational Governance of Artificial Intelligence [see details]

Standard | IEEE P2874 Standard for Spatial Web Protocol, Architecture and Governance [see details]

Guide | IEEE P2894 Guide for an Architectural Framework for Explainable



Artificial Intelligence [see details]

Standard | IEEE P2941.1 Standard for Operator Interfaces of Artificial Intelligence [see details]

Standard | IEEE P2975 Standard for Industrial Artificial Intelligence (AI) Data Attributes [see details]

Standard | IEEE P2976 Standard for XAI eXplainable Artificial Intelligence for Achieving Clarity and Interoperability of AI Systems Design [see details]

Standard | IEEE P3119 Standard for the Procurement of Artificial Intelligence and Automated Decision Systems [see details]

Standard | IEEE P3123 Standard for Artificial Intelligence and Machine Learning Terminology and Data Formats [see details]

Recommended Practice | IEEE P3128 Recommended Practice for The Evaluation of Artificial Intelligence (AI) Dialogue System Capabilities [see details]

Standard | IEEE P3129 Standard for Robustness Testing and Evaluation of Artificial Intelligence (AI)-based Image Recognition Service [see details]

Standard | IEEE P3152 Standard for the Description of the Natural or Artificial Character of Intelligent Communicators [see details]

Standard | IEEE P7014 Standard for Ethical considerations in Emulated Empathy in Autonomous and Intelligent Systems [see details]

Standard | IEEE P7015 Standard for Data and Artificial Intelligence (AI) Literacy, Skills, and Readiness [see details]

Guide | ISO/AWI 23143-1 Information exchange between BIM and GIS Part 1: Core principles and specifications [see details]

Guide | ISO/AWI 23143-2 Information exchange between BIM and GIS Part 2: Facilitating data exchange through metadata [see details]

## 4.4.5 Internet of Things (IoT)

### Standard | ISO/IEC 21823-3:2021 Internet of Things (IoT) Interoperability for IoT systems Part 3: Semantic interoperability

ISO/IEC 21823-3:2021 provides the basic concepts for IoT systems semantic interoperability, as described in the facet model of ISO/IEC 21823-1, including:

- (1) requirements of the core ontologies for semantic interoperability;
- (2) best practices and guidance on how to use ontologies and to develop domain-specific applications, including the need to allow for extensibility and connection to external ontologies;
- (3) cross-domain specification and formalization of ontologies to provide harmonized utilization of existing ontologies;
- (4) relevant IoT ontologies along with comparative study of the characteristics and approaches in terms of modularity, extensibility, reusability, scalability, interoperability with upper ontologies, and so on; and
- (5) use cases and service scenarios that exhibit necessities and requirements of semantic interoperability.

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ISO/IEC JTC 1/SC 41

📅 PUBLISHED: 2021-09

🔗 URL: <https://www.iso.org/standard/83752.html>

### OTHER

Standard | ISO/IEC 30141 ED2 Internet of Things (IoT) Reference architecture [see details]

Technical specification | ISO/IEC TS 30149 ED1 Internet of Things (IoT) Trustworthiness Principles [see details]

Standard | ISO/AWI 8000-220 Data quality Part 220: Sensor data: Quality measurement [see details]

Standard | ISO/CD 8000-210 Data quality Part 210: Sensor data: Data quality characteristics [see details]

Technical report | ISO/IEC TR 30194 ED1 Internet of Things (IoT) and Digital Twin Best practices for use case projects [see details]

Standard | PWI JTC1-SC41-17 Guidance on the integration of IoT and digital twins in data spaces [see details]

Standard | PWI JTC1-SC41-8 Internet of Things (IoT) Behavioral and policy interoperability [see details]

Standard | ISO/IEC 23093-3:2022 Information technology Internet of media things Part 3: Media data formats and APIs [see details]

## 4.4.6 Security Computing

### Technical specification | ISO/IEC AWI TS 27115 Cybersecurity evaluation of complex systems Introduction and framework overview

This document provides the foundations and concepts for the cybersecurity evaluation of complex systems. Two frameworks are defined:

1. The first is used to specify the cybersecurity of a complex system, including system of systems.
2. The second is used to evaluate the corresponding cybersecurity solutions. The frameworks use basic architecture concepts:
  - ▷ to enable description of reference or solution cybersecurity architectures;
  - ▷ to support model-based, comprehensive and scalable security solutions and their evaluation; and
  - ▷ to allow for the definition of architecture-based cybersecurity profiles (ACP) and hierarchies of profiles.

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: ISO/IEC JTC 1/SC 27

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/81627.html>

### OTHER

Technical report | ETSI TR 103 957 V0.0.3 Cyber Security (CYBER); Extended Reality Cyber Security Analysis [see details]

Standard | ISO/IEC DIS 5927 Augmented and Virtual Reality safety Guidance on safe immersion, setup and usage [see details]

Standard | IEEE 2813-2020 Standard for Big Data Business Security Risk Assessment [see details]

Recommended Practice | IEEE P7004.1 Recommended Practices for Virtual Classroom Security, Privacy and Data Governance [see details]

Standard | ISO 31700-1:2023 Consumer protection Privacy by design for consumer goods and services Part 1: High-level requirements [see details]

Standard | ISO/IEC 20889:2018 Privacy enhancing data de-identification terminology and classification of techniques [see details]

Standard | ISO/IEC 24760-1:2019 IT Security and Privacy A framework for identity management Part 1: Terminology and concepts [see details]

Standard | ISO/IEC 24760-2:2015 Information technology Security techniques A framework for identity management [see details]

Standard | ISO/IEC 27551:2021 Information security, cybersecurity and privacy protection Requirements for attribute-based unlinkable entity authentication [see details]

Standard | ISO/IEC 27556:2022 Information security, cybersecurity and privacy protection User-centric privacy preferences management framework [see

details]

Standard | ISO/IEC 27559:2022 Information security, cybersecurity and privacy protection Privacy enhancing data de-identification framework [see details]

Standard | ISO/IEC 29100:2011 Information technology Security techniques Privacy framework [see details]

Standard | ISO/IEC 29115:2013 Information technology Security techniques Entity authentication assurance framework [see details]

Standard | ISO/IEC 29134:2023 Information technology Security techniques Guidelines for privacy impact assessment [see details]

Standard | ISO/IEC 29146:2016 Information technology Security techniques A framework for access management [see details]

Standard | ISO/IEC 29184:2020 Information technology Online privacy notices and consent [see details]

Technical report | ISO/IEC TR 27550:2019 Information technology Security techniques Privacy engineering for system life cycle processes [see details]

Technical specification | ISO/IEC TS 27110:2021 Information technology, cybersecurity and privacy protection Cybersecurity framework development guidelines [see details]

Technical specification | ISO/IEC TS 27560:2023 Privacy technologies Consent record information structure [see details]

Technical specification | ISO/IEC TS 27570:2021 Privacy protection Privacy guidelines for smart cities [see details]

Technical specification | ISO/IEC TS 27570:2021 Privacy protection Privacy guidelines for smart cities [see details]

Technical report | ISO/TR 31700-2:2023 Consumer protection Privacy by design for consumer goods and services Part 2: Use cases [see details]

## ■ 4.5 Processing

### 4.5.1 Blockchain

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#### Standard | IEEE 2140.1-2020 Standard for General Requirements for Cryptocurrency Exchanges

Self-discipline and professional ethics of cryptocurrency exchange platforms, as well as relevance between them and to cryptocurrency wallets are covered in this standard. Exchange business logic, operational procedures, user authentication programs are also covered in this standard. In addition, a small but necessary technical category of requirements, including terminologies, basic architectural framework, key indicators, end-user interface specifications, in order to achieve the previously mentioned goals is covered in this standard.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2020-11

🔗 URL: <https://standards.ieee.org/ieee/2140.1/7615/>

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#### Standard | IEEE 2140.2-2021 Standard for Security Management for Customer Cryptographic Assets on Cryptocurrency Exchanges

In this standard requirements are defined for multiple aspects of security management for customer cryptographic assets on cryptocurrency exchanges, such as user identification using multi-factor authentication, prioritized protection of customer assets under unforeseen circumstances, and professional ethics of operation for cryptocurrency exchange platforms.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2022-01

🔗 URL: <https://standards.ieee.org/ieee/2140.2/7616/>

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#### Standard | IEEE 2140.4-2023 Standard for Distributed/Decentralized Exchange Framework Using Distributed Ledger Technology (DLT)

This standard defines an extension framework based on IEEE 2140.1-2020. The extension framework uses a Smart Contract mechanism to process transactions on an exchange, to replace the role of exchange operators. This standard also defines a series of extensible interfaces for the exchange scenario, enabling support of third-party financial derivatives using tokens.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2023-04

🔗 URL: <https://standards.ieee.org/ieee/2140.4/7621/>

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## Standard | IEEE 2140.5-2020 Standard for a Custodian Framework of Cryptocurrency

A framework of a custodian service for cryptocurrency and token assets is defined in this standard. Custodian reference technical architecture, business logic description, custodian service business models, digital asset evaluation criteria, operational procedure models, and regulatory requirement support models are included in this framework.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2020-07

🔗 URL: <https://standards.ieee.org/ieee/2140.5/7622/>

## Recommended Practice | IEEE 2142.1-2021 Recommended Practice for E-Invoice Business Using Blockchain Technology

Described in this standard is the blockchain-based application reference architecture of e-invoice business, including roles of participants, typical business scenarios, platform frameworks, and security requirements.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2021-03

🔗 URL: <https://standards.ieee.org/ieee/2142.1/7590/>

## Standard | IEEE 2143.1-2020 Standard for General Process of Cryptocurrency Payment

Defined in this standard is the general process of cryptocurrency payment between consumers and merchants. This process describes how a consumer purchases goods or services with cryptocurrency and how the merchant receives fiat money in return. It involves multiple aspects such as cryptocurrency payment operators playing an agent role, consumers owning cryptocurrency, merchant accessing to a cryptocurrency payment platform, banks, and cryptocurrency exchanges.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2020-06

🔗 URL: <https://standards.ieee.org/ieee/2143.1/7623/>

## Standard | IEEE 2144.1-2020 Standard for Framework of Blockchain-based Internet of Things (IoT) Data Management

A framework of blockchain-based Internet of Things (IoT ) data management is defined in this standard. It identifies the common building blocks of the framework that blockchain enabled during IoT data lifecycle including data acquisition, processing, storage, analyzing, usage/exchange and obsolescence, and the interactions among these building blocks.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2021-01

🔗 URL: <https://standards.ieee.org/ieee/2144.1/7626/>

## Standard | IEEE 2146.1-2022 Approved Draft Standard for Entity-Based Risk Mutual Assistance Model through Blockchain Technology

The standard defines the Entity Risk Mutual Assistance Model (RMAM) based on blockchain technology, including the involved entities of interest, the relationship between entities, organizational framework, and design method. A framework of blockchain-based Internet of Things (IoT) data management is defined in this standard. It identifies the common building blocks of the framework that blockchain enabled during IoT data lifecycle including data acquisition, processing, storage, analyzing, usage/exchange and obsolescence, and the interactions among these building blocks.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2022-08

🔗 URL: <https://standards.ieee.org/ieee/2146.1/10144/>

## Standard | IEEE 2418.10-2022 Standard for Blockchain based Digital Asset Management

A baseline architectural framework will be defined in this standard. In addition, the general process for digital asset management on blockchain will be outlined.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: 2022-06

🔗 URL: <https://standards.ieee.org/ieee/2418.10/7630/>

## Standard | IEEE 2418.2-2020 Standard Data Format for Blockchain Systems

Data format requirements for blockchain systems are established in this standard. This standard addresses data structures, data types, and data elements.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/SAB

📅 PUBLISHED: 2020-12

🔗 URL: <https://standards.ieee.org/ieee/2418.2/7309/>

## Standard | IEEE 2418.7-2021 Standard for the Use of Blockchain in Supply Chain Finance

This standard defines a baseline architectural framework and defines functional roles for blockchain-driven supply chain finance (SCF) implementations, e.g., core enterprise, supplier, bank, blockchain platform provider, and so on. The procedures of registration, asset issuance, asset transfer, financing based on asset on chain, asset clearing and settlement, and asset tracing, are explained. Finally, the technique requirement of the business system, and blockchain platform are discussed.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: 2021-10

🔗 URL: <https://standards.ieee.org/ieee/2418.7/7447/>

## Standard | IEEE 3205-2023 Standard for Blockchain Interoperability Data Authentication and Communication Protocol

Blockchain interoperability is the ability of two or more blockchain systems or applications to exchange information and to mutually use the information that has been exchanged. The interfaces and protocols play a very important role in realizing interoperability. Therefore, the standard of cross-chain interoperability interfaces and protocols, especially those for data authentication and communication among homogeneous and heterogeneous blockchains systems, is needed. Such protocols coordinate blockchains while supporting multiple cross-chain models and levels to meet business demands without the need to customize gateways or exchanges for specific use cases. Provided in this standard are an infrastructure of cross-chain interoperability, as well as interfaces and protocols of data authentication and communication for homogeneous and heterogeneous blockchain interoperability. The protocols include the distributed identity protocol, metadata protocol, on-chain proof transformation protocol, and cross-chain communication protocol.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: 2023-04

🔗 URL: <https://standards.ieee.org/ieee/3205/10237/>

## Standard | IEEE 3801-2022 Standard for Blockchain-based Electronic Contracts

This standard defines a technical reference framework and terminology for the platform of blockchain in electronic contracts. Functional requirements and technical indicators are also defined.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/DFESC

📅 PUBLISHED: 2022-04

🔗 URL: <https://standards.ieee.org/ieee/3801/10299/>

## Standard | IEEE P2140.3 Standard for User Identification and Anti-Money Laundering on Cryptocurrency Exchanges

This standard defines requirements for multiple aspects of user identification and Anti-Money Laundering on cryptocurrency exchanges, such as KYC (Know Your Customer) and AML (Anti-Money Laundering) regulations, outsourcing proper compliance measures to third-party solutions, and building up a self-regulatory layer of security and accountability among exchanges. It is to keep customers from malignant influence of unethical and illegal money that can be traced back inside/outside the cryptocurrency space. It is different from the IEEE P2140.2 standard, which is based on the protection of customer cryptographic assets.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: under development

🔗 URL: <https://sagroups.ieee.org/2140/>


## Standard | IEEE P2143.2 Standard for Cryptocurrency Payment Performance Metrics

This standard defines the performance metrics of cryptocurrency payment between consumers and merchants required to quantify the experience assessment of both consumers and merchants, such as the duration time required to complete a transaction made in cryptocurrency through a general process of cryptocurrency payment.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC



 PUBLISHED: under development

 URL: <https://sagroups.ieee.org/2143/>

## Standard | IEEE P2143.3 Standard for Risk Control Requirements for Cryptocurrency Payment

This standard defines the risk control requirements for cryptocurrency payment between consumers and merchants. It addresses how to control the risks on related sides and manage the security of fiat money and cryptocurrency in the value transferring process.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE CTS/BSC


 PUBLISHED: under development

 URL: <https://sagroups.ieee.org/2143/>

## Standard | IEEE P2144.2 Standard for Functional Requirements in Blockchain-based Internet of Things (IoT) Data Management

This standard defines the functional requirements in data compliance, governance and risk management in the operational process for Blockchain-based IoT data management systems.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE CTS/BSC


 PUBLISHED: under development

 URL: <https://sagroups.ieee.org/2144/>

## Standard | IEEE P2144.3 Standard for Assessment of Blockchain-based Internet of Things (IoT) Data Management

This standard defines the assessment framework for data compliance, governance and risk management and provides performance metrics such as availability, security, privacy, integrity, continuance, scalability, etc.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE CTS/BSC


 PUBLISHED: under development


 URL: <https://sagroups.ieee.org/2144/>

## Standard | IEEE P2145 Draft Standard for Framework and Definitions for Blockchain Governance

This standard provides a common nomenclature and framework for describing blockchain governance across all use cases and contexts, including public, private, permissioned, permissionless, and hybrid. The standard is only normative regarding terminology. It is non-normative with respect to the design of particular blockchain protocols and systems. Where two terms are in common use for one concept, the standard shall define both terms and elaborate on any meaningful distinctions between them.

 ENABLERS: Security, Trust

 COMMITTEE: IEEE CTS/BSC

 PUBLISHED: under development

 URL: <https://standards.ieee.org/project/2145.html>

## Standard | IEEE P2146.2 Standard for External Data Retrieval of Blockchain for Risk Mutual Assistance Model

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: under development

🔗 URL: [https://standards.ieee.org/project/2146\\_2.html](https://standards.ieee.org/project/2146_2.html)

## Standard | IEEE P2418.1 Standard for the Framework of Blockchain Use in Internet of Things (IoT)

This standard provides a common framework for blockchain usage, implementation, and interaction with the Internet of Things (IoT). The framework addresses items such as security and privacy challenges with regards to Blockchain in IoT. Blockchain permissioned IoT blockchain, and permissionless IoT blockchain will be included in the framework.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/BSC

📅 PUBLISHED: under development

🔗 URL: [https://standards.ieee.org/project/2418\\_1.html](https://standards.ieee.org/project/2418_1.html)

## Framework | IEEE P2418.11 Framework for Use of Distributed Ledger Technology in Security of Electronic Voting (e-Voting) Systems

e-Voting is an application of modern Web and Distributed Ledger Technology (DLT) for more choices and security in registration and voting. Choices range from voting with anonymous paper ballots and postal mail, to online voting where an electronic ballot can be authenticated that it was received and recorded as intended. For security, DLT-enabled systems: validate sources with cryptographic methods, secure communications with digital signatures, and confirm valid transaction with a transparent ledger. Suspicious transactions are recorded as part of a private real-time audit and database, and e-Voting can be tailored for the local needs and methods of a country or administrative sub-division.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE IES/SC

📅 PUBLISHED: under development

🔗 URL: [https://standards.ieee.org/project/2418\\_11.html](https://standards.ieee.org/project/2418_11.html)

## Standard | IEEE P2418.3 Standard for the Framework of Distributed Ledger Technology (DLT) Use in Agriculture

This standard provides a common framework for distributed ledger technology (DLT) usage, implementation, and interaction in agriculture. The framework maps DLT terms including transactions, smart contracts, tokens, assets and networks to terms in agriculture, and addresses technical aspects including scalability, security and privacy challenges with regard to DLT in agriculture. Concerns from different stakeholders and requirements in horizontal and vertical categories of agriculture are included in the framework.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/SAB

📅 PUBLISHED: under development

🔗 URL: [https://standards.ieee.org/project/2418\\_3.html](https://standards.ieee.org/project/2418_3.html)

## Standard | IEEE P2418.5 Standard for Blockchain in Energy

This guide provides an open, common, and interoperable reference framework model for distributed ledger technology (DLT), such as blockchain in the energy sector. It also covers three aspects:

- 1) Serve as a guideline for Blockchain DLT use cases in Electrical Power industry; energy value industry chain, covering the Renewable energy industry and their renewable related sources services of generation.
- 2) Create guide on reference architecture framework, including interoperability, terminology, functionality, and system interfaces for blockchain DLT applications in the energy sector by building an open protocol and technology agnostic layered framework.
- 3) Evaluate and provide guidelines on scalability, performance, security, and interoperability through evaluation of consensus algorithm, smart contracts, and type of blockchain DLT implementation, etc. for the Energy sector.

🔒 ENABLERS: Security, Trust

👥 COMMITTEE: IEEE PES/SBLC

📅 PUBLISHED: under development

🔗 URL: [https://standards.ieee.org/project/2418\\_5.html](https://standards.ieee.org/project/2418_5.html)

## Standard | IEEE P2418.6 Standard for the Framework of Distributed Ledger Technology (DLT) Use in Healthcare and the Life and Social Sciences

This standard provides a framework for the implementation, and interaction utilizing Web 3.0 (Web3) in healthcare and life sciences involving privacy challenges. Web 3.0 represents the next iteration of the evolution of the web and is built upon the core concepts of decentralization, openness, and greater user utility. Digital Ledger Technology (DLT) tokens, smart contracts, transactions, assets, networks, off-chain data storage and access architectural patterns, and Web3 permissioned and permission-less DLT are included in the framework.

🔒 ENABLERS: Security, Trust

👥 COMMITTEE: IEEE EMB/SC

📅 PUBLISHED: under development

🔗 URL: [https://standards.ieee.org/project/2418\\_6.html](https://standards.ieee.org/project/2418_6.html)

## Standard | IEEE P2958 Standard for a Decentralized Identity and Access Management Framework for Internet of Things

This standard defines a decentralized identity and access management (IAM) framework for the Internet of Things (IoT) based on the emerging concepts such as decentralized identifiers (DIDs) and verifiable credentials (VCs). The framework addresses the integration of DIDs and VCs into the lifecycle of IoT devices as well as the decentralized IoT security services such as device authentication, data authorization and access control.

🔒 ENABLERS: Security, Trust

👥 COMMITTEE: IEEE SA BOG/CAG

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/2958.html>

## Standard | IEEE P3201 Standard for Blockchain Access Control

The standard establishes access control requirements for blockchain systems. The standard addresses the following access control attributes of the system, including but not limited to:

- a) Node permissions the permissions of block generation, block synchronization, block verification and broadcasting, and sending transactions.

- b) Smart contract access permissions interface access control, user access control, and hybrid access control.
- c) User permissions registered user permissions and unregistered permissions. The concept of role is applied to differentiate the permissions of registered users, which means permissions vary according to the role of a user.
- d) Global permissions user access to deploy smart contracts, and to read smart contracts.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3201.html>

### Standard | IEEE P3202 Standard for Capability Evaluation Requirements of Blockchain Practitioners

This standard defines the types of occupations, competency requirements, and evaluation methods of blockchain and distributed ledger technology for service practitioners, including but not limited to competency elements, evaluated process, and employment grade. This standard applies to the ability evaluation and training of blockchain and distributed ledger technology service practitioners.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3202.html>

### Standard | IEEE P3203 Draft Standard for Blockchain Interoperability Naming Protocol

This standard defines a set of protocols that enable Blockchain networks to locate each other's trusted nodes through standardized names. The set of protocols define a naming scheme, an interface for name registration, and the data format that request and response messages use to resolve names.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3203.html>

### Standard | IEEE P3204 Draft Standard for Blockchain Interoperability Cross Chain Transaction Consistency Protocol

The technical architecture and details of three cross-chain approaches is described in this standard, including Centralized/Multi-signature Notary-based cross-chain technology, HTLC-based cross chain technology and Relay Chain-based cross-chain technology.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3204.html>

## Standard | IEEE P3206 Draft Standard for Blockchain-based Digital Asset Classification

Blockchain-based digital assets exist in a specific system in the form of digitization. Considering the diversity of blockchain systems and applications, as well as the diversity of digital assets in these systems and applications, digital assets based on blockchain systems have typical characteristics such as intangibility, encryption verification mechanism, use of distributed ledgers, decentralization, consensus algorithms, etc. For better classification and management, this standard provides a unified classification method for blockchain digital assets for reference. This standard proposes the principles and methods for the classification of blockchain-based digital assets. This standard follows the principles of scientificity, systematicness and scalability, and proposes an attribute-based classification method for blockchain digital assets, whose classification attributes include technical attributes, economic attributes and legal attributes.

🔒 ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3206.html>

## Standard | IEEE P3207 Standard for Blockchain-based Digital Asset Identification

The data fields, types, and formats related to digital assets to improve digital asset identification efficiency are defined by this standard. Moreover, guidance for blockchain-based digital asset identification is provided by the definition and description of methods and data structures in this standard.

🔒 ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: 2023-03

🔗 URL: <https://standards.ieee.org/project/3207.html>

## Standard | IEEE P3208 Standard for Blockchain-based Digital Asset Exchange Model

This standard defines an exchange model for blockchain-based digital assets. The exchange model includes operational processes, data security and information security requirements, and transaction rules. The standard also defines the general technical requirements of the exchange model and describes the entity functions in the exchange model.

🔒 ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3208.html>

## Standard | IEEE P3209 Draft Standard for Blockchain Identity Key Management

The current blockchain has problems such as a wide variety of chains, independent design rules for each identity account, and different cryptographic curve signature algorithms. If the traditional private key mode is used to manage multiple accounts on the same chain or multiple accounts on different chains Identity requires users to perform multiple backups, and faces complex management and authentication problems. Therefore, the design of hierarchical deterministic schemes and related proposals have emerged. The IEEE P3209 standard will unite many blockchain technology providers to jointly formulate international standards for hierarchical deterministic schemes, output uniform and standardized cryptographic derivation rules between different chains, and determine multiple

blockchains through mutual signature and self-certification of private keys of different chains. The same identity corresponding to the public and private keys on the chain.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3209.html>

## Standard | IEEE P3210 Standard for Blockchain-based Digital Identity System Framework

The standard establishes requirements for blockchain based digital identity systems. The standard addresses the following attributes of the system, including but not limited to, digital identity definition, distributed digital identity creation, distributed digital identity authentication, distributed digital identity note (refers to identity credentials such as identity card, work card, member card), data or asset circulation protocols.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3210.html>

## Standard | IEEE P3211 Standard for Blockchain-based Electronic Evidence Interface Specification

This standard defines the data format, classification and application programming interface of blockchain in the field of electronic evidence.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3211.html>

## Standard | IEEE P3212 Standard for Blockchain System Governance Specification

For permissioned and permission-less blockchains, this standard specifies a governance structure, governance tools and methods. Furthermore, the standard defines a governance structure and its principles as well as a life cycle management and compliance system.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development


🔗 URL: <https://standards.ieee.org/project/3212.html>

## Standard | IEEE P3214 Standard for Testing Specification of Blockchain Systems

This standard defines definitions, types, test specifications, test methods and test processes for blockchain systems. Test contents are included for each type of test. This standard also defines the test architecture of blockchain systems, including but not limited to functional testing, performance testing, security testing, stability testing, and compliance testing.

⚙️ ENABLERS: Security, Trust


👥 COMMITTEE: IEEE C/BDL

 PUBLISHED: under development

 URL: <https://standards.ieee.org/project/3214.html>

## Standard | IEEE P3216 Standard for Blockchain Service Capability Evaluation

This standard defines a framework of service capability which includes the technology, human resource and qualifications of the entity and provides a set of indicators for the evaluation of service capability. It also proposes evaluation methods for the blockchain industry.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE C/BDL

 PUBLISHED: under development

 URL: <https://standards.ieee.org/ieee/3216/10464/>

## Standard | IEEE P3217 Draft Standard for Application Interface Specification for Blockchain Systems

This standard is IEEE Standard for Application Interface Specification for Blockchain Systems. It defines an application programming interface (API) collection and data transmission format between the chain layer and the application layer in a blockchain system and standardizes the string, encoding, and request-response format of the API.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE C/BDL

 PUBLISHED: 2023-06

 URL: <https://standards.ieee.org/ieee/3217/10565/>

## Standard | IEEE P3218 Standard for Using Blockchain for Carbon Trading Applications

Technical framework, application processes and technical requirements for carbon trading applications based on blockchain, including functions, access, interface, security, and carbon consumption voucher coding are described in this standard.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE C/BDL

 PUBLISHED: 2023-03

 URL: <https://standards.ieee.org/ieee/3218/10607/>

## Standard | IEEE P3219 Draft Standard for Blockchain-based Zero-Trust Framework for Internet of Things (IoT)

The surging needs for the Internet of Things (IoT) are dramatically shifting the network structure and challenging the traditional perimeter security paradigm. To establish secure and trustworthy interoperability among billions of heterogeneous interconnected devices, there is a need for standards defining a common framework. This standard defines a blockchain-based Zero-Trust access control framework and gives a typical implementation model and deployment variations, addressing general security and trust in IoT applications with the inspiration of the emerging Zero-Trust paradigm and blockchain technology. The leverage of blockchain and Zero-Trust could provide reliable interactions among people, things, and applications in the presence of failures and attacks, and improve an IoT system's overall information technology security posture.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE C/BDL

 PUBLISHED: under development

 URL: <https://standards.ieee.org/ieee/3219/10608/>

## Guide | IEEE P3220 Guide for the Application of Non-Fungible Token (NFT) Based Digital Asset

This guide describes the processes used in the conversion of physical assets to NFTs, the lifecycle management process of NFT derivatives, and the interaction and display modes of NFTs in the real world. Specifically it includes the generation, issuance, exchange, rights confirmation, system interaction and display process of NFTs.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE C/BDL

 PUBLISHED: under development

 URL: <https://standards.ieee.org/ieee/3220/10689/>

## Standard | IEEE P3221 Standard for Technical Requirements of Digital Collection Services Based on Blockchain Technologies

This standard defines technical requirements of a digital collection service based on blockchain technologies. A technical architecture, functional components, and security requirements are defined.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE C/BDL

 PUBLISHED: under development

 URL: <https://standards.ieee.org/ieee/3221/10924/>

## Standard | IEEE P3222 Standard for the Reference Architecture of Blockchain as a Service

This standard specifies a reference architecture for Blockchain as a Service (BaaS) in the consortium blockchain. It defines the terms and definitions, reference architecture, basic functional requirements and non-functional requirements for BaaS in the consortium blockchain.

 ENABLERS: Security, Trust


 COMMITTEE: IEEE C/BDL

 PUBLISHED: under development


 URL: <https://standards.ieee.org/ieee/3222/10877/>

## Standard | IEEE P3223 Standard for the Reference Architecture of Blockchain Fusion Server

This standard defines a technical architecture as well as primary functional and non-functional requirements for blockchain fusion servers.

 ENABLERS: Security, Trust

 COMMITTEE: IEEE C/BDL

 PUBLISHED: under development

 URL: <https://standards.ieee.org/ieee/3223/10878/>



## Standard | IEEE P3224 Standard for Blockchain-based Green Power Identification Application

This standard defines an application model and technical framework for green power identification based on blockchain. This standard also specifies the technical and operation management requirements of green power identification based on blockchain.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/3224/10960/>

## Standard | IEEE P3225 Standard for Using Blockchain in Low Carbon Zones Evaluation

This standard defines an evaluation model and evaluation index system for using blockchain in low carbon zones, combining carbon emission scenarios and zone types. This standard also defines the technical requirements and management requirements for using blockchain for low carbon zones, including carbon accounting data sources, data storage, data interaction, data accounting, emission factor database establishment, carbon accounting method selection and prediction.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/3225/10961/>

## Standard | IEEE P3226 Standard for Trusted Data Circulation based on Blockchain and Distributed Ledger Technologies (DLT)

This standard defines a trusted data circulation platform based on blockchain and distributed ledger technologies. The system overview of trusted data circulation platform is defined including underlying computation engine layer, blockchain and DLT core function layer, trusted data circulation layer, and interface layer. The functional modules, data circulation processes, technical and security requirements are specified. This standard includes recommendations for controlling the allowable purposes and amount of data utilization, and for data privacy and resistance to tampering during the relevant data operations.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE C/BDL

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/3226/10962/>

## Standard | IEEE P3800 Standard for a data-trading system: overview, terminology and reference model

This standard establishes a system designed to trade data through domain-independent and principled marketplaces operating under a unified architecture. It defines terminology, a reference model, and the roles and functions of data providers, data users, and data marketplaces. The standard provides an overview of the data trading system using its reference model.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/DFESC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/project/3800.html>

## Standard | IEEE P3802 Standard for Application Technical Specification of Blockchain-based E-Commerce Transaction Evidence Collecting

This standard specifies the terminology, technical reference framework, basic functional requirements, and technical indicators for the platform of blockchain-based e-commerce transaction evidence collecting, which is the foundation of digital business interactions.

⚙️ ENABLERS: Security, Trust

👥 COMMITTEE: IEEE CTS/DFESC

📅 PUBLISHED: 2022-04

🔗 URL: <https://standards.ieee.org/project/3802.html>

## 4.5.2 Computer Graphics

### Standard | ISO/IEC 23090-5:2023 Information technology Coded representation of immersive media Part 5: Visual volumetric video-based coding (V3C) and video-based point cloud compression (V-PCC)

This document specifies the syntax, semantics and decoding for visual volumetric media using video-based coding methods. This document also specifies processes that can be needed for reconstruction of visual volumetric media, which can also include additional processes such as post-decoding, pre-reconstruction, post-reconstruction and adaptation.

📖 OTHER VERTICALS: Metaverse

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2023-11

🔗 URL: <https://www.iso.org/standard/83535.html>

### Standard | ISO/IEC 19775-1:2013 Information technology Computer graphics, image processing and environmental data representation Extensible 3D (X3D) Part 1: Architecture and base components

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 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. The semantics of X3D describe an abstract functional behaviour of time-based, interactive 3D, multimedia information. ISO/IEC 19775-1:2013 does not define physical devices or any other implementation-dependent concepts (e.g. screen resolution and input devices). It is intended for a wide variety of devices and applications, and provides wide latitude in interpretation and implementation of the functionality. For example, it does not assume the existence of a mouse or 2D display device. Each X3D application:

- (1) implicitly establishes a world coordinate space for all objects defined, as well as all objects included by the application;
- (2) explicitly defines and composes a set of 3D and multimedia objects;
- (3) can specify hyperlinks to other files and applications;
- (4) can define programmatic or data-driven object behaviours;
- (5) can connect to external modules or applications via programming and scripting languages;
- (6) explicitly declares its functional requirements by specifying a profile; and
- (7) can declare additional functional requirements by specifying components.

📖 OTHER VERTICALS: Extended Reality

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 2013-11

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🔗 URL: <https://www.iso.org/standard/60760.html>

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## Standard | ISO/IEC 9592-1:1997 Information technology Computer graphics and image processing Programmer's Hierarchical Interactive Graphics System (PHIGS) Part 1: Functional description

This document is the first of a family of standards. This part of ISO/IEC 9592 specifies a set of functions for computer graphics programming, the Programmer's Hierarchical Interactive Graphics System (PHIGS). PHIGS is a graphics system for application programs that produce computer generated pictures on output devices. It supports operator input and interactions by supplying basic functions for graphical input and hierarchical picture definition. Picture definitions can be retained centrally where they may be edited by an application. Alternatively, graphical data may be processed without first storing it. To assist in this processing, explicit control over resources used to encapsulate the results of these processing operations is provided. Basic application requirements in the areas of lighting and shading are provided through primitives and functions for controlling the rendering of 3D objects. Utilization of raster images in the generation of PHIGS pictures is provided. Pictures are displayed on output devices which may have associated input devices. Several input devices can be used simultaneously. The application program is allowed to adapt its behaviour to make best use of their capabilities. Graphical output can be constrained to particular views. Views can be specified parametrically and automatic processing of input operations can be used to control viewing. New input devices can be defined from the capabilities available. Functions are specified for archiving picture definitions to file. In addition an interface to the Computer Graphics Metafile (ISO/IEC 8632) is described. This part of ISO/IEC 9592 defines a language independent nucleus of a graphics system for integration into a programming language. PHIGS is embedded in a language layer obeying the particular conventions of the language. Such language bindings are specified in ISO/IEC 9593.

📖 OTHER VERTICALS: Multimedia Coding

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⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 1997-11

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🔗 URL: <https://www.iso.org/standard/29417.html>

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## Standard | ISO 12637-1:2006 Graphic technology Vocabulary Part 1: Fundamental terms

This document is the first of a family of standards. ISO 12637-1:2006 defines a set of fundamental terms that can be used in the drafting of other International Standards for graphic technology. In order to facilitate their translation into other languages, the definitions are worded so as to avoid, where possible, any peculiarity attached to one language. The entries in ISO 12637-1:2006 are arranged alphabetically.

⚙️ ENABLERS: Computation, Interoperability

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👥 COMMITTEE: ISO TC 130

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📅 PUBLISHED: 2006-02

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🔗 URL: <https://www.iso.org/standard/40144.html>

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Standard | ISO 16760:2014 Graphic technology Prepress data exchange  
Preparation and visualization of RGB images to be used in RGB-based graphics  
arts workflows

ISO 16760:2014 specifies requirements for an RGB workflow for graphic arts printing based on the use of reflection prints (RGB Reference Prints) as the evaluation vehicle for coloured images. It provides guidelines on the creation of print-targeted RGB images (RGB Reference Images) and simulation prints. This International Standard requires the identification of a pair of ICC profiles for each image: an image profile and a profile describing the reference printing system. These profiles provide individual colour transformations for gamut mapping and colour separation. This International Standard does not provide any guidance as to how these gamut mapping or colour separation transforms can be specified.

⚙️ ENABLERS: Computation, Interoperability

👥 COMMITTEE: ISO TC 130

📅 PUBLISHED: 2014-12

🔗 URL: <https://www.iso.org/standard/57616.html>

Standard | ISO 8805:1988 Information processing systems Computer graphics  
Graphical Kernel System for Three Dimensions (GKS-3D) functional description

This document specifies a set of functions for computer graphics programming, i.e. the Graphical Kernel System for Three Dimensions (GKS-3D) as the basic graphics system of computer-generated three dimensional pictures on graphics output devices. Provides application programs to define and display 3D graphical primitives, specified using 3D coordinates. Functions are provided to for storage on and retrieval from an external graphics file with the functions being organized in upward compatible levels with increasing capabilities. Additional functions are defined to generate output primitives.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 1988-09

🔗 URL: <https://www.iso.org/standard/16253.html>

Standard | ISO/IEC 10641:1993 Information technology Computer graphics  
and image processing Conformance testing of implementations of graphics  
standards

This document specifies a general framework addressing the following six components: conformance in the standard itself; test requirements document (defining what shall be tested for a computer graphics standard); test specifications document (addressing the test technique and the content of each test); test method (defining the implementation of the test specification document, including the test software); test procedures (defining the application of the test software, which consists of the procedures to be used in conformance testing); the establishment of test services. Is applicable to all standards within the scope of the ISO/IEC JTC1 subcommittee responsible for computer graphics and image processing.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 1993-07

🔗 URL: <https://www.iso.org/standard/18736.html>

## Standard | ISO/IEC 11072:1992 Information technology Computer graphics Computer Graphics Reference Model

This document defines a set of concepts and their inter-relationships which should be applicable to the complete range of future computer graphics standard. May be applied to verify and refine requirements for computer graphics; to identify needs for computer graphics standards and external interfaces; to develop models based on requirements for computer graphics; to define the architecture of new computer graphics standards; compare computer graphics standards.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 1992-10

🔗 URL: <https://www.iso.org/standard/19059.html>

## Standard | ISO/IEC 12087-1:1995 Information technology Computer graphics and image processing Image Processing and Interchange (IPI) Functional specification Part 1: Common architecture for imaging

This document is the first of a family of standards. ISO/IEC 12087 is concerned with the manipulation, processing, and interchange of all types of digital images. The main purpose of this part is to define a generic, unifying imaging architecture to which other parts of ISO/IEC 12087 conform. This part of ISO/IEC 12087 also defines those specializations or delineations of the generic imaging architecture that are required to support IPI-PIKS and IPI-IIF.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 1995-04

🔗 URL: <https://www.iso.org/standard/21133.html>

## Standard | ISO/IEC 14478-1:1998 Information technology Computer graphics and image processing Presentation Environment for Multimedia Objects (PREMO) Part 1: Fundamentals of PREMO

The document is the first of a family of standards. ISO/IEC 14478 specifies techniques for supporting interactive Single, and multiple media applications which recognize and emphasize the interrelationships among user interfaces, multimedia applications, and multimedia information interchange. ISO/IEC 14478 defines a flexible environment to encompass modular functionality and is extensible through the creation of future components, both within and outside of Standards committees. It supports a wide range of multimedia applications in a consistent way, from simple drawings up to full motion Video, Sound, and virtual reality environments. ISO/IEC 14478 is independent of any particular implementation language, development environment, or execution environment. For integration into a programming environment, the Standard shall be embedded in a System dependent interface following the particular conventions of that environment. ISO/IEC 14478 provides versatile packaging techniques beyond the capabilities of monolithic Single-media Systems. This allows rearranging and extending functionality to satisfy requirements specific to particular application areas. ISO/IEC 14478 is developed incrementally with Parts 1 through 4 initially available. Other components are expected to be standardized by ISO/IEC JTC 1 SC24 or other subcommittees. ISO/IEC 14478 provides a framework within which application-defined ways of interacting with the environment can be integrated. Methods for the definition, presentation, and manipulation of both input and output objects are described. Application-supplied structuring of objects is also allowed and can, for example, be used as a basis for the development of toolkits for the creation of, presentation of, and interaction with multimedia and hyper-media documents and product model data. ISO/IEC 14478 is able to support construction, presentation, and interaction with multiple simultaneous inputs and Outputs using multiple media. Several such activities may occur simultaneously, and the application program can adapt its behaviour to make best use of the capabilities of its environment. ISO/IEC 14478 includes interfaces for external storage, retrieval and interchange of multimedia objects.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 1998-12

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🔗 URL: <https://www.iso.org/standard/21669.html>

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## Standard | ISO/IEC 15948:2004 Information technology Computer graphics and image processing Portable Network Graphics (PNG): Functional specification

ISO/IEC 15948:2004 specifies a datastream and an associated file format, Portable Network Graphics (PNG, pronounced 'ping'), for a lossless, portable, compressed individual computer graphics image transmitted across the Internet. Indexed-colour, greyscale, and truecolour images are supported, with optional transparency. Sample depths range from 1 to 16 bits. PNG is fully streamable with a progressive display option. It is robust, providing both full file integrity checking and simple detection of common transmission errors. PNG can store gamma and chromaticity data as well as a full ICC colour profile for accurate colour matching on heterogenous platforms. ISO/IEC 15948:2004 defines the Internet Media type "image/png". The datastream and associated file format have value outside of the main design goal.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 2004-03

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🔗 URL: <https://www.iso.org/standard/29581.html>

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## Standard | ISO/IEC 18023-1:2006 SEDRIS (Synthetic Environment Data Representation and Interchange Specification) Part 1: Functional specification

ISO/IEC 18023-1:2005 addresses the concepts, syntax and semantics for the representation and interchange of environmental data. It specifies:

- ▶ a data representation model for expressing environmental data;
- ▶ specifications of the data types and classes that together constitute the data representation model; and
- ▶ an application program interface that supports the storage and retrieval of environmental data using the data representation model.

ISO/IEC 18023-1:2005 also specifies topological, rule-based, and other constraints that ensure appropriate data can be available for applications that rely on automatically generated behaviours when interacting with environmental data.

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 2006-08

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🔗 URL: <https://www.iso.org/standard/38442.html>

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## Standard | ISO/IEC 7942-1:1994 Information technology Computer graphics and image processing Graphical Kernel System (GKS) Part 1: Functional description

This document is the first of a family of standards. It specifies a set of functions for computer graphics programming, the graphical kernel system. Provides functions for two dimensional graphical output, the storage and dynamic modification of pictures, and operator input. Applicable to a wide range of applications that produce two dimensional pictures on vector or raster graphical devices in monochrome or colour.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO/IEC JTC 1/SC 24

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📅 PUBLISHED: 1994-11

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🔗 URL: <https://www.iso.org/standard/14915.html>

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## Standard | ISO/IEC 8632-1:1999 Information technology Computer graphics Metafile for the storage and transfer of picture description information Part 1: Functional specification

This document is the first of a family of standards. ISO/IEC 8632 provides a file format suitable for the storage and retrieval of picture description information. The file format consists of an ordered set of elements that may be used to describe pictures in a way that is compatible between systems of different architectures, compatible with devices of differing capabilities and design, and meaningful to application constituencies. This picture description includes the capability for describing static images. The elements specified provide for the representation of a wide range of pictures on a wide range of graphical devices. The elements are organized into groups that delimit major structures (metafiles, pictures, and application structures), that specify the representations used within the metafile, that control the display of the picture, that perform basic drawing actions, that control the attributes of the basic drawing actions, that allow application-specific structuring to be overlaid on the graphical content, and that provide access to non-standard device capabilities. The metafile is defined in such a way that, in addition to sequential access to the whole metafile, random access to individual pictures and individual context-independent application structures is well-defined. Applications which require random access to pictures and/or context-independent application structures within pictures may, within the metafile, define directories to these pictures and/or context-independent application structures. The metafile may then be opened and randomly accessed without interpreting the entire metafile. In addition to a functional specification, two standard encodings of the metafile syntax are specified. These encodings address the needs of applications that require small metafile size plus minimum effort to generate and interpret, and maximum flexibility for a human reader or editor of the metafile. This part of ISO/IEC 8632 describes the format using an abstract syntax. The remaining parts of ISO 8632 specify standardized encodings that conform to this syntax: ISO/IEC 8632-3 specifies a binary encoding; ISO/IEC 8632-4 specifies a clear text encoding.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 1999-12

🌐 URL: <https://www.iso.org/standard/32378.html>

## Standard | ISO/IEC 9636-1:1991 Information technology Computer graphics Interfacing techniques for dialogues with graphical devices (CGI) Functional specification Part 1: Overview, profiles, and conformance

This document is the first of a family of standards. ISO/IEC 9636 establishes the conceptual model, functional capability, and minimum conformance requirements of the Computer Graphics Interface (CGI). It specifies design requirements for encodings of the CGI. ISO/IEC 9636 defines a set of CGI functions that is expected to satisfy the following needs of a majority of the computer graphics community:

- (a) provide an interface standard for computer graphics software package implementors;
- (b) provide an interface standard for computer graphics device manufacturers and suppliers;
- (c) provide an inquiry and response mechanism for graphics device capabilities, characteristics, and states;
- (d) provide a standard graphics escape mechanism to access non-standard graphics device capabilities; and
- (e) allow for future functional extension of the CGI.

In addition to the CGI functionality, device classes, and Foundation and Constituency Profiles are defined. The device classes included in the CGI are output (OUTPUT), input (INPUT), and output/input (OUTIN). Profiles allow subsets of the CGI functions and features to be defined to suit particular well-identified groups of users. There is also provision for Constituency Profiles to be registered after ISO/IEC 9636 is published. The Computer Graphics Interface (CGI) is a standard functional and syntactical specification of the control and data exchange between device-independent graphics software and an implementation of a CGI Virtual Device. The syntax of the CGI, presented in ISO/IEC 9636, is an encoding-independent and binding-independent specification. Any similarity of the examples or function specifications to a particular encoding technique or language is coincidental unless explicitly stated otherwise. The functions specified provide for the representation of a wide range of two-dimensional pictures and for control over their display on a wide range of graphics



devices. The functions are split into groups that perform device and CGI session control, specify the data representations used, control the display of the picture, perform basic drawing actions, control the attributes of the basic drawing actions, acquire data from input devices, and provide access to non-standard device capabilities. This part of ISO/IEC 9636 gives an overview of ISO/IEC 9636, explains the relationship between its parts and their relation to other standards, describes a reference model for graphics systems, and defines certain Foundation and Constituency Profiles. ISO/IEC 9636-2, ISO/IEC 9636-3, ISO/IEC 9636-4, ISO/IEC 9636-5, and ISO/IEC 9636-6 specify the CGI functions for different functional areas using an abstract notation. ISO/IEC 9637 and ISO/IEC 9638 define standard data stream encodings, procedural library bindings, and single entry point procedural bindings of the CGI.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 1991-12

🔗 URL: <https://www.iso.org/standard/17450.html>

## Standard | ISO/IEC 9973:2013 Information technology Computer graphics, image processing and environmental data representation Procedures for registration of items

ISO/IEC 9973:2013 specifies procedures to be followed in preparing, maintaining and publishing the International Register of Items for any standard whose classes of items are applicable to this register. The items that may be registered fall into several broad categories including:

- ▶ computer graphics concepts,
- ▶ data structures used by relevant standards,
- ▶ spatial and environmental concepts, and
- ▶ profiles of relevant standards.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2013-07

🔗 URL: <https://www.iso.org/standard/61820.html>

## Technical specification | ISO/IEC TS 5147:2023 Information technology Computer graphics, image processing and environmental data representation Guidelines for representation and visualization of smart cities

This document specifies guidelines for the representation and visualization of smart cities. This document:

- (a) describes the concepts of a smart city, smart city object and smart city data,
- (b) describes categories of data associated with smart cities, provides guidance for representation of smart cities,
- (c) describes guidance for visualization of smart cities,
- (d) provides guidance in selecting the appropriate representation and visualization technique for different categories of smart city data using standards, and
- (e) provides use cases for applying standards to the representation and visualization of smart cities.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2023-07

🔗 URL: <https://www.iso.org/standard/80918.html>



## OTHER

Standard | 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) [see details]

Technical report | ETSI TR 102 794 V1.1.1 Media Content Distribution (MCD); 3D Gaming Graphics Delivery Overview [see details]

Standard | ISO/IEC 18026:2009 Information technology Spatial Reference Model (SRM) [see details]

Standard | ISO/IEC 18025:2014 Information technology Environmental Data Coding Specification (EDCS) [see details]

Standard | ISO 14306:2017 Industrial automation systems and integration JT file format specification for 3D visualization [see details]

### 4.5.3 Image Processing

## OTHER

Standard | 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) [see details]

### 4.5.4 Multimedia Coding

#### Technical report | MPAA ARA Avatar Representation and Animation

Avatar Representation and Animation (ARA) is a Technical Specification being developed to provide data format specifications enabling a party to represent and animate an avatar transmitted by another independent party. The goal is represented by the following use case: Avatar-Based Videoconference: avatars representing humans with a high degree of accuracy participate in a videoconference. A virtual secretary (VS) represented as an avatar displaying PS creates an online summary of the meeting with a quality enhanced by the VS's ability to understand the PS of the avatar it converses with.

OTHER VERTICALS: Avatars

COMMITTEE: MPAA Community

PUBLISHED: under development

URL: <https://mpaa.community/mpaa-ara/>

#### Standard | IEEE 1857.9-2021 Standard for Immersive Visual Content Coding

Efficient coding tool sets for compression, decompression, and reconstructing of the immersive visual content data is provided. The target applications and services include, but are not limited to,

virtual reality (VR), such as unmanned aerial vehicle-based VR, augmented reality, panorama video, free-view TV, panoramic stereo video, and other video-/audio-enabled services and applications, such as immersive video streaming, broadcasting, storage, and communication.

📁 OTHER VERTICALS: Extended Reality

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⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: IEEE C/DCSC

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📅 PUBLISHED: 2022-03

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🔗 URL: <https://standards.ieee.org/ieee/1857.9/6659/>

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## Standard | ISO/IEC 23007-1:2010 Information technology Rich media user interfaces Part 1: Widgets

This document is the first of a family of standards. ISO/IEC 23007-1:2010 defines a specification for the exchange, the control and the communication of widgets with other entities, a widget being a self-contained living entity with an interactive and dynamic visualization.

⚙️ ENABLERS: Computation

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👥 COMMITTEE: ISO/IEC JTC 1/SC 29

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📅 PUBLISHED: 2010-11

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🔗 URL: <https://www.iso.org/standard/55497.html>

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## Standard | ISO/IEC 23093-2:2022 Information technology Internet of media things Part 2: Discovery and communication API

This document specifies the abstract class of a media thing (MThing), which is a basic component to construct the Internet of media things. The MThing class contains the basic APIs to:

- (a) discover other MThing(s) in the network;
- (b) connect/disconnect MThing(s); and
- (c) support transactions (e.g. payments) using media tokens between MThings.

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

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📅 PUBLISHED: 2022-03

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🔗 URL: <https://www.iso.org/standard/81587.html>

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## Standard | ISO/IEC 23094-1:2020 Information technology General video coding Part 1: Essential video coding

This document specifies a video coding technology known as essential video coding (EVC), which contains syntax format, semantics and an associated decoding process. The decoding process is designed to guarantee that all EVC decoders conform to a specified combination of capabilities known as the profile, level and toolset. Any decoding process that produces identical cropped decoded output pictures to those produced by the described process is considered to be in conformance with the requirements of this document. This document is designed to cover a wide range of application, including but not limited to digital storage media, television broadcasting and real-time communications.

⚙️ ENABLERS: Interoperability

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👥 COMMITTEE: ISO/IEC JTC 1/SC 29

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📅 PUBLISHED: 2020-10

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🔗 URL: <https://www.iso.org/standard/57797.html>

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## Technical report | ISO/IEC CD TR 23090-27 Information technology Coded representation of immersive media Part 27: Media and architectures for render-based systems and applications

This document provides context, motivation, and use case descriptions for a set of MPEG standards that collectively deliver media directly to render-based applications such as game engines with a renderer component, or standalone renderers. Emerging examples where such applications are especially relevant include “metaverse” applications and immersive displays where such displays provide an interface to components (e.g., renderers) of existing game engines; e.g., Unreal Engine by Epic Games, Inc. and Unity by Unity Technologies. This document:

- (1) describes the motivators leading to the development of new MPEG standards that facilitate the streaming of media to render-based applications;
- (2) provides an overview of a media workflow from content production to content distribution;
- (3) provides general information on relevant components of render-based systems including game engines, and renderers;
- (4) differentiates between visual media distributed for video-based applications and visual media distributed to render-based applications;
- (5) identifies key components and resources (compute, storage, or network) comprising a heterogeneous set of immersive displays and other render-based applications; and
- (6) documents use cases for end-to-end interoperability, including Audio, Video, Graphics and Systems aspects for render-based systems and applications.

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: under development

URL: <https://www.iso.org/standard/84568.html>

## Standard | ISO/IEC DIS 23094-21 Information technology Coded representation of immersive media Part 21: Reference Software for G-PCC

This recommendation International Standard provides accompanying reference software for ISO/IEC 23090-9 as an electronic attachment. The use of this reference software is not required for making an implementation of an encoder or decoder in conformance to ISO/IEC 23090-9. Requirements established in ISO/IEC 23090-9 take precedence over the behavior of the reference software.

ENABLERS: Interoperability

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: under development

URL: <https://www.iso.org/standard/81601.html>

## Standard | ISO/IEC FDIS 23093-4 Information technology Internet of media things Part 4: Reference software and conformance

This document specifies the conformance and reference software implementing ISO/IEC 23093-3. The information provided is applicable for determining the reference software modules available for ISO/IEC 23093-3, understanding the functionality of the available reference software modules, and utilizing the available reference software modules. Furthermore, this document provides means for conformance testing, i.e. bitstreams XML descriptions that conform or do not conform to ISO/IEC 23093-3.

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: under development

URL: <https://www.iso.org/standard/84239.html>

## Technical report | MPAA-MMM Architecture Call for Technologies: MPAA-MMM Architecture

This document is a Call for Technologies (CfT) for the MPai Metaverse Model (MPai-MMM) Architecture Technical Specification. MPai has already published two documents belonging to the MPai-MMM project: MPai Metaverse Model Functionalities [3] and MPai Metaverse Model Functionality Profiles [4]. They were developed as a basis for the planned Technical Specification: MPai-MMM Architecture. Three documents are attached to this Call for Technologies:

Use Cases and Functional Requirements: MPai Metaverse Model Architecture.

Framework Licence: MPai Metaverse Model Architecture.

Template of Responses: MPai Metaverse Model Architecture.

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: MPai Community

📅 PUBLISHED: under development

🔗 URL: <https://mpai.community/standards/mpai-mmm/call-for-technologies-mpai-mmm-architecture/>

### Technical report | MPai-MMM Functionalities Technical Report MPai Metaverse Model (MPai-MMM) Functionalities

This document is the first of a planned series of technical documents designed to facilitate interoperability between Metaverse Instances.

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: MPai Community

📅 PUBLISHED: 2023-01

🔗 URL: <https://mpai.community/standards/mpai-mmm/mpai-metaverse-model-mmm-functionality-profiles-mpai-metaverse-model/mmm-functionalities/>

### Technical report | MPai-MMM Functionality Profiles Technical Report MPai Metaverse Model (MPai-MMM) Functionality Profiles

Technical Report MPai Metaverse Model Functionality Profiles is the second of a planned series of technical metaverse interoperability technical documents.

⚙️ ENABLERS: Interoperability

👥 COMMITTEE: MPai Community

📅 PUBLISHED: 2023-04

🔗 URL: <https://mpai.community/standards/mpai-mmm/mpai-metaverse-model-mmm-functionality-profiles/>

### Standard | ISO/IEC 23008-3:2022 Information technology High efficiency coding and media delivery in heterogeneous environments Part 3: 3D audio

This document specifies technology that supports the efficient transmission of immersive audio signals and flexible rendering for the playback of immersive audio in a wide variety of listening scenarios. These include home theatre setups with 3D loudspeaker configurations, 22.2 loudspeaker systems, automotive entertainment systems and playback over headphones connected to a tablet or smartphone.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2022-08

🔗 URL: <https://www.iso.org/standard/83525.html>

## Standard | IEC PWI 100-49 ED1 Concept of metaverse for multimedia equipment and standardization areas in TC 100

COMMITTEE: IEC TC 100

PUBLISHED: under development

URL: [https://www.iec.ch/dyn/www/?p=103:38:17155273168177:::FSP\\_ORG\\_ID.FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:1297,23,114635](https://www.iec.ch/dyn/www/?p=103:38:17155273168177:::FSP_ORG_ID.FSP_APEX_PAGE,FSP_PROJECT_ID:1297,23,114635)

### Technical specification | MPAI-MMCV2 Multimodal Conversation

Multimodal Conversation (MPAI-MMC) V2 specifies:

1. data formats for analysis of text, speech, and other non-verbal components, used in human-machine and machine-machine conversation, and
2. use cases providing recognised applications by using data formats from MPAI-MMC and other MPAI standards.

COMMITTEE: MPAI Community

PUBLISHED: 2023-09

URL: <https://mpai.community/standards/mpai-mmc/>

## OTHER

Standard | ISO/IEC 23093-1:2022 Information technology Internet of media things Part 1: Architecture [see details]

Standard | ISO/IEC 23090-5:2023 Information technology Coded representation of immersive media Part 5: Visual volumetric video-based coding (V3C) and video-based point cloud compression (V-PCC) [see details]

Standard | ISO/IEC 9592-1:1997 Information technology Computer graphics and image processing Programmer's Hierarchical Interactive Graphics System (PHIGS) Part 1: Functional description [see details]

Standard | ISO 10303-21:2016 Industrial automation systems and integration Product data representation and exchange Part 21: Implementation methods: Clear text encoding of the exchange structure [see details]

Standard | ISO/IEC 14496-16:2011 Information technology Coding of audio-visual objects Part 16: Animation Framework eXtension (AFX) [see details]

Standard | ISO/IEC 14496-27:2009 Information technology Coding of audio-visual objects Part 27: 3D Graphics conformance [see details]

Standard | ISO/IEC 15938-3:2002 Information technology Multimedia content description interface Part 3: Visual [see details]

Standard | ISO/IEC 15938-5:2003 Information technology Multimedia content description interface Part 5: Multimedia description schemes [see details]

Standard | ISO/IEC 23090-14:2023 Information technology Coded representation of immersive media Part 14: Scene description [see details]

Technical report | ISO/IEC TR 15938-8:2002 Information technology Multimedia content description interface Part 8: Extraction and use of MPEG-7 descriptions [see details]

Standard | ISO/IEC 23093-3:2022 Information technology Internet of media things Part 3: Media data formats and APIs [see details]

Standard | ISO/IEC 14496-25:2011 Information technology Coding of audio-visual objects Part 25: 3D Graphics Compression Model [see details]

## ■ 4.6 Virtual World

### 4.6.1 Avatars

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#### Standard | ISO/IEC 19774-1:2019 Information technology Computer graphics, image processing and environmental data representation Part 1: Humanoid animation (HAnim) architecture

This document specifies a systematic system for representing humanoids in a network-enabled 3D graphics and multimedia environment. Conceptually, each humanoid is an articulated character that can be embedded in different representation systems and animated using the facilities provided by the representation system. This document specifies the abstract form and structure of humanoids. Further, this document specifies the semantics of humanoid animation as an abstract functional behaviour of time-based, interactive 3D, multimedia articulated characters. This document does not define physical shapes for such characters but does specify how such characters can be structured for animation. This document is intended for a wide variety of presentation systems and applications, providing wide latitude in interpretation and implementation of the functionality.

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2019-11

🔗 URL: <https://www.iso.org/standard/64788.html>

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#### Standard | ISO/IEC 19774-2:2019 Information technology Computer graphics, image processing and environmental data representation Part 2: Humanoid animation (HAnim) motion data animation

This document specifies the method of motion capture animation using H-Anim humanoid models. Each humanoid model consists of an articulated character with specified joints and motion capture data. As specified in ISO/IEC 19774-1, each character consists of joints and segments in a hierarchical structure. This document includes the following:

- (1) Concepts of motion capture as related to humanoid animation,
- (2) Concepts of motion capture data definition,
- (3) Definition of motion parameters and motion-capture animation data for transferring or exchanging motion between different humanoid character models,
- (4) Mapping the structure of motion capture data to the structure of H-Anim objects,
- (5) HAnim motion capture animation using interpolators,
- (6) HAnim motion definition using H-Anim Motion objects, and
- (7) A method for generating and specifying an H-Anim motion capture animation.

This document specifies a standard technique for exchanging humanoid animation using motion capture. It does not mandate using any specific run-time system to render the H-Anim characters or animations.

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2019-11

🔗 URL: <https://www.iso.org/standard/64791.html>

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## Standard | ISO/IEC 23090-14:2023/CD Amd 2 Information technology Coded representation of immersive media Part 14: Scene description Amendment 2: Support for haptics, augmented reality, avatars, Interactivity, MPEG-I audio, and lighting

This document specifies extensions to existing scene description formats in order to support MPEG media, in particular immersive media. MPEG media includes but is not limited to media encoded with MPEG codecs, media stored in MPEG containers, MPEG media and application formats as well as media provided through MPEG delivery mechanisms. Extensions include scene description format syntax and semantics and the processing model when using these extensions by a Presentation Engine. It also defines a Media Access Function (MAF) API for communication between the Presentation Engine and the Media Access Function for these extensions. While the extensions defined in this document can be applicable to other scene description formats, they are provided for ISO/IEC 12113.

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: under development

🔗 URL: <https://www.iso.org/standard/86439.html>

## Recommendation | ITU-T F.3DIDH-reqts Framework and requirements for the construction of 3D intelligent driven digital human application system based on multimedia services

This recommendation specifies the framework and requirements for the construction of 3D intelligent driven digital human application system based on multimedia services. The scope of this Recommendation includes:

- (a) Overview of 3D intelligent driven digital human application system.
- (b) Framework of 3D intelligent driven digital human application system.
- (c) Requirements of 3D intelligent driven digital human application system.

👥 COMMITTEE: ITU-T SG 16

📅 PUBLISHED: under development

🔗 URL: [https://www.itu.int/itu-t/workprog/wp\\_item.aspx?isn=18604](https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=18604)

## Recommendation | ITU-T F.748.14 Requirements and evaluation methods of non-interactive 2D real-person digital human application systems

Recommendation ITU-T F.748.14 specifies requirements and evaluation methods for non-interactive two-dimensional (2D) real-person digital human application systems, in terms of image, voice, movement, display, etc. It can be used to guide relevant parties to test, select or evaluate a non-interactive 2D real-person digital human application system. The evaluation methodology can reflect the current state of a non-interactive 2D real-person digital human application system by providing meaningful comparison dimensions.

👥 COMMITTEE: ITU-T SG 16

📅 PUBLISHED: 2022-03

🔗 URL: <https://itu.int/ITU-T/recommendations/rec.aspx?id=14961>



## Recommendation | ITU-T F.748.15 Framework and metrics for digital human application systems

Recommendation ITU-T F.748.15 specifies a framework for digital human application systems, and proposes corresponding subjective and objective metrics for the dimensions of image, speech, animation, interactive processing and multimodal input/output. This Recommendation can be used to guide relevant parties to test, select or evaluate a digital human application system. The metrics can reflect the current state of the digital human application system by providing meaningful comparison dimensions.

COMMITTEE: ITU-T SG 16

PUBLISHED: 2022-03

URL: <https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14962>

## Recommendation | ITU-T F.CEMP-DHS Requirements and architectures of multimedia platform for digital human services using edge cloud

Media services by using digital human technology covers a wide range of application scenarios. Also, it involves a variety of key technologies, such as modeling, animation and rendering technologies. In order to meet high fidelity, real-time and high concurrency requirements for digital human services, this new work item is to propose new additional multimedia-based functional capabilities for cloud and edge computing platforms for various media services by using the existing digital human technology. This Recommendation describes typical use cases and specifies requirements for this platform including requirements for the multimedia processing, interaction and management function. And a user-edge-cloud media service platform based on requirements and existing technologies of cloud-edge computing and digital human for media service providers as a reference.

COMMITTEE: ITU-T SG 16

PUBLISHED: under development

URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=18602](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18602)

## Recommendation | ITU-T F.CSDH Requirements of communication services for digital human

This recommendation describes the concept, use cases and requirements of communication services for digital human. The scope of this recommendation includes:

- (a) Use cases of the communication services for digital human,
- (b) Requirements on the user interface for those who are creating digital humans, and
- (c) Requirements on the digital human creation and utilization procedures.

COMMITTEE: ITU-T SG 16

PUBLISHED: under development

URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=18531](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18531)

## Recommendation | ITU-T F.DH.PE Requirements and evaluation methods of digital human platform

Under the stimulation of the concept of the metaverse, digital human is accelerating from technological innovation to industrial application. However, in the actual project implementation, most enterprises do not have the ability to directly develop and maintain digital human, so they often encounter the problems of high technical threshold, complex installation and deployment, and high management and maintenance cost. Therefore, there is a strong demand for reducing the cost of using digital human and simplifying the construction and operation and maintenance of digital human. By providing the service of creating, managing and maintaining enterprise-level digital human applications, digital human platform can help users reduce the development and use costs, and become an important way of digital human development, deployment, operation

and maintenance. However, there are many kinds of digital human platforms on the market, and their quality is uneven. From service support to code implementation, there are huge differences. Therefore, the functionality, compatibility, reliability, scalability, time response, and ease of use of the platform need to be strictly tested and verified before large-scale deployment to the production environment. In addition, at present, the standard of requirement and test method of digital human platform is still blank. The purpose of this Recommendation is to provide technical guidance and technical specification support for the research and development, selection and testing of digital human platform, to achieve a fair, just, scientific and objective evaluation of digital human platform, and to promote the progress of digital human technology products. This Recommendation provides the requirements and evaluation methods for the digital human platform from the aspects of function, compatibility, reliability, scalability, time response, and ease of use.

COMMITTEE: ITU-T SG 16

PUBLISHED: under development

URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=18650](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18650)

### Recommendation | ITU-T F.DHAI Framework and requirements of digital human access interfaces

This draft Recommendation describes the general access interface framework, including interface module description, application scenarios etc. It defines unified access interface requirements of digital human services for the developers to integrate the capabilities of digital human into different applications.

COMMITTEE: ITU-T SG 16

PUBLISHED: under development

URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=18655](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18655)

### Recommendation | ITU-T F.DHSMD Technical requirements and evaluation methods of 3D digital human system based on smart mobile device

This recommendation specifies requirements of 3D digital human system based on smart mobile devices from the dimensions of functional requirements, performance requirements and system requirements according to subjective and objective metrics. The evaluation methods of some unique requirements for 3D digital human and SMD application are also described. This recommendation applies to 3D digital human system based on smart mobile devices, including but not limited to smart phone assistants, e-commerce anchors, intelligent customer service, weather anchors, digital employees, etc.

COMMITTEE: ITU-T SG 16

PUBLISHED: under development

URL: [https://www.itu.int/ITU-T/workprog/wp\\_item.aspx?isn=18524](https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=18524)

### Technical specification | MPAI-PAF V1 Portable Avatar Format

Digital humans are computer-created digital objects that can be rendered with a human appearance and called Avatars. As Avatars have mostly been created, animated, and rendered in closed environments, it is no surprise that there has been very little need for standards.

In a communication context, say, in an interoperable metaverse, digital humans may not be constrained to be in a closed environment. Therefore, if a sender requires that a remote receiving client reproduce a digital human as intended by the sender, standards are needed.

Technical Specification: Portable Avatar Format is a first response to this need, with the following goals:

Objective 1: To enable a user to reproduce a virtual environment as intended.

Objective 2: to enable a user to reproduce a sender's avatar and its animation as intended by the sender.

Objective 3: to estimate the personal status of a human or avatar.

Objective 4: to display an avatar with a selected personal status.

COMMITTEE: MPai Community

PUBLISHED: 2023-09

URL: <https://mpai.community/standards/mpai-paf/>

## OTHER

Standard | 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) [see details]

Technical report | ISO/TR 24464:2020 Automation systems and integration Industrial data Visualization elements of digital twins [see details]

Technical report | MPai ARA Avatar Representation and Animation [see details]

Standard | ISO/IEC 23005-4:2018 Information technology Media context and control Part 4: Virtual world object characteristics [see details]

Standard | ISO 16792:2021 Technical product documentation Digital product definition data practices [see details]

Standard | ISO/IEC 23488:2022 Information technology Computer graphics, image processing and environment data representation Object/environmental representation for image-based rendering in virtual/mixed and augmented reality (VR/MAR) [see details]

Technical specification | ISO/IEC TS 23884:2021 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) [see details]

Standard | IEEE P3141 Standard for 3D Body Processing [see details]

Standard | ISO 18163:2016 Clothing Digital fittings Vocabulary and terminology used for the virtual garment [see details]

Standard | ISO 18825-1:2016 Clothing Digital fittings Part 1: Vocabulary and terminology used for the virtual human body [see details]

Standard | ISO 18825-2:2016 Clothing Digital fittings Part 2: Vocabulary and terminology used for attributes of the virtual human body [see details]

Standard | ISO 20947-1:2021 Performance evaluation protocol for digital fitting systems Part 1: Accuracy of virtual human body representation [see details]

Standard | ISO/DIS 17097 3-D human body scan data Part 1: Terminologies and methodologies for processing of human scan data [see details]

Standard | ISO/IEC 39794-16:2021 Information technology Extensible biometric data interchange formats Part 16: Full body image data [see details]

## 4.6.2 Extended Reality

Standard | ISO/IEC 23000-13:2017 Information technology Multimedia application format (MPEG-A) Part 13: Augmented reality application format

ISO/IEC 23000-13:2017 specifies the following:  
scene description elements for representing AR content; and  
mechanisms to connect to local and remote sensors and actuators; mechanisms to integrated compressed media (image, audio, video, graphics); mechanisms to connect to remote resources such as maps and compressed media.

OTHER VERTICALS: Metaverse
ENABLERS: Interoperability
COMMITTEE: ISO/IEC JTC 1/SC 29
PUBLISHED: 2017-11
URL: <a href="https://www.iso.org/standard/69465.html">https://www.iso.org/standard/69465.html</a>

Standard | ISO/IEC 23005-2:2018 Information technology Media context and control Part 2: Control information

The technologies of this document specified are:  
Description languages and vocabularies to characterize devices and users;  
Control information to fine tune the sensed information and the actuator command for the control of virtual/real worlds, i.e., user's actuation preference information, user's sensor preference information, actuator capability description, and sensor capability description. The adaptation engine is not within the scope of this document. This document specifies syntax and semantics of the tools required to provide interoperability in controlling devices (actuators and sensors) in real as well as virtual worlds: Control Information Description Language (CIDL) as an XML schema-based language which enables one to describe a basic structure of control information;  
Device Capability Description Vocabulary (DCDV), an XML representation for describing capabilities of actuators such as lamps, fans, vibrators, motion chairs, scent generators, etc.;  
Sensor Capability Description Vocabulary (SCDV), interfaces for describing capabilities of sensors such as a light sensor, a temperature sensor, a velocity sensor, a global position sensor, an intelligent camera sensor, etc.;  
Sensory Effect Preference Vocabulary (SEPV), interfaces for describing preferences of individual user on specific sensorial effects such as light, wind, scent, vibration, etc.; and  
Sensor Adaptation Preference Vocabulary (SAPV), interfaces for describing preferences on a sensor of an individual user on each type of sensed information.

OTHER VERTICALS: Metaverse
COMMITTEE: ISO/IEC JTC 1/SC 29
PUBLISHED: 2018-09
URL: <a href="https://www.iso.org/standard/73580.html">https://www.iso.org/standard/73580.html</a>

## Standard | ISO/IEC 23005-3:2019 Information technology Media context and control Part 3: Sensory information

The technologies specified in this document are description languages and vocabularies which describe sensorial effects. The adaptation engine is not within the scope of this document (or the ISO/IEC 23005 series). This document specifies syntax and semantics of the tools describing sensory information to enrich audio-visual contents: Sensory Effect Description Language (SEDL) as an XML schema-based language which enables one to describe a basic structure of sensory information; Sensory Effect Vocabulary (SEV), an XML representation for describing sensorial effects such as light, wind, fog, vibration, etc. that trigger human senses.

📖 OTHER VERTICALS: Metaverse

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2019-08

🔗 URL: <https://www.iso.org/standard/71076.html>

## Standard | ISO/IEC 23005-5:2019 Information technology Media context and control Part 5: Data formats for interaction devices

This document specifies syntax and semantics of the data formats for interaction devices by providing a standardized format for interfacing actuators and sensors by defining XML schema-based language named Interaction Information Description Language (IIDL). IIDL provides a basic structure with common information for communication with various actuators and sensors in consistency. Device Command Vocabulary (DCV) is defined to provide a standardized format for commanding individual actuator, and Sensed Information Vocabulary (SIV) is defined to provide a standardized format for holding information from individual sensors either to get environmental information from real world or to influence virtual world objects using the acquired information on the basis of IIDL.

📖 OTHER VERTICALS: Metaverse

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2019-02

🔗 URL: <https://www.iso.org/standard/73438.html>

## Standard | ISO/IEC 23005-6:2019 Information technology Media context and control Part 6: Common types and tools

This document provides definitions of data types and tools, which are used in other parts of the ISO/IEC 23005 series, but are not specific to a single part. This document specifies syntax and semantics of the data types and tools common to the tools defined in the other parts of the ISO/IEC 23005 series, such as basic data types which are used as basic building blocks in more than one of the tools in the ISO/IEC 23005 series, colour-related basic types which are used in light and colour-related tools to help in specifying colour-related characteristics of the devices or commands, and time stamp types which can be used in device commands, and sensed information to specify timing related information. Classification schemes, which provide semantics of words or terms and normative way of referencing them, are also defined in Annex A, if they are used in more than one part of the ISO/IEC 23005 series. The tools defined in this document are not intended to be used alone, but to be used as a part or as a supporting tool of other tools defined in other parts of the ISO/IEC 23005 series, except for the profile and level definitions. This document also contains standard profiles and levels to be used in specific application domains. The profile and level definitions include collection of tools from ISO/IEC 23005-2 and ISO/IEC 23005-5 with necessary constraints.

📖 OTHER VERTICALS: Metaverse

👥 COMMITTEE: ISO/IEC JTC 1/SC 29

📅 PUBLISHED: 2019-04

🔗 URL: <https://www.iso.org/standard/73439.html>

Standard | ISO/IEC 23090-9:2023 Information technology Coded representation of immersive media Part 9: Geometry-based point cloud compression

This document specifies geometry-based point cloud compression.

OTHER VERTICALS: Metaverse

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: 2023-03

URL: <https://www.iso.org/standard/78990.html>

Standard | ISO/IEC AWI 23090-29 Information technology Coded representation of immersive media Part 29: Video-based dynamic mesh coding (V-DMC)

OTHER VERTICALS: Metaverse

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: under development

URL: <https://www.iso.org/standard/85254.html>

Standard | ISO/IEC AWI 23090-30 Information technology Coded representation of immersive media Part 30: Low latency, low complexity LiDAR coding

OTHER VERTICALS: Metaverse

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: under development

URL: <https://www.iso.org/standard/85255.html>

Standard | ISO/IEC DIS 23090-31 Information technology Coded representation of immersive media Part 31: Haptics coding

OTHER VERTICALS: Metaverse

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: under development

URL: <https://www.iso.org/standard/86122.html>

Standard | ISO/IEC FDIS 23090-12 Information technology Coded representation of immersive media Part 12: MPEG immersive video

OTHER VERTICALS: Metaverse

COMMITTEE: ISO/IEC JTC 1/SC 29

PUBLISHED: under development

URL: <https://www.iso.org/standard/79113.html>

Technical report | 3GPP TR 26.999 V17.0.0 Virtual Reality (VR) streaming interoperability and characterization

The present document provides reference test material and test results for improved usability of technologies in TS 26.118: Virtual Reality (VR) profiles for streaming applications.

The specification TS 26.118 includes several VR media profiles for video and a single media profile for audio with different configuration options. The specification focuses primarily on interoperability requirements for VR360 applications, but does not address performance characterization of the solutions. In order for content providers and the rest of the ecosystem to be able to select and configure the technologies defined in TS 26.118 and to generate content for streaming applications, collecting such information would be most valuable.

COMMITTEE: 3GPP S4

PUBLISHED: 2022-04

URL: <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3685>

## Technical specification | 3GPP TS 26.118 V18.0.0 Virtual Reality (VR) profiles for streaming applications

The present document defines interoperable formats for Virtual Reality for streaming services. Specifically, the present document defines operation points, media profiles and presentation profiles for Virtual Reality. The present document builds on the findings and conclusions in TR 26.918.

COMMITTEE: 3GPP S4

PUBLISHED: 2023-03

URL: <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3325>

## Technical specification | 3GPP TS 26.119 V0.2.0 Media Capabilities for Augmented Reality

The present document defines the supported media formats, codecs, processing functions and guaranteed minimum performances per AR device category. The present document addresses the interoperability gaps identified in the conclusions of TS 26.998.

COMMITTEE: 3GPP S4

PUBLISHED: 2023-06

URL: <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=4038>

## Technical specification | 3GPP TS 26.918 V17.0.0 Virtual Reality (VR) media services over 3GPP

The scope of the present document is to investigate the relevance of Virtual Reality in the context of 3GPP. Virtual Reality is the ability to be virtually present in a non-physical world created by the rendering of natural and/or synthetic image and sound correlated by the movements of the immersed user allowing to interact with that world. With recent progress made in rendering devices, such as Head mounted displays (HMD), a significant quality of experience can be offered. By collecting comprehensive information on VR use cases, existing technologies and subjective quality, the report attempts to identify potential gaps and relevant interoperability points that may require further work and potential standardization in 3GPP in order to support VR use cases and experiences in 3GPP user services. The report primarily focuses on 360 degrees video and associated audio, which support three degrees of freedom (3DOF).

COMMITTEE: 3GPP S4

PUBLISHED: 2022-04

URL: <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3053>

## Technical specification | 3GPP TS 26.929 V17.0.0 QoE parameters and metrics relevant to the Virtual Reality (VR) user experience

The present document provides a study on the QoE metrics relevant to VR service. The study focuses on:

1. Defining a device reference model for VR QoE measurement points.
2. Studying key performance indicators that may impact the experience of VR service.
3. Identifying the existing QoE parameters and metrics defined in SA4 standards such as TS 26.247, TS 26.114 which are relevant to Virtual Reality user experience;
4. Identifying and defining new QoE parameters and metrics relevant to Virtual Reality user experience, taking into consideration the use cases listed in TR 26.918, and any sources that show the relevance of new metrics, e.g. scientific literature, specifications/solutions from other standard organizations.
5. Analysing potential improvements to the existing QoE reporting so as to better accommodate VR services.
6. Providing recommendations to future standards work in SA4 on the QoE parameters and metrics and, as necessary, coordinate with other 3GPP groups and external SDOs, e.g. MPEG, ITU-T.

COMMITTEE: 3GPP S4

PUBLISHED: 2022-04

URL: <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3327>

## Technical report | ETSI GR ARF 001 V1.1.1 Augmented Reality Framework (ARF); AR standards landscape

The report will identify the role of existing standards relevant to augmented reality and document any interoperability gaps. This activity will analyse the standardization work done around augmented reality in various standards setting organizations.

COMMITTEE: ETSI ISG ARF

PUBLISHED: 2019-04

URL: [https://portal.etsi.org/webapp/workprogram/Report\\_WorkItem.asp?WKI\\_ID=54068](https://portal.etsi.org/webapp/workprogram/Report_WorkItem.asp?WKI_ID=54068)

## Standard | IEEE 1589-2020 Standard for an Augmented Reality Learning Experience Model

Augmented Reality (AR) promises to provide significant boosts in operational efficiency by making information available to employees needing task support in context in real time. To support according implementations of AR training systems, this document proposes an overarching integrated conceptual model that describes interactions between the physical world, the user, and digital information, the context for AR-assisted learning and other parameters of the environment. It defines two data models and their binding to XML and JSON for representing learning activities (also known as employee tasks and procedures) and the learning environment in which these tasks are performed (also known as the workplace). The interoperability specification and standard is presented in support of an open market where interchangeable component products provide alternatives to monolithic Augmented Reality-assisted learning systems. Moreover, it facilitates the creation of experience repositories and online marketplaces for Augmented Reality-enabled learning content. Specific attention was given to reuse and repurposing of existing learning content and catering to 'mixed' experiences combining real world learner guidance with the consumption (or production) of traditional contents such as instructional video material or learning apps and widgets.

COMMITTEE: IEEE C/LTSC

PUBLISHED: 2020-04

URL: <https://standards.ieee.org/ieee/1589/6073/>



## Standard | IEEE 3079-2020 Standard for Head Mounted Display (HMD) Based Virtual Reality (VR) Sickness Reduction Technology

Head-mounted display-based virtual reality sickness-reducing technology is defined.

👤 COMMITTEE: IEEE C/SAB

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📅 PUBLISHED: 2021-04

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🔗 URL: <https://standards.ieee.org/ieee/3079/7283/>

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## Standard | IEEE 3333.1.3-2022 Standard for the Deep Learning-Based Assessment of Visual Experience Based on Human Factors

Measuring quality of experience (QoE) aims to explore the factors that contribute to a user's perceptual experience including human, system, and context factors. Since QoE stems from human interaction with various devices, the estimation should be started by investigating the mechanism of human visual perception. Therefore, measuring QoE is still a challenging task. In this standard, QoE assessment is categorized into two subcategories which are perceptual quality and virtual reality (VR) cybersickness. In addition, deep learning models considering human factors for various QoE assessments are covered, along with a reliable subjective test methodology and a database construction procedure.

👤 COMMITTEE: IEEE C/SAB

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📅 PUBLISHED: 2022-05

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🔗 URL: <https://standards.ieee.org/ieee/3333.1.3/7136/>

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## Standard | IEEE P1918.1 Draft Standard for Tactile Internet: Application Scenarios, Definitions and Terminology, Architecture, Functions, and Technical Assumptions

This standard defines a framework for the Tactile Internet, including descriptions of various application scenarios, definitions and terminology, functions, and technical assumptions. This framework prominently also includes a reference model and architecture, which defines common architectural entities, interfaces between those entities, and the mapping of functions to those entities. The Tactile Internet encompasses mission critical applications (e.g., manufacturing, transportation, healthcare and mobility), as well as non-critical applications (e.g., edutainment and events).

👤 COMMITTEE: IEEE COM/MobiNet-SC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/1918.1/6721/>

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## Standard | IEEE P2048.101 Draft Standard for Augmented Reality on Mobile Devices: General Requirements for Software Framework, Components, and Integration

This standard specifies the general technical framework, components, integration, and main business processes of augmented reality systems applied to mobile devices, and defines its technical requirements, including functional requirements, performance requirements, safety requirements and corresponding test methods. This standard is applicable to the design, development, and management of augmented reality enabled applications or features of applications on mobile devices.

👤 COMMITTEE: IEEE CTS/MS

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/2048.101/10390/>

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## Standard | IEEE P2888.4 Standard on Architecture for Virtual Reality Disaster Response Training System with Six degrees of Freedom

This standard defines an architecture required to implement a virtual reality system that can simulate responses to possible disasters in physical spaces, where users can actually move around with six degrees of freedom, for training. This reference architecture includes the physical-to-virtual component that transfers sensor data in the physical space to the virtual world, the virtual-to-virtual component that conveys the data between virtual world objects, and the virtual-to-physical component that transfers the simulated responses in the virtual world to actuators in the physical world.

COMMITTEE: IEEE C/SAB

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/2888.4/10471/>

## Standard | IEEE P3079.1 Motion to Photon (MTP) Latency in Virtual Environments

This standard specifies the requirements and test methods for the motion to photon (MTP) latency that causes virtual reality (VR) sickness while users are using the virtual reality content. This standard is applicable to VR content related with software, hardware, and human factors regarding MTP latency.

COMMITTEE: IEEE C/SAB

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/3079.1/10383/>

## Standard | IEEE P3079.2 Mixed Reality (MR) Standard Framework for Motion Learning

This standard defines a framework for mixed reality content aimed at effective motion learning, including terms and definitions, requirements and data formats. Mechanisms to synchronize the motion sensor and projector coordinate system are defined. Motion acquisition methods, application programming interfaces and user interfaces are described.

COMMITTEE: IEEE C/SAB

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/3079.2/10384/>

## Standard | IEEE P3079.2.1 Standard for a Basic Framework for Motion Training System

This standard defines the basic framework within the overall architectural framework for motion training systems. This standard includes definitions for the functions and input/output interfaces of each component module, and the related data components and formats. To utilize this standard basic framework, various application-specific user interface/user experience (UI/UX) and service frameworks are specified. The meaning of “motion training” includes:

Human gestures and postures

Animated human gestures and postures

Expressions of human body animation for Virtual Reality (VR) and Mixed Reality (MR).

COMMITTEE: IEEE C/SAB

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/3079.2.1/10841/>

## Recommended Practice | IEEE P7030 Recommended Practice for Ethical Assessment of Extended Reality (XR) Technologies

This standard establishes a uniform set of definitions, and a methodology to assess the socio-technical considerations and practices regarding (“XR”) Extended Reality (Augmented Reality, Virtual Reality, Immersive Web and Spatial Web technologies) where this methodology shapes the positive design of XR systems. The Standard provides the following:

- a) a high-level overview of the technical and socio-technical aspects of XR;
- b) a set of XR definitions and classifications based on existing XR research and application verticals;
- c) a standardized definition of ethical assessment methodologies of XR products, services and systems; and
- d) a high-level ethical (where “ethical” is defined as “Supporting the realization of positive values or the reduction of negative values”) assessment methodology for the design of XR products, services, or systems.

The applied ethical approach utilizes IEEE’s Ethically Aligned Design (EAD). “Positive” is defined as the support of improved human flourishing” (or “human wellbeing and environmental flourishing.”)

👤 COMMITTEE: IEEE SSIT/SC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/7030/10799/>

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## Standard | 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

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.

NOTE 1: This document assumes the images are viewed under appropriate defined conditions. See Annex B for the appropriate viewing conditions.

NOTE 2: This document is useful for the design, development, and supply of image contents, as well as electronic displays for reducing VIMS.

NOTE 3 ISO 9241-392[3] provides guidelines for stereoscopic 3D displays, of which the methods are also used in HMDs.

NOTE 4 The International Telecommunication Union (ITU) generally sets the standards for broadcasting.

🔗 ENABLERS: Interaction, User Acceptance & Values

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👤 COMMITTEE: ISO TC 159 SC 4

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📅 PUBLISHED: 2020-04

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🔗 URL: <https://www.iso.org/standard/73227.html>

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## Standard | ISO 9241-910:2011 Ergonomics of human-system interaction Part 910: Framework for tactile and haptic interaction

ISO 9241-910:2011 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. It does not address purely kinaesthetic interactions, such as gestures, although it might be useful for understanding such interactions.

🔗 ENABLERS: Interaction, User Acceptance & Values

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👤 COMMITTEE: ISO TC 159 SC 4

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📅 PUBLISHED: 2011-07

🔗 URL: <https://www.iso.org/standard/51097.html>

## Standard | ISO 9241-920:2009 Ergonomics of human-system interaction Part 920: Guidance on tactile and haptic interactions

ISO 9241-920:2009 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; interaction techniques. It does not provide recommendations specific to Braille, but can apply to interactions that make use of Braille. The recommendations given in ISO 9241-920:2009 are applicable to at least the controls of a virtual workspace, but they can also be applied to an entire virtual environment — consistent, in as far as possible, with the simulation requirements.

⚙️ ENABLERS: Interaction, User Acceptance & Values

👥 COMMITTEE: ISO TC 159 SC 4

📅 PUBLISHED: 2009-03

🔗 URL: <https://www.iso.org/standard/42904.html>

## Standard | ISO 9241-940:2017 Ergonomics of human-system interaction Part 940: Evaluation of tactile and haptic interactions

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). It applies to the following types of interaction: augmented reality information overlaid on a real scene, e.g. vibrating belt indicating distance; gesture control of a device or a virtual scenario; unidirectional interaction such as a vibrating phone or a vibrating belt; virtual environment virtual space with which a user can interact with the aid of a haptic device. This document applies to the following types of devices: gesture sensor, e.g. video that discerns 3D hand movements, touch screens that sense 2D touches; kinaesthetic haptic device, e.g. desktop haptic interface; tactile display, e.g. vibrating phone. This document is not applicable to standard input devices such as keyboards, mice or track balls.

NOTE: ISO 9241-400 covers standard input devices, and ISO 9241-411 applies to the evaluation of input devices such as keyboards and mice. This document can be used to identify the types of methods and measures for:

- ▶ establishing benchmarks
- ▶ establishing requirements for haptic interaction
- ▶ identifying problems with haptic interaction (formative evaluation), and
- ▶ use of the criteria to establish whether a haptic system meets requirements (summative evaluation).

⚙️ ENABLERS: Interaction, User Acceptance & Values

👥 COMMITTEE: ISO TC 159 SC 4

📅 PUBLISHED: 2017-11

🔗 URL: <https://www.iso.org/standard/61362.html>

## Standard | ISO/IEC 14772-2:2004 Information technology Computer graphics and image processing The Virtual Reality Modeling Language (VRML) Part 2: External authoring interface (EAI)

ISO/IEC 14772-1, the Virtual Reality Modeling Language (VRML), defines a file format that integrates 3D graphics and multimedia. Conceptually, each VRML file is a 3D time-based space that contains graphic and aural objects that can be dynamically modified through a variety of mechanisms. This part of ISO/IEC 14772 defines the interface that applications external to the VRML browser may use to access and manipulate the objects defined in ISO/IEC 14772-1. The interface described here is designed to allow an external environment to access nodes in a VRML scene using the existing VRML event model. In this model, an eventOut of a given node can be routed to an eventIn of another node. When the eventOut generates an event, the eventIn is notified and its node processes that event. Additionally, if a script in a Script node has a reference to a given node it can send events directly to any eventIn of that node and it can read the last value sent from any of its eventOuts. The scope of this standard is to cover all forms of access to a VRML browser from external applications. It is equally valid for a database with a object interface to access a standalone browser in a presentation slide as it is for a Java applet operating within a web browser and the available services do not vary. This standard does not provide a byte level protocol description as there can be many valid ways of expressing an interaction with a browser. Instead, it represents the interface in terms of the services provided and the parameters that are passed to access these services. Individual language and protocol bindings to these services are available as annexes to this part of ISO/IEC 14772.

🏢 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2004-03

🔗 URL: <https://www.iso.org/standard/30893.html>

## Standard | ISO/IEC 18023-2:2006 SEDRIS (Synthetic Environment Data Representation and Interchange Specification) Part 2: Abstract transmittal format

ISO/IEC 18023-2:2006 specifies the abstract syntax of a SEDRIS transmittal. Actual encodings (e.g. binary encoding) are specified in other parts of ISO/IEC 18023.

🏢 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2006-07

🔗 URL: <https://www.iso.org/standard/39352.html>

## Standard | ISO/IEC 18023-3:2006 SEDRIS (Synthetic Environment Data Representation and Interchange Specification) Part 3: Transmittal format binary encoding

ISO/IEC 18023-3:2006 defines a binary encoding for DRM objects specified in ISO/IEC 18023-1 according to the abstract syntax specified in ISO/IEC 18023-2.

🏢 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2006-07

🔗 URL: <https://www.iso.org/standard/39412.html>

## Standard | ISO/IEC 18023-4:2006 SEDRIS (Synthetic Environment Data Representation and Interchange Specification) language bindings Part 4: C

ISO/IEC 18024-4:2006 specifies a language-dependent layer for the C programming language. ISO/IEC 18023-1 specifies a language-independent application program interface (API) for SEDRIS. For integration into a programming language, the SEDRIS API is embedded in a language-dependent layer obeying the particular conventions of that language.

🏢 COMMITTEE: ISO/IEC JTC 1/SC 24

## Standard | 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)

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. This document specifies the following functionalities: a) definitions for an LAE in MAR; b) representation of an LAE; c) representation of properties of an LAE; d) sensing of an LAE in a physical world; e) integration of an LAE into a 2D/3D virtual scene; f) interaction between an LAE and objects in a 2D/3D virtual scene; g) transmission of information related to an LAE in an MAR scene. This document defines a reference model for LAE representation-based MAR applications to represent and to exchange data related to LAEs in a 2D/3D virtual scene in an MAR scene. It does not define specific physical interfaces necessary for manipulating LAEs, that is, it does not define how specific applications need to implement a specific LAE in an MAR scene, but rather defines common functional interfaces for representing LAEs that can be used interchangeably between MAR applications.

⚙️ ENABLERS: Computation

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2019-05

🔗 URL: <https://www.iso.org/standard/70721.html>

## Standard | ISO/IEC 19775-2:2015 Information technology Computer graphics, image processing and environmental data representation Extensible 3D (X3D) Part 2: Scene Access Interface

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.

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

📅 PUBLISHED: 2015-09

🔗 URL: <https://www.iso.org/standard/60500.html>

## Standard | ISO/IEC 19776-1:2015 Information technology Computer graphics, image processing and environmental data representation Extensible 3D (X3D) encodings Part 1: Extensible Markup Language (XML) encoding

ISO/IEC 19775-1:2015, Extensible 3D (X3D), defines a system that integrates 3D graphics and multimedia. Conceptually, each X3D file is a 3D time-based space that contains graphic and aural objects that can be dynamically modified through a variety of mechanisms. This part of ISO/IEC 19776 defines a mapping of the abstract objects in X3D to a specific X3D encoding using the Extensible Markup Language. Each XML-encoded X3D file:

- a. supports all of the purposes of X3D files defined in the X3D abstract specification ISO/IEC 19775; and
- b. encodes X3D constructs in an XML format.

An XML-encoded X3D file may be referenced from files using other X3D encodings and may itself reference other X3D files encoded using other X3D encodings. Such files can only be processed by browsers that conform to all of the utilized X3D encodings.

👥 COMMITTEE: ISO/IEC JTC 1/SC 24

## Standard | ISO/IEC 19776-2 2015 Information technology Computer graphics, image processing and environmental data representation Extensible 3D (X3D) encodings Part 2: Classic VRML encoding

ISO/IEC 19775-2:2015, Extensible 3D (X3D), defines a system that integrates 3D graphics and multimedia. Conceptually, each X3D file is a 3D time-based space that contains graphic and aural objects that can be dynamically modified through a variety of mechanisms. This part of ISO/IEC 19776 defines a mapping of the abstract objects in X3D to a specific encoding using the technique defined in ISO/IEC 14772 ? Virtual reality modeling language (VRML). Each Classic VRML-encoded X3D file:

- a. supports all of the purposes of X3D files defined in ISO/IEC 19775; and
- b. encodes X3D constructs in Classic VRML format.

A Classic VRML-encoded X3D file may be referenced from files using other encodings and may itself reference X3D files encoded using other encodings. Such files can only be processed by browsers which conform to all of the utilized encodings.

 COMMITTEE: ISO/IEC JTC 1/SC 24

 PUBLISHED: 2015-12

 URL: <https://www.iso.org/standard/60503.html>

## Standard | ISO/IEC 19776-3:2015 Information technology Computer graphics, image processing and environmental data representation Extensible 3D (X3D) encodings Part 3: Compressed binary encoding

ISO/IEC 19776-3:2015, Extensible 3D (X3D), defines a system that integrates 3D graphics and multimedia. Conceptually, each X3D file is a 3D time-based space that contains graphic and aural objects that can be dynamically modified through a variety of mechanisms. This part of ISO/IEC 19776 defines a mapping of the abstract objects in X3D to a specific X3D encoding written out in a compact binary form. Each X3D file encoded using the Compressed binary encoding:

- a. supports all of the purposes of X3D files defined in the X3D abstract specification ISO/IEC 19775; and
- b. encodes X3D constructs in a compressed binary format, taking advantage of geometric and information-theoretic compression techniques.

X3D files encoded using the Compressed binary encoding may be referenced from files using other X3D encodings, and may itself reference other X3D files encoded using other X3D encodings. Sets of X3D files that use multiple encodings can only be processed by browsers that support all of the utilized X3D encodings.

 COMMITTEE: ISO/IEC JTC 1/SC 24

 PUBLISHED: 2015-10

 URL: <https://www.iso.org/standard/60504.html>

## Standard | ISO/IEC CD 9234 Information modeling for VR/AR/MR based education and training systems

This document describes guidelines for developing education and training systems using VR/AR/MR technology. It defines VR/AR/MR based information modelling that can be used for education and training systems. It provides procedures and methods to be used when developing 3D VR/AR/MR based education and training systems using ISO/IEC JTC 1 standards. It also provides a systematic approach to developing VR/AR/MR based applications for systems integration areas. This work will:

- define concepts of VR/AR/MR based education and training.
- define an information modelling architecture for VR/AR/MR based education and training systems.
- specify standards based functional components for VR/AR/MR based education and training systems.



specify framework components for implementing VR/AR/MR based education and training systems. include use cases for VR/AR/MR based education and training systems based on the information modelling architecture.

Device hardware technology for VR/AR/MR based education and training systems is excluded from this draft.

COMMITTEE: ISO/IEC JTC 1/SC 24

PUBLISHED: under development

URL: <https://www.iso.org/standard/83436.html>

## Technical report | ISO/IEC TR 23842-1:2020 Information technology for learning, education and training Human factor guidelines for virtual reality content Part 1: Considerations when using VR content

This document presents considerations for using VR content in the learning, education and training (LET) domain for reducing reality and virtual reality crossover confusion among users and assisting users to effectively use these emerging technologies. This document addresses VR content that uses a head-mounted display (HMD) in the LET domain. It does not address VR content using immersive technology and does not address augmented reality, mixed or merged reality content.

ENABLERS: Interaction

COMMITTEE: ISO/IEC JTC 1/SC 36

PUBLISHED: 2020-10

URL: <https://www.iso.org/standard/77140.html>

## Standard | ISO/IEC TR 23843:2020 Information technology for learning, education and training Catalogue model for virtual, augmented and mixed reality content

This document describes how to search for virtual reality (VR), augmented reality (AR) and mixed reality (MR) content through a curriculum catalogue based on curriculum and achievement standards information. The curriculum catalogue metadata is defined in order to search for educational VR and MR content information.

ENABLERS: Accessibility, Inclusivity, Interaction, Usability

COMMITTEE: ISO/IEC JTC 1/SC 36

PUBLISHED: 2020-10

URL: <https://www.iso.org/standard/77143.html>

## Standard | ISO/IEC/IEEE 12207:2017 Systems and software engineering Software life cycle processes

ISO/IEC/IEEE 12207:2017 also provides processes that can be employed for defining, controlling, and improving software life cycle processes within an organization or a project.

The processes, activities, and tasks of this document can also be applied during the acquisition of a system that contains software, either alone or in conjunction with ISO/IEC/IEEE 15288:2015, Systems and software engineering?System life cycle processes.

In the context of this document and ISO/IEC/IEEE 15288, there is a continuum of human-made systems from those that use little or no software to those in which software is the primary interest. It is rare to encounter a complex system without software, and all software systems require physical system components (hardware) to operate, either as part of the software system-of-interest or as an enabling system or infrastructure. Thus, the choice of whether to apply this document for the software life cycle processes, or ISO/IEC/IEEE 15288:2015, Systems and software engineering system life cycle processes, depends on the system-of-interest. Processes in both documents have the same process purpose



and process outcomes, but differ in activities and tasks to perform software engineering or systems engineering, respectively.

⚙️ ENABLERS: Ethics, Safety, Sustainability

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👥 COMMITTEE: ISO/IEC JTC 1/SC 7

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📅 PUBLISHED: 2017-11

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🔗 URL: <https://www.iso.org/standard/63712.html>

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### Technical report | ISO/TR 9241-380:2022 Ergonomics of human-system interaction Part 380: Survey result of HMD (Head-Mounted Displays) characteristics related to human-system interaction

This document provides information based on a study of the characteristics of head-mounted displays (HMDs) regarding the ergonomics of human-system interaction. Although this document covers the broad range of ergonomics issues that arise, it specifically provides more-detailed information about the visual aspects of the interaction, and it provides information that could form the basis for future possible standards related to HMDs.

NOTE: It is preferable to take systematic approach to consider characteristics of HMD, since HMD affects a viewer not only by visual aspects, but also by some other physical aspects.

⚙️ ENABLERS: Interaction, User Acceptance & Values

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👥 COMMITTEE: ISO TC 159 SC 4

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📅 PUBLISHED: 2022-06

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🔗 URL: <https://www.iso.org/standard/76430.html>

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### Technical report | ISO/TR 9241-393:2020 Ergonomics of human-system interaction Part 393: Structured literature review of visually induced motion sickness during watching electronic images

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. Different aspects of human-system interaction are covered in other parts of the ISO 9241 series (see Annex A).

⚙️ ENABLERS: Interaction, User Acceptance & Values

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👥 COMMITTEE: ISO TC 159 SC 4

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📅 PUBLISHED: 2020-03

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🔗 URL: <https://www.iso.org/standard/73225.html>

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### Technical specification | ISO/TS 9241-430:2021 Ergonomics of human-system interaction Part 430: Recommendations for the design of non-touch gestural input for the reduction of biomechanical stress

This document provides guidance on the design, selection and optimization of non-contacting hand and arm gestures for human-computer interaction. It addresses the assessment of usability and fatigue associated with different gesture set designs and provides recommendations for approaches to evaluating the design and selection of gestures. This document also provides guidance on the documentation of the process for selecting gesture sets. This document applies to gestures expressed by humans. It does not consider the technology for detecting gestures or the system response when interpreting a gesture. Non-contacting hand gestures can be used for input in a variety of settings, including the workplace or in public settings and when using fixed screens, mobile, virtual reality, augmented reality or mixed-mode reality devices.

⚙️ ENABLERS: Interaction, User Acceptance & Values

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## OTHER

Technical report | ETSI GR ARF 002 V1.1.1 Augmented Reality Framework (ARF); Industrial use cases for AR applications and services [see details]

Standard | IEEE 1857.9-2021 Standard for Immersive Visual Content Coding [see details]

Standard | ISO 32000-1:2008 Document management Portable document format Part 1: PDF 1.7 [see details]

Standard | ISO/IEC 12113:2022 Information technology Runtime 3D asset delivery format Khronos glTF™ 2.0 [see details]

Standard | ISO/IEC 14772-1:1997 Information technology Computer graphics and image processing The Virtual Reality Modeling Language Part 1: Functional specification and UTF-8 encoding [see details]

Standard | ISO/IEC 18038:2020 Information technology Computer graphics, image processing and environmental representation Sensor representation in mixed and augmented reality [see details]

Standard | ISO/IEC 19775-1:2013 Information technology Computer graphics, image processing and environmental data representation Extensible 3D (X3D) Part 1: Architecture and base components [see details]

Standard | ISO/IEC DIS 3721-1 Information model for MAR (Mixed and Augmented Reality) contents [see details]

Technical specification | ISO/IEC TS 23884:2021 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) [see details]

Standard | ISO/IEC DIS 5927 Augmented and Virtual Reality safety Guidance on safe immersion, setup and usage [see details]

Standard | ISO/IEC 23488:2022 Information technology Computer graphics, image processing and environment data representation Object/environmental representation for image-based rendering in virtual/mixed and augmented reality (VR/MAR) [see details]

Standard | ISO/IEC 23090-5:2023 Information technology Coded representation of immersive media Part 5: Visual volumetric video-based coding (V3C) and video-based point cloud compression (V-PCC) [see details]

Standard | ISO/IEC 23005-4:2018 Information technology Media context and

control Part 4: Virtual world object characteristics [see details]

Standard | ISO/IEC 19777-1:2006-Information technology Computer graphics and image processing Extensible 3D (X3D) language bindings Part 1: ECMAScript [see details]

Standard | ISO/IEC 19777-2:2006-Information technology Computer graphics and image processing Extensible 3D (X3D) language bindings Part 2: Java [see details]

Standard | 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) [see details]

Standard | ISO/IEC 18025:2014 Information technology Environmental Data Coding Specification (EDCS) [see details]

Standard | ISO 16792:2021 Technical product documentation Digital product definition data practices [see details]

Technical report | ETSI TR 103 957 V0.0.3 Cyber Security (CYBER); Extended Reality Cyber Security Analysis [see details]

Technical report | ETSI TR 126 928 V16.1.0 Extended Reality (XR) in 5G (3GPP TR 26.928 version 16.1.0 Release 16) [see details]

Technical report | ETSI TR 126 998 V17.1.0 Support of 5G glass-type Augmented Reality / Mixed Reality (AR/MR) devices (3GPP TR 26.998 version 17.1.0 Release 17) [see details]

Technical report | ETSI TR 126 999 V17.0.0 5G; LTE; Virtual Reality (VR) streaming interoperability and characterization [see details]

Technical specification | ETSI GS ARF 003 V1.1.1 Augmented Reality Framework (ARF); AR framework architecture [see details]

Technical specification | ETSI GS ARF 004-5 V1.1.1 Augmented Reality Framework (ARF); Interoperability Requirements for AR components, systems and services; Part 5: External Communications [see details]

Technical specification | ETSI GS ARF 005 V1.1.1 Augmented Reality Framework (ARF); Open APIs for the Creation and Management of the World Representation [see details]

Standard | ISO/IEC 18039:2019 Information technology Computer graphics, image processing and environmental data representation Mixed and augmented reality (MAR) reference model [see details]

### 4.6.3 Metaverse

#### Standard | IEEE P2048 Standard for Metaverse: Terminology, Definitions, and Taxonomy

This standard specifies the terminology, definitions, and taxonomy for metaverse and related terms. This standard defines categories and levels of metaverse to provide clarification for metaverse users and a roadmap for metaverse developers.

COMMITTEE: IEEE CTS/MSC

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/2048/11169/>

#### Standard | IEEE P3812.1 Draft Standard for General Requirements for Identity Framework for Metaverse

This standard defines the requirements of an identity framework for metaverse. This standard provides an identity framework for use across different metaverse systems. Furthermore, the standard helps to recognize the relevance between real world and virtual world entities. The standard covers business logic, operational procedures, and authentication programs. Also, the standard defines terminologies, a basic architectural framework, and key indicators.

COMMITTEE: IEEE CTS/DFESC

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/3812.1/11168/>

#### Standard | IEEE P7016 Standard for Ethically Aligned Design and Operation of Metaverse Systems

This standard defines a methodology for creating possible Metaverse systems. A description of the techno-socio aspects of Metaverse systems is provided, together with a high level ethical assessment methodology for the design and operation of Metaverse systems.

COMMITTEE: IEEE SSIT/SC

PUBLISHED: under development

URL: <https://standards.ieee.org/ieee/7016/11078/>

#### Technical specification | MPAI-MMM V1 MPAI Metaverse Model

Technical Specification: MPAI Metaverse Model (MPAI-MMM) – Architecture specifies Terms and Definitions; Operation Model; Functional Requirements of Processes, Actions, Items, and Data Types; and Functional Profiles enabling Interoperability of two or more metaverse instances (M-Instances) if they rely on the Operation Model, and use the same Profile Architecture, and either the same technologies, or independent technologies while accessing Conversion Services that losslessly transform Data of an M-Instance(A) to Data of an M-Instance(B).

COMMITTEE: MPAI Community

PUBLISHED: 2023-09

URL: <https://mpai.community/standards/mpai-mmm/>

## OTHER

Standard | ISO/IEC 23090-5:2023 Information technology Coded representation of immersive media Part 5: Visual volumetric video-based coding (V3C) and video-based point cloud compression (V-PCC) [see details]

Standard | ISO/IEC 23000-13:2017 Information technology Multimedia application format (MPEG-A) Part 13: Augmented reality application format [see details]

Standard | ISO/IEC 23005-2:2018 Information technology Media context and control Part 2: Control information [see details]

Standard | ISO/IEC 23005-3:2019 Information technology Media context and control Part 3: Sensory information [see details]

Standard | ISO/IEC 23005-5:2019 Information technology Media context and control Part 5: Data formats for interaction devices [see details]

Standard | ISO/IEC 23005-6:2019 Information technology Media context and control Part 6: Common types and tools [see details]

Standard | ISO/IEC 23090-9:2023 Information technology Coded representation of immersive media Part 9: Geometry-based point cloud compression [see details]

Standard | ISO/IEC AWI 23090-29 Information technology Coded representation of immersive media Part 29: Video-based dynamic mesh coding (V-DMC) [see details]

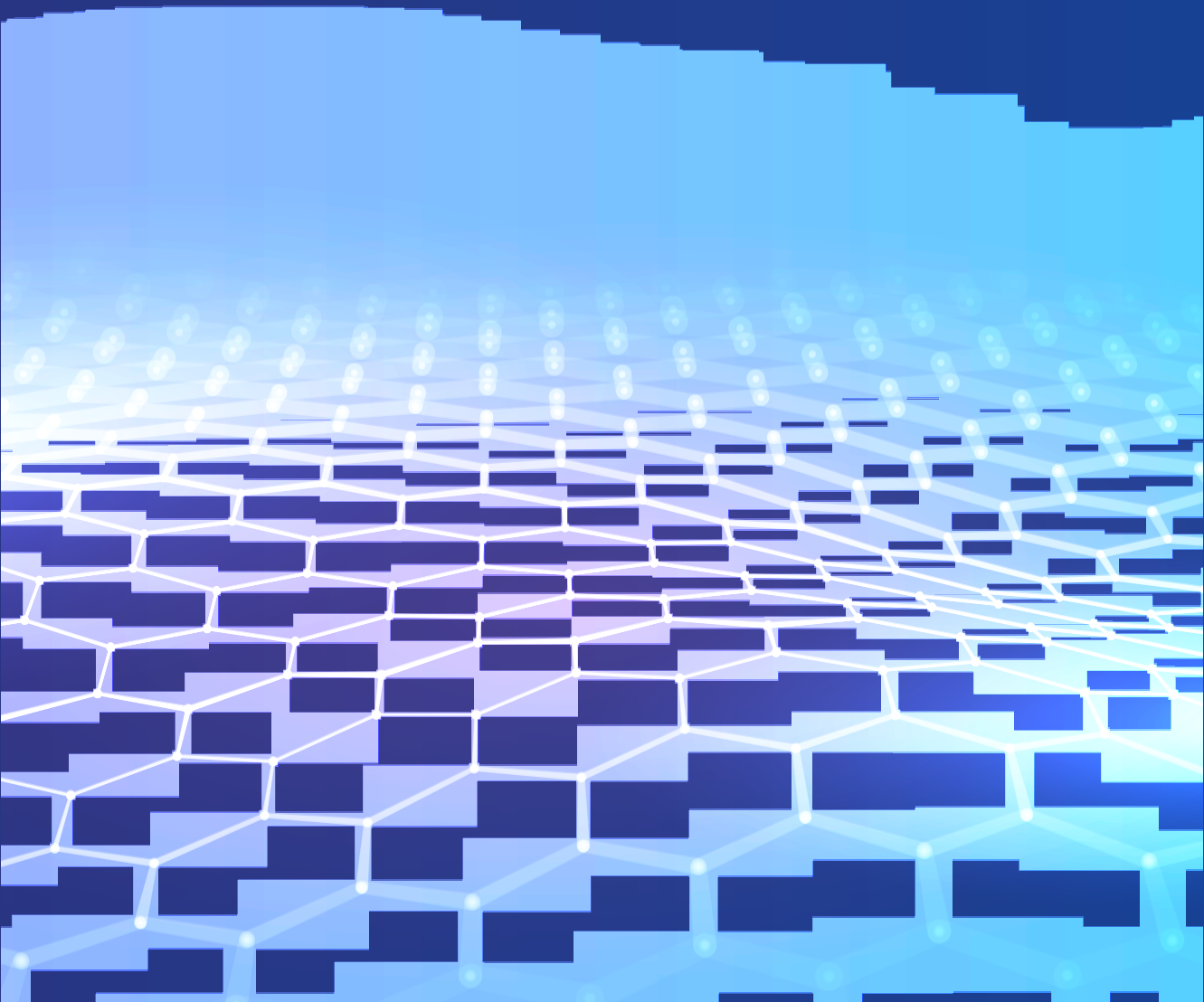
Standard | ISO/IEC AWI 23090-30 Information technology Coded representation of immersive media Part 30: Low latency, low complexity LiDAR coding [see details]

Standard | ISO/IEC DIS 23090-31 Information technology Coded representation of immersive media Part 31: Haptics coding [see details]

Standard | ISO/IEC FDIS 23090-12 Information technology Coded representation of immersive media Part 12: MPEG immersive video [see details]

Standard | ISO/IEC 23005-4:2018 Information technology Media context and control Part 4: Virtual world object characteristics [see details]

# 5. Landscape of Standards - Enablers



## ■ 5.1 People-centric

### 5.1.1 Accessibility

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#### Standard | IEC 62731:2018 Text-to-speech for television General requirements Edition 2.0

IEC 62731:2018 specifies the text-to-speech functionality for a (broadcast) receiver with a text-to-speech system. Such a system may be one device, i.e. a receiver with an integrated text-to-speech generator, or may be two devices, i.e. a receiver interfacing with an external text-to-speech device. This document applies only to completely functional stationary (or semi-stationary) digital TV receivers such as set top boxes, integrated digital TVs, recorders and other products whose primary function is to receive TV content. Where this document refers to TV, this will be shorthand for all such receivers.

This document does not apply to products that are capable of receiving TV as a secondary function (e.g. PCs or game consoles with digital television receivers). It also does not apply to sub-assemblies (e.g. PC tuner cards).

This edition includes the following significant technical changes with respect to the previous edition:

- a) in 6.2, the levels of announcement quality were revised as well as considerations for ways in which device users can provide service providers with feedback on incorrectly announced terms.
- b) in 6.3, the following TV functionality was added: the TV can receive updated words, associated conversions and updated conversion rules for the TTS engine via a network connection.

👥 COMMITTEE: IEC TC 100/TA 16

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📅 PUBLISHED: 2018-01

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🔗 URL: <https://webstore.iec.ch/publication/27131>

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#### Standard | IEC 62944:2016 Audio, video and multimedia systems and equipment Digital television accessibility Functional specifications Edition 1.0

IEC 62944:2016 specifies a set of principles and considerations for digital television products in support of older people and persons with disabilities in addition to mainstream users. The effect of following the principles and considerations as set out in this document is to ensure that the widest range of users can access, understand and use digital television products. These principles and considerations cover four main user profiles such as individuals with hearing impairments, individuals with sight impairments, individuals with mobility impairments and individuals with cognitive impairments.

👥 COMMITTEE: IEC TC 100/TA 16

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📅 PUBLISHED: 2016-12

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🔗 URL: <https://webstore.iec.ch/publication/29772>

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#### Standard | IEC 63080:2017 Accessibility terms and definitions Edition 1.0

IEC 63080:2017 contains a list of currently used terminology to describe accessibility and terms that writers of standards need when writing and designing International Standards. It is important to standardize and define a recognized list of the terms already used and in existing ITU Recommendations and Resolutions, along with those in the UN Convention on the Rights of Persons with Disabilities (UNCRPD). Without such a list, there could be confusion not only on the part of writers and implementers of standards, but also by the public at large. It is also important to eliminate terminology that is no longer used, offensive, and demeaning to persons with disabilities (PWD) and others.

👥 COMMITTEE: IEC TC 100/TA 16

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 PUBLISHED: 2017-07

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 URL: <https://webstore.iec.ch/publication/30052>

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## Standard | IEC 63087-1:2021 Assistive listening devices and systems for active assisted living Part 1: General

IEC 63087-1:2021 specifies requirements, and the associated methods of measurement, for the electroacoustic performance of personal listening systems.

This document specifies requirements for the provision of assistive listening in audio, video and multimedia systems and equipment. The requirements are of different kinds, because of the diversity of the hardware concerned. Existing IEC standards for methods of measurement are normatively referenced if they exist. Methods of measurement and performance requirements are specified in IEC 63087-2.

This document does not apply to hearing aids. Also excluded are devices entirely worn on or in the ear, which cannot be measured independently.

 COMMITTEE: IEC TC 100/TA 16

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 PUBLISHED: 2021-08


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 URL: <https://webstore.iec.ch/publication/28388>

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## Technical report | IEC TR 63071:2016 Power supplying scheme for wearable system and equipment Edition 1.0

IEC TR 63071:2016(E) provides models and frameworks for the power-supplying scheme for wearable systems and equipment. This document does not specify power generating or energy harvesting methods and the devices themselves.

 COMMITTEE: IEC TC 100/TA 16

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 PUBLISHED: 2016-12

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 URL: <https://webstore.iec.ch/publication/33300>

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## Technical report | IEC TR 63481 ED1 Accessibility Goals and Needs with an exemplar of use with a household voice control system

This Technical Report (TR) provides information on accessibility and usability terms, and discusses approaches to making a product or service accessible and usable. Comments about demographics and public policies are included. A table of key international and regional standardisation activities is included and an annex provides additional details of specific standards. The accessibility goals from Guide 71 are reviewed together with information on how to use the user needs that can be identified in conjunction with these eleven accessibility goals.

An example of using the process of identifying user accessibility needs for a Voice Control System is provided. Different industry experts can choose to apply different parts of this information when they evaluate opportunities to integrate support for accessibility and usability in their work.

 COMMITTEE: IEC TC 100/TA 16

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 PUBLISHED: under development

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 URL: [https://www.iec.ch/dyn/www/?p=103:38:401021447303193:::FSP\\_ORG\\_ID,FSP\\_APEX\\_PAGE,FSP\\_PROJECT\\_ID:11009,23,107702](https://www.iec.ch/dyn/www/?p=103:38:401021447303193:::FSP_ORG_ID,FSP_APEX_PAGE,FSP_PROJECT_ID:11009,23,107702)

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## Standard | ISO/IEC 20071-23:2018 Information technology User interface component accessibility Part 23: Visual presentation of audio information (including captions and subtitles)

This document provides guidance for producers, exhibitors, and distributors on the visual presentation of alternatives to audio information in audiovisual content, such as captions/subtitles.

This document provides requirements and recommendations that are intended to support users who are not able to use the audio information, prefer to use a visual representation of audio information, or prefer both audio and visual presentations.

NOTE Many users do not have a choice, for instance, when in a noisy environment (e.g. bar, restaurant, etc.). In these situations, the user does not select a visual presentation of audio information but is offered the content with captions/subtitles.

This document acknowledges the various needs and preferences of viewers (end users) as well as the different approaches to visual presentation of audio information. It applies to all presentations of visual alternatives to audio information intended to be presented as captions/subtitles.

This document does not apply to the presentation devices or transmission mechanisms used to deliver the content or visual presentations of audio information. These devices could include, but are not limited to: televisions, computers, wireless devices, projection equipment, DVD and home cinema equipment, video game consoles, and other forms of user interfaces technology. This document does not apply to transcoding files and formats for the various video outputs.

This document gives guidance on visual presentations which are delivered in the same language as in the audio (i.e., intra-lingual captions/subtitles) and visual presentations which are translated into a different language (i.e., inter-lingual captions/subtitles). This document does not apply to the specific process of language translation.

This document helps to improve accessibility. This document does not establish requirements on specific industries (e.g. television broadcasting, motion pictures) nor is it intended to supersede specific international standards within their domain.

👥 COMMITTEE: ISO/IEC JTC 1/SC 35

📅 PUBLISHED: 2018-09

🔗 URL: <https://www.iso.org/standard/70722.html>

## Standard | ISO/IEC 20071-5:2022 Information technology User interface component accessibility Part 5: Accessible user interfaces for accessibility settings on information devices

This document specifies requirements and recommendations for making accessibility settings accessible and usable. It provides guidance on specific accessibility settings, saving settings and modifying settings. It specifies how to access and operate the accessibility setting mode, and how to directly activate specific accessibility features.

This document applies to all operating system user interfaces on all types of information and communications technologies (ICTs) from the point where the operating system is fully functional and waiting for the user to interact with it.

This document does not apply to:

- ▷ storing and retrieving information from a stored user profile, including personally identifiable information;
- ▷ accessibility of the closed functionality that does not support access by assistive technology;
- ▷ accessibility of boot mode.

👥 COMMITTEE: ISO/IEC JTC 1/SC 35

📅 PUBLISHED: 2022-05

🔗 URL: <https://www.iso.org/standard/78040.html>

## Standard | ISO/IEC 23859:2023 Information technology User interfaces Requirements and recommendations on making written text easy to read and understand

This document provides requirements and recommendations on all written text so that it is easy to read and understand in any user interface, regardless of its format.

This document addresses the process of creation, adaptation and evaluation of written text that is easy to read and understand.

This document does not consider devices or transmission mechanisms used to deliver written text. It does not provide language-specific guidance.

COMMITTEE: ISO/IEC JTC 1/SC 35

PUBLISHED: 2023-07

URL: <https://www.iso.org/standard/77178.html>

## Standard | ISO/IEC 29138-1:2018 Information technology User interface accessibility Part 1: User accessibility needs

This document identifies a collection of user accessibility needs that diverse users have of ICT systems to make these systems accessible to them. Each user accessibility need might be required of a system by an individual. Different users can have different sets of user accessibility needs in different contexts.

While this set of user accessibility needs was developed for the domain of ICT, many of the user accessibility needs in this set also apply in other domains.

This document does not provide requirements or specific processes and methods for the application and evaluation of user accessibility needs. However, it could inform the development of such requirements.

This document is not designed for certification purposes or regulatory or contractual use.

The user accessibility needs in this document are intended to inform and encourage those responsible for accessibility to go beyond the minimum provisions of accessibility legislation and regulations.

COMMITTEE: ISO/IEC JTC 1/SC 35

PUBLISHED: 2018-11

URL: <https://www.iso.org/standard/71953.html>

## Standard | ISO/IEC 30071-1:2019 Information technology Development of user interface accessibility Part 1: Code of practice for creating accessible ICT products and services

This document takes a holistic approach to the accessibility of information and communications technology (ICT) by combining guidance on implementing the accessibility of ICT systems (ICT accessibility) both at organizational and system development levels.

This document gives guidelines for building and maintaining ICT systems (including products and services) that are accessible to diverse users (including users with disabilities and older people).

This document is applicable to all types of organizations. This document applies to the breadth of ICT systems and the results of convergent and emerging technologies within an organization including, but not limited to: information systems; intranet systems; websites; mobile and wearable applications; social media; and Internet of Things (IoT) systems.

It gives requirements and recommendations for organizations:

- a) ensuring accessibility is considered in their policies or strategy by creating an organizational ICT accessibility policy;
- b) embedding the consideration of accessibility decisions through the entire process of developing procuring, installing, operating and maintaining ICT systems, and documenting these choices;
- c) justifying decisions on accessibility;
- d) communicating the ICT system's accessibility decisions to its users at launch, through creating and publishing its accessibility statement.

COMMITTEE: ISO/IEC JTC 1/SC 35

PUBLISHED: 2019-05

URL: <https://www.iso.org/standard/70913.html>

## Standard | ISO/IEC 40500:2012 Information technology W3C Web Content Accessibility Guidelines (WCAG) 2.0

ISO/IEC 40500:2012 [Web Content Accessibility Guidelines (WCAG) 2.0] covers a wide range of recommendations for making Web content more accessible. Following these guidelines will make content accessible to a wider range of people with disabilities, including blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movement, speech disabilities, photo-sensitivity and combinations of these. Following these guidelines will also often make your Web content more usable to users in general.

WCAG 2.0 success criteria are written as testable statements that are not technology-specific. Guidance about satisfying the success criteria in specific technologies, as well as general information about interpreting the success criteria, is provided in separate documents.

COMMITTEE: ISO/IEC JTC 1

PUBLISHED: 2012-10

URL: <https://www.iso.org/standard/58625.html>

## Guide | ISO/IEC Guide 71:2014 Guide for addressing accessibility in standards, available as CEN-CENELEC GUIDE 6 Guide for addressing accessibility in standards

ISO/IEC Guide 71:2014 provides guidance to standards developers on addressing accessibility requirements and recommendations in standards that focus, whether directly or indirectly, on systems (i.e. products, services and built environments) used by people. To assist standards developers to define accessibility requirements and recommendations, it presents a summary of current terminology relating to accessibility, issues to consider in support of accessibility in the standards development process, a set of accessibility goals (used to identify user accessibility needs), descriptions of (and design considerations for) human abilities and characteristics, and strategies for addressing user accessibility needs and design considerations in standards.

COMMITTEE: ISO/TMBG

PUBLISHED: 2014-12

URL: <https://www.iso.org/standard/57385.html>

## Technical specification | ISO/IEC TS 20071-25:2017 Information technology User interface component accessibility Part 25: Guidance on the audio presentation of text in videos, including captions, subtitles and other on-screen text

ISO/IEC TS 20071-25:2017 provides recommendations on the audio presentation of captions/subtitles and other on-screen text for use in all type of videos regardless of the language and technology being used to transmit and present the recorded or live video.

ISO/IEC TS 20071-25:2017 applies to making captions/subtitles and other on-screen text accessible to users with various needs, including but not limited to people with learning and reading disabilities, people with cognitive disabilities, people who are blind or have low vision, older people, and non-native language speakers. It does not apply to captions/subtitles or other on-screen text whose content is already provided in the soundtrack in a language and a way users can access.

ISO/IEC TS 20071-25:2017 provides guidance on spoken captions/subtitles as a stand-alone access service but it also provides guidance on how to integrate spoken captions/subtitles, other spoken on-screen text and audio description, if needed, in different types of videos.

NOTE 1 Extensive guidance on audio description is provided in ISO/IEC/TS 20071-21.

ISO/IEC TS 20071-25:2017 does not consider the devices or transmission mechanisms used to deliver and play the content or the audio presentation of text in videos. These devices include, but are not limited to televisions, computers, wireless devices, projection equipment, DVD and home cinema equipment, cinema equipment and other forms of user interfaces technology. Therefore, this document does not consider transcoding files for the various video and audio outputs.

NOTE 2 Technical matters of transmission and distribution are covered by other documents (e.g. MPEG standards and other technical standards such as IEC 62731:2013).

ISO/IEC TS 20071-25:2017 acknowledges the various needs and preferences of users, as well as the different approaches to the audio presentation of text in videos.

It applies to audio presentations intended to be heard simultaneously along with the original video.

COMMITTEE: ISO/IEC JTC 1/SC 35

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PUBLISHED: 2017-02

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URL: <https://www.iso.org/standard/69060.html>

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## OTHER

Standard | ISO/IEC TR 23843:2020 Information technology for learning, education and training Catalogue model for virtual, augmented and mixed reality content [see details]

## 5.1.2 Ethics

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Standard | IEEE 2089-2021 Standard for an Age Appropriate Digital Services Framework Based on the 5Rights Principles for Children

A set of processes by which organizations seek to make their services age appropriate is established in this standard. The growing desire of organizations to design digital products and services with children in mind and reflects their existing rights under the United Nations Convention on the Rights of the Child (the Convention) is supported by this standard. While different jurisdictions may have different laws and regulations in place, the best practice for designing digital services that impact directly or indirectly on children is offered by this standard. It sets out processes through the life cycle of development, delivery and distribution, that will help organizations ask the right relevant questions of their services, identify risks and opportunities by which to make their services age appropriate and take steps to mitigate risk and embed beneficial systems that support increased age appropriate engagement. One in three users online is under 18, which means that this standard has wide application.

COMMITTEE: IEEE CTS/ETSC

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PUBLISHED: 2021-11

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URL: <https://standards.ieee.org/ieee/2089/7633/>

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Standard | IEEE 7000 Standard Model Process for Addressing Ethical Concerns during System Design

A set of processes by which organizations can include consideration of ethical values throughout the stages of concept exploration and development is established by this standard. Management and engineering in transparent communication with selected stakeholders for ethical values elicitation and prioritization is supported by this standard, involving traceability of ethical values through an operational concept, value propositions, and value dispositions in the system design. Processes that provide for traceability of ethical values in the concept of operations, ethical requirements, and ethical risk-based design are described in the standard. All sizes and types of organizations using their own life cycle models are relevant to this standard.

COMMITTEE: IEEE C/S2ESC

PUBLISHED: 2021-09

URL: <https://standards.ieee.org/ieee/7000/6781/>

## Standard | IEEE 7007 Ontological Standard for Ethically Driven Robotics and Automation Systems

A set of ontologies with different abstraction levels that contain concepts, definitions, axioms, and use cases that assist in the development of ethically driven methodologies for the design of robots and automation systems is established by this standard. It focuses on the robotics and automation domain without considering any particular applications and can be used in multiple ways, for instance, during the development of robotics and automation systems as a guideline or as a reference “taxonomy” to enable clear and precise communication among members from different communities that include robotics and automation, ethics, and correlated areas. Users of this standard need to have a minimal knowledge of formal logics to understand the axiomatization expressed in Common Logic Interchange Format.

OTHER ENABLERS: Interoperability

COMMITTEE: IEEE RAS/SC

PUBLISHED: 2021-11

URL: <https://standards.ieee.org/ieee/7007/7070/>

## Recommended Practice | IEEE 7010-2020 Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Well-Being

The impact of artificial intelligence or autonomous and intelligent systems (A/IS) on humans is measured by this standard. The positive outcome of A/IS on human well-being is the overall intent of this standard. Scientifically valid well-being indices currently in use and based on a stakeholder engagement process ground this standard. Product development guidance, identification of areas for improvement, risk management, performance assessment, and the identification of intended and unintended users, uses and impacts on human well-being of A/IS are the intents of this standard.

COMMITTEE: IEEE SMC/SC

PUBLISHED: 2020-05

URL: <https://standards.ieee.org/ieee/7010/7718/>

## OTHER

Standard | IEEE P7008 Standard for Ethically Driven Nudging for Robotic, Intelligent and Autonomous Systems [see details]

Guide | IEEE 1232.3-2014 Guide for the Use of Artificial Intelligence Exchange and Service Tie to All Test Environments [see details]

Framework | IEEE 2807-2022 Framework of Knowledge Graphs Series [see details]

Standard | IEEE 2937-2022 Standard for Performance Benchmarking for AI Server Systems [see details]

Standard | IEEE 2941-2021 Standard for Artificial Intelligence (AI) Model Representation, Compression, Distribution and Management [see details]

Guide | IEEE 3652.1-2020 Guide for Architectural Framework and Application of

Federated Machine Learning [see details]

Recommended Practice | IEEE P2247.4 Recommended Practice for Ethically Aligned Design of Artificial Intelligence (AI) in Adaptive Instructional Systems [see details]

Recommended Practice | IEEE P2863 Recommended Practice for Organizational Governance of Artificial Intelligence [see details]

Standard | IEEE P2874 Standard for Spatial Web Protocol, Architecture and Governance [see details]

Guide | IEEE P2894 Guide for an Architectural Framework for Explainable Artificial Intelligence [see details]

Standard | IEEE P2941.1 Standard for Operator Interfaces of Artificial Intelligence [see details]

Standard | IEEE P2975 Standard for Industrial Artificial Intelligence (AI) Data Attributes [see details]

Standard | IEEE P2976 Standard for XAI eXplainable Artificial Intelligence for Achieving Clarity and Interoperability of AI Systems Design [see details]

Standard | IEEE P3119 Standard for the Procurement of Artificial Intelligence and Automated Decision Systems [see details]

Standard | IEEE P3123 Standard for Artificial Intelligence and Machine Learning Terminology and Data Formats [see details]

Recommended Practice | IEEE P3128 Recommended Practice for The Evaluation of Artificial Intelligence (AI) Dialogue System Capabilities [see details]

Standard | IEEE P3129 Standard for Robustness Testing and Evaluation of Artificial Intelligence (AI)-based Image Recognition Service [see details]

Standard | IEEE P3152 Standard for the Description of the Natural or Artificial Character of Intelligent Communicators [see details]

Standard | IEEE P7014 Standard for Ethical considerations in Emulated Empathy in Autonomous and Intelligent Systems [see details]

Standard | IEEE P7015 Standard for Data and Artificial Intelligence (AI) Literacy, Skills, and Readiness [see details]

Standard | IEEE P7003 Algorithmic Bias Considerations [see details]

Standard | ISO/IEC/IEEE 12207:2017 Systems and software engineering Software life cycle processes [see details]

### 5.1.3 Inclusivity

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#### OTHER

Standard | IEEE P7003 Algorithmic Bias Considerations [see details]

Standard | ISO/IEC TR 23843:2020 Information technology for learning, education and training Catalogue model for virtual, augmented and mixed reality content [see details]

Technical specification | ISO/IEC TS 30149 ED1 Internet of Things (IoT) Trustworthiness Principles [see details]

### 5.1.4 Interaction

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#### OTHER

Recommendation | ITU-T F.746.12 Requirements for a real-time interactive multimedia service under poor network conditions [see details]

Standard | ISO 29481-2:2012 Building information models Information delivery manual Part 2: Interaction framework [see details]

Technical report | ISO/IEC TR 23842-1:2020 Information technology for learning, education and training Human factor guidelines for virtual reality content Part 1: Considerations when using VR content [see details]

Standard | ISO/IEC DIS 5927 Augmented and Virtual Reality safety Guidance on safe immersion, setup and usage [see details]

Standard | 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 [see details]

Standard | ISO 9241-910:2011 Ergonomics of human-system interaction Part 910: Framework for tactile and haptic interaction [see details]

Standard | ISO 9241-920:2009 Ergonomics of human-system interaction Part 920: Guidance on tactile and haptic interactions [see details]

Standard | ISO 9241-940:2017 Ergonomics of human-system interaction Part 940: Evaluation of tactile and haptic interactions [see details]

Technical report | ISO/TR 9241-380:2022 Ergonomics of human-system interaction Part 380: Survey result of HMD (Head-Mounted Displays) characteristics related to human-system interaction [see details]

Technical report | ISO/TR 9241-393:2020 Ergonomics of human-system interaction Part 393: Structured literature review of visually induced motion sickness during watching electronic images [see details]

Technical specification | ISO/TS 9241-430:2021 Ergonomics of human-system interaction Part 430: Recommendations for the design of non-touch gestural input for the reduction of biomechanical stress [see details]

Standard | ISO/IEC TR 23843:2020 Information technology for learning, education and training Catalogue model for virtual, augmented and mixed reality content [see details]

## 5.1.5 Privacy

### Standard | IEEE P7002 IEEE Standard for Data Privacy Process

The requirements for a systems/software engineering process for privacy-oriented considerations regarding products, services, and systems utilizing employee, customer, or other external user's personal data are defined by this standard. Organizations and projects that are developing and deploying products, systems, processes, and applications that involve personal information are candidate users of the IEEE 7002 standard. Specific procedures, diagrams, and checklists are provided for users of the IEEE 7002 standard to perform conformity assessments on their specific privacy practices. Privacy impact assessments (PIAs) are described as a tool for both identifying where privacy controls and measures are needed and for confirming they are in place.

👥 COMMITTEE: IEEE C/S2ESC

📅 PUBLISHED: 2022-04

🔗 URL: <https://standards.ieee.org/ieee/7002/6898/>

### Standard | IEEE P7012 Standard for Machine Readable Personal Privacy Terms

The standard identifies/addresses the manner in which personal privacy terms are proffered and how they can be read and agreed to by machines.

👥 COMMITTEE: IEEE SSIT/SC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/7012/7192/>

### Technical report | Metaverse: Security and Privacy Issues DOI: 10.1109/TPSISA52974.2021.00032. The Third IEEE International Conference on Trust, Privacy and Security in Intelligent Systems, and Applications

The metaverse promises a host of bright opportunities for business, economics, and society. Though, a number of critical aspects are still to be considered and the analysis of their impact is almost non-existent. In this paper, we provide several contributions. We start by analysing the foundations of the metaverse, later we focus on the novel privacy and security issues introduced by this new paradigm, and finally we broaden the scope of the contribution highlighting some of the far-reaching yet logical implications of the metaverse on a number of domains, not all of them in tech. Throughout the paper, we also discuss possible research directions. We believe that the provided holistic view on the foundations, technology, and issues related to the metaverse (with a focus on security and privacy), other than being an interesting contribution on its own, could also pave the way for a few multidisciplinary research avenues.

⚙️ OTHER ENABLERS: Security

👥 CONTRIBUTORS: Roberto Di Pietro, Stefano Cresci

📅 PUBLISHED: 2021-12

🔗 URL: [https://www.researchgate.net/publication/357116743\\_Metaverse\\_Security\\_and\\_Privacy\\_Issues](https://www.researchgate.net/publication/357116743_Metaverse_Security_and_Privacy_Issues)



## OTHER

Recommended Practice | IEEE P7004.1 Recommended Practices for Virtual Classroom Security, Privacy and Data Governance [see details]

Standard | ISO 31700-1:2023 Consumer protection Privacy by design for consumer goods and services Part 1: High-level requirements [see details]

Standard | ISO/IEC 20889:2018 Privacy enhancing data de-identification terminology and classification of techniques [see details]

Standard | ISO/IEC 27551:2021 Information security, cybersecurity and privacy protection Requirements for attribute-based unlinkable entity authentication [see details]

Standard | ISO/IEC 27556:2022 Information security, cybersecurity and privacy protection User-centric privacy preferences management framework [see details]

Standard | ISO/IEC 27559:2022 Information security, cybersecurity and privacy protection Privacy enhancing data de-identification framework [see details]

Standard | ISO/IEC 29100:2011 Information technology Security techniques Privacy framework [see details]

Standard | ISO/IEC 29134:2023 Information technology Security techniques Guidelines for privacy impact assessment [see details]

Standard | ISO/IEC 29184:2020 Information technology Online privacy notices and consent [see details]

Technical report | ISO/IEC TR 27550:2019 Information technology Security techniques Privacy engineering for system life cycle processes [see details]

Technical specification | ISO/IEC TS 27560:2023 Privacy technologies Consent record information structure [see details]

Technical specification | ISO/IEC TS 27570:2021 Privacy protection Privacy guidelines for smart cities [see details]

Technical report | ISO/TR 31700-2:2023 Consumer protection Privacy by design for consumer goods and services Part 2: Use cases [see details]

## 5.1.6 Safety

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### Standard | IEEE P7009 Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems

This standard establishes a practical, technical baseline of specific methodologies and tools for the development, implementation, and use of effective fail-safe mechanisms in autonomous and semi-autonomous systems. The standard includes (but is not limited to): clear procedures for measuring, testing, and certifying a system's ability to fail safely on a scale from weak to strong, and instructions for improvement in the case of unsatisfactory performance. The standard serves as the basis for developers, as well as users and regulators, to design fail-safe mechanisms in a robust, transparent, and accountable manner.

👥 COMMITTEE: IEEE RS/SC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/7009/7096/>

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### OTHER

### Standard | ISO/IEC/IEEE 12207:2017 Systems and software engineering Software life cycle processes [see details]

## 5.1.7 Trust

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### Standard | IEEE P7011 Standard for the Process of Identifying and Rating the Trustworthiness of News Sources

This standard provides semi-autonomous processes using standards to create and maintain news purveyor ratings for purposes of public awareness. It standardizes processes to identify and rate the factual accuracy of news stories in order to produce a rating of online news purveyors and the online portion of multimedia news purveyors. This process will be used to produce truthfulness scorecards through multi-faceted and multi-sourced approaches. The standard defines an algorithm using open source software and a score card rating system as methodology for rating trustworthiness as a core tenant in an effort to establish trust and acceptance.

👥 COMMITTEE: IEEE SSIT/SC

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📅 PUBLISHED: under development

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🔗 URL: <https://standards.ieee.org/ieee/7011/7191/>

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### OTHER

### Standard | IEEE 2140.1-2020 Standard for General Requirements for Cryptocurrency Exchanges [see details]

### Standard | IEEE 2140.2-2021 Standard for Security Management for Customer Cryptographic Assets on Cryptocurrency Exchanges [see details]

### Standard | IEEE 2140.4-2023 Standard for Distributed/Decentralized Exchange Framework Using Distributed Ledger Technology (DLT) [see details]

### Standard | IEEE 2140.5-2020 Standard for a Custodian Framework of Cryptocurrency [see details]

Recommended Practice | IEEE 2142.1-2021 Recommended Practice for E-Invoice Business Using Blockchain Technology [see details]

Standard | IEEE 2143.1-2020 Standard for General Process of Cryptocurrency Payment [see details]

Standard | IEEE 2144.1-2020 Standard for Framework of Blockchain-based Internet of Things (IoT) Data Management [see details]

Standard | IEEE 2146.1-2022 Approved Draft Standard for Entity-Based Risk Mutual Assistance Model through Blockchain Technology [see details]

Standard | IEEE 2418.10-2022 Standard for Blockchain based Digital Asset Management [see details]

Standard | IEEE 2418.2-2020 Standard Data Format for Blockchain Systems [see details]

Standard | IEEE 2418.7-2021 Standard for the Use of Blockchain in Supply Chain Finance [see details]

Standard | IEEE 3205-2023 Standard for Blockchain Interoperability Data Authentication and Communication Protocol [see details]

Standard | IEEE 3801-2022 Standard for Blockchain-based Electronic Contracts [see details]

Standard | IEEE P2140.3 Standard for User Identification and Anti-Money Laundering on Cryptocurrency Exchanges [see details]

Standard | IEEE P2143.2 Standard for Cryptocurrency Payment Performance Metrics [see details]

Standard | IEEE P2143.3 Standard for Risk Control Requirements for Cryptocurrency Payment [see details]

Standard | IEEE P2144.2 Standard for Functional Requirements in Blockchain-based Internet of Things (IoT) Data Management [see details]

Standard | IEEE P2144.3 Standard for Assessment of Blockchain-based Internet of Things (IoT) Data Management [see details]

Standard | IEEE P2145 Draft Standard for Framework and Definitions for Blockchain Governance [see details]

Standard | IEEE P2146.2 Standard for External Data Retrieval of Blockchain for Risk Mutual Assistance Model [see details]

Standard | IEEE P2418.1 Standard for the Framework of Blockchain Use in Internet of Things (IoT) [see details]

Framework | IEEE P2418.11 Framework for Use of Distributed Ledger Technology in Security of Electronic Voting (e-Voting) Systems [see details]

Standard | IEEE P2418.3 Standard for the Framework of Distributed Ledger Technology (DLT) Use in Agriculture [see details]

Standard | IEEE P2418.5 Standard for Blockchain in Energy [see details]

Standard | IEEE P2418.6 Standard for the Framework of Distributed Ledger Technology (DLT) Use in Healthcare and the Life and Social Sciences [see details]

Standard | IEEE P2958 Standard for a Decentralized Identity and Access Management Framework for Internet of Things [see details]

Standard | IEEE P3201 Standard for Blockchain Access Control [see details]

Standard | IEEE P3202 Standard for Capability Evaluation Requirements of Blockchain Practitioners [see details]

Standard | IEEE P3203 Draft Standard for Blockchain Interoperability Naming Protocol [see details]

Standard | IEEE P3204 Draft Standard for Blockchain Interoperability Cross Chain Transaction Consistency Protocol [see details]

Standard | IEEE P3206 Draft Standard for Blockchain-based Digital Asset Classification [see details]

Standard | IEEE P3207 Standard for Blockchain-based Digital Asset Identification [see details]

Standard | IEEE P3208 Standard for Blockchain-based Digital Asset Exchange Model [see details]

Standard | IEEE P3209 Draft Standard for Blockchain Identity Key Management [see details]

Standard | IEEE P3210 Standard for Blockchain-based Digital Identity System Framework [see details]

Standard | IEEE P3211 Standard for Blockchain-based Electronic Evidence Interface Specification [see details]

Standard | IEEE P3212 Standard for Blockchain System Governance Specification [see details]

Standard | IEEE P3214 Standard for Testing Specification of Blockchain Systems [see details]

Standard | IEEE P3216 Standard for Blockchain Service Capability Evaluation [see details]

Standard | IEEE P3217 Draft Standard for Application Interface Specification for Blockchain Systems [see details]

Standard | IEEE P3218 Standard for Using Blockchain for Carbon Trading Applications [see details]

Standard | IEEE P3219 Draft Standard for Blockchain-based Zero-Trust Framework for Internet of Things (IoT) [see details]

Guide | IEEE P3220 Guide for the Application of Non-Fungible Token (NFT) Based Digital Asset [see details]

Standard | IEEE P3221 Standard for Technical Requirements of Digital Collection Services Based on Blockchain Technologies [see details]

Standard | IEEE P3222 Standard for the Reference Architecture of Blockchain as a Service [see details]

Standard | IEEE P3223 Standard for the Reference Architecture of Blockchain Fusion Server [see details]

Standard | IEEE P3224 Standard for Blockchain-based Green Power Identification Application [see details]

Standard | IEEE P3225 Standard for Using Blockchain in Low Carbon Zones Evaluation [see details]

Standard | IEEE P3226 Standard for Trusted Data Circulation based on Blockchain and Distributed Ledger Technologies (DLT) [see details]

Standard | IEEE P3800 Standard for a data-trading system: overview, terminology and reference model [see details]

Standard | IEEE P3802 Standard for Application Technical Specification of Blockchain-based E-Commerce Transaction Evidence Collecting [see details]

Technical specification | ISO/IEC TS 30149 ED1 Internet of Things (IoT) Trustworthiness Principles [see details]

## 5.1.8 Usability

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### OTHER

Technical report | ETSI TR 126 999 V17.0.0 5G; LTE; Virtual Reality (VR) streaming interoperability and characterization [see details]

Standard | ISO/IEC TR 23843:2020 Information technology for learning, education and training Catalogue model for virtual, augmented and mixed reality content [see details]

## 5.1.9 User Acceptance & Values

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### OTHER

Standard | 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 [see details]

Standard | ISO 9241-910:2011 Ergonomics of human-system interaction Part 910: Framework for tactile and haptic interaction [see details]

Standard | ISO 9241-920:2009 Ergonomics of human-system interaction Part 920: Guidance on tactile and haptic interactions [see details]

Standard | ISO 9241-940:2017 Ergonomics of human-system interaction Part 940: Evaluation of tactile and haptic interactions [see details]

Technical report | ISO/TR 9241-380:2022 Ergonomics of human-system interaction Part 380: Survey result of HMD (Head-Mounted Displays) characteristics related to human-system interaction [see details]

Technical report | ISO/TR 9241-393:2020 Ergonomics of human-system interaction Part 393: Structured literature review of visually induced motion sickness during watching electronic images [see details]

Technical specification | ISO/TS 9241-430:2021 Ergonomics of human-system interaction Part 430: Recommendations for the design of non-touch gestural input for the reduction of biomechanical stress [see details]

## ■ 5.2 Governance

### 5.2.1 Governance & Regulation

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#### Recommended Practice | IEEE P7010.1 Recommended Practice for Environmental Social Governance (ESG) and Social Development Goal (SDG) Action Implementation and Advancing Corporate Social Responsibility

This recommended practice provides recommendations for next steps in the application of IEEE Std 7010, applied to meeting Environmental Social Governance (ESG) and Social Development Goal (SDG) initiatives and targets. It provides action steps and map elements to review and address when applying IEEE Std 7010. This recommended practice serves to enhance the quality of the published standard by validating the design outcomes with expanded use. It provides recommendations for multiple users to align processes, collect data, develop policies and practices and measure activities against the impact on corporate goals and resulting stakeholders. This recommended practice does not set metrics for measurement and/or reporting, but rather identifies well recognized indicators to consider in assessment and measurement of progress.

👥 COMMITTEE: IEEE SSIT/SC

📅 PUBLISHED: under development

🔗 URL: <https://standards.ieee.org/ieee/7010.1/10756/>

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#### OTHER

Standard | IEEE 7005 Standard for Transparent Employer Data Governance [see details]

Standard | IEEE P7004 Standard for Child and Student Data Governance [see details]

Guide | IEEE 1232.3-2014 Guide for the Use of Artificial Intelligence Exchange and Service Tie to All Test Environments [see details]

Framework | IEEE 2807-2022 Framework of Knowledge Graphs Series [see details]

Standard | IEEE 2937-2022 Standard for Performance Benchmarking for AI Server Systems [see details]

Standard | IEEE 2941-2021 Standard for Artificial Intelligence (AI) Model Representation, Compression, Distribution and Management [see details]

Guide | IEEE 3652.1-2020 Guide for Architectural Framework and Application of Federated Machine Learning [see details]

Recommended Practice | IEEE P2247.4 Recommended Practice for Ethically Aligned Design of Artificial Intelligence (AI) in Adaptive Instructional Systems [see details]

Recommended Practice | IEEE P2863 Recommended Practice for Organizational Governance of Artificial Intelligence [see details]

Standard | IEEE P2874 Standard for Spatial Web Protocol, Architecture and Governance [see details]

Guide | IEEE P2894 Guide for an Architectural Framework for Explainable Artificial Intelligence [see details]

Standard | IEEE P2941.1 Standard for Operator Interfaces of Artificial Intelligence [see details]

Standard | IEEE P2975 Standard for Industrial Artificial Intelligence (AI) Data Attributes [see details]

Standard | IEEE P2976 Standard for XAI eXplainable Artificial Intelligence for Achieving Clarity and Interoperability of AI Systems Design [see details]

Standard | IEEE P3119 Standard for the Procurement of Artificial Intelligence and Automated Decision Systems [see details]

Standard | IEEE P3123 Standard for Artificial Intelligence and Machine Learning Terminology and Data Formats [see details]

Recommended Practice | IEEE P3128 Recommended Practice for The Evaluation of Artificial Intelligence (AI) Dialogue System Capabilities [see details]

Standard | IEEE P3129 Standard for Robustness Testing and Evaluation of Artificial Intelligence (AI)-based Image Recognition Service [see details]

Standard | IEEE P3152 Standard for the Description of the Natural or Artificial Character of Intelligent Communicators [see details]

Standard | IEEE P7014 Standard for Ethical considerations in Emulated Empathy in Autonomous and Intelligent Systems [see details]

Standard | IEEE P7015 Standard for Data and Artificial Intelligence (AI) Literacy, Skills, and Readiness [see details]

Recommended Practice | IEEE P7004.1 Recommended Practices for Virtual Classroom Security, Privacy and Data Governance [see details]



## 5.2.2 Openness

### Standard | ISO/IEC 5230:2020 Information technology OpenChain Specification

This document specifies the key requirements of a quality open source license compliance program in order to provide a benchmark that builds trust between organizations exchanging software solutions comprised of open source software.

👥 COMMITTEE: ISO/IEC JTC 1

📅 PUBLISHED: 2020-12

🔗 URL: <https://www.iso.org/standard/81039.html>

## 5.2.3 Security

### OTHER

Standard | IEEE 2813-2020 Standard for Big Data Business Security Risk Assessment [see details]

Standard | ISO/IEC 24760-1:2019 IT Security and Privacy A framework for identity management Part 1: Terminology and concepts [see details]

Standard | ISO/IEC 24760-2:2015 Information technology Security techniques A framework for identity management [see details]

Standard | ISO/IEC 29115:2013 Information technology Security techniques Entity authentication assurance framework [see details]

Standard | ISO/IEC 29146:2016 Information technology Security techniques A framework for access management [see details]

Technical specification | ISO/IEC TS 27110:2021 Information technology, cybersecurity and privacy protection Cybersecurity framework development guidelines [see details]

Technical specification | ISO/IEC TS 29003:2018 Information technology Security techniques Identity proofing [see details]

Recommended Practice | IEEE P7004.1 Recommended Practices for Virtual Classroom Security, Privacy and Data Governance [see details]

Standard | ISO/IEC DIS 5927 Augmented and Virtual Reality safety Guidance on safe immersion, setup and usage [see details]

Technical report | Metaverse: Security and Privacy Issues DOI: 10.1109/TPSISA52974.2021.00032. The Third IEEE International Conference on Trust, Privacy and Security in Intelligent Systems, and Applications [see details]

Standard | IEEE 2140.1-2020 Standard for General Requirements for Cryptocurrency Exchanges [see details]

Standard | IEEE 2140.2-2021 Standard for Security Management for Customer Cryptographic Assets on Cryptocurrency Exchanges [see details]

Standard | IEEE 2140.4-2023 Standard for Distributed/Decentralized Exchange Framework Using Distributed Ledger Technology (DLT) [see details]

Standard | IEEE 2140.5-2020 Standard for a Custodian Framework of Cryptocurrency [see details]

Recommended Practice | IEEE 2142.1-2021 Recommended Practice for E-Invoice Business Using Blockchain Technology [see details]

Standard | IEEE 2143.1-2020 Standard for General Process of Cryptocurrency Payment [see details]

Standard | IEEE 2144.1-2020 Standard for Framework of Blockchain-based Internet of Things (IoT) Data Management [see details]

Standard | IEEE 2146.1-2022 Approved Draft Standard for Entity-Based Risk Mutual Assistance Model through Blockchain Technology [see details]

Standard | IEEE 2418.10-2022 Standard for Blockchain based Digital Asset Management [see details]

Standard | IEEE 2418.2-2020 Standard Data Format for Blockchain Systems [see details]

Standard | IEEE 2418.7-2021 Standard for the Use of Blockchain in Supply Chain Finance [see details]

Standard | IEEE 3205-2023 Standard for Blockchain Interoperability Data Authentication and Communication Protocol [see details]

Standard | IEEE 3801-2022 Standard for Blockchain-based Electronic Contracts [see details]

Standard | IEEE P2140.3 Standard for User Identification and Anti-Money Laundering on Cryptocurrency Exchanges [see details]

Standard | IEEE P2143.2 Standard for Cryptocurrency Payment Performance Metrics [see details]

Standard | IEEE P2143.3 Standard for Risk Control Requirements for Cryptocurrency Payment [see details]

Standard | IEEE P2144.2 Standard for Functional Requirements in Blockchain-based Internet of Things (IoT) Data Management [see details]

Standard | IEEE P2144.3 Standard for Assessment of Blockchain-based Internet of Things (IoT) Data Management [see details]

Standard | IEEE P2145 Draft Standard for Framework and Definitions for Blockchain Governance [see details]

Standard | IEEE P2146.2 Standard for External Data Retrieval of Blockchain for Risk Mutual Assistance Model [see details]

Standard | IEEE P2418.1 Standard for the Framework of Blockchain Use in Internet of Things (IoT) [see details]

Framework | IEEE P2418.11 Framework for Use of Distributed Ledger Technology in Security of Electronic Voting (e-Voting) Systems [see details]

Standard | IEEE P2418.3 Standard for the Framework of Distributed Ledger Technology (DLT) Use in Agriculture [see details]

Standard | IEEE P2418.5 Standard for Blockchain in Energy [see details]

Standard | IEEE P2418.6 Standard for the Framework of Distributed Ledger Technology (DLT) Use in Healthcare and the Life and Social Sciences [see details]

Standard | IEEE P2958 Standard for a Decentralized Identity and Access Management Framework for Internet of Things [see details]

Standard | IEEE P3201 Standard for Blockchain Access Control [see details]

Standard | IEEE P3202 Standard for Capability Evaluation Requirements of Blockchain Practitioners [see details]

Standard | IEEE P3203 Draft Standard for Blockchain Interoperability Naming Protocol [see details]

Standard | IEEE P3204 Draft Standard for Blockchain Interoperability Cross Chain Transaction Consistency Protocol [see details]

Standard | IEEE P3206 Draft Standard for Blockchain-based Digital Asset Classification [see details]

Standard | IEEE P3207 Standard for Blockchain-based Digital Asset Identification [see details]

Standard | IEEE P3208 Standard for Blockchain-based Digital Asset Exchange Model [see details]

Standard | IEEE P3209 Draft Standard for Blockchain Identity Key Management [see details]

Standard | IEEE P3210 Standard for Blockchain-based Digital Identity System Framework [see details]

Standard | IEEE P3211 Standard for Blockchain-based Electronic Evidence Interface Specification [see details]

Standard | IEEE P3212 Standard for Blockchain System Governance Specification [see details]

Standard | IEEE P3214 Standard for Testing Specification of Blockchain Systems [see details]

Standard | IEEE P3216 Standard for Blockchain Service Capability Evaluation [see details]

Standard | IEEE P3217 Draft Standard for Application Interface Specification for Blockchain Systems [see details]

Standard | IEEE P3218 Standard for Using Blockchain for Carbon Trading Applications [see details]

Standard | IEEE P3219 Draft Standard for Blockchain-based Zero-Trust Framework for Internet of Things (IoT) [see details]

Guide | IEEE P3220 Guide for the Application of Non-Fungible Token (NFT) Based Digital Asset [see details]

Standard | IEEE P3221 Standard for Technical Requirements of Digital Collection Services Based on Blockchain Technologies [see details]

Standard | IEEE P3222 Standard for the Reference Architecture of Blockchain as a Service [see details]

Standard | IEEE P3223 Standard for the Reference Architecture of Blockchain Fusion Server [see details]

Standard | IEEE P3224 Standard for Blockchain-based Green Power Identification Application [see details]

Standard | IEEE P3225 Standard for Using Blockchain in Low Carbon Zones Evaluation [see details]

Standard | IEEE P3226 Standard for Trusted Data Circulation based on Blockchain and Distributed Ledger Technologies (DLT) [see details]

Standard | IEEE P3800 Standard for a data-trading system: overview, terminology and reference model [see details]

Standard | IEEE P3802 Standard for Application Technical Specification of Blockchain-based E-Commerce Transaction Evidence Collecting [see details]

## 5.2.4 Sustainability

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### OTHER

Standard | ISO/IEC/IEEE 12207:2017 Systems and software engineering Software life cycle processes [see details]

## ■ 5.3 Technical

### 5.3.1 Computation

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#### OTHER

Recommendation | ITU-T F.746.14 Requirements and reference framework for cloud virtual reality systems [see details]

Recommendation | ITU-T F.746.17 Requirements for media processing services [see details]

Technical report | ISO/IEC CD TR 5259-6 Artificial intelligence Data quality for analytics and machine learning (ML) Part 6: Visualization framework for data quality [see details]

Standard | ISO/IEC 19775-1:2013 Information technology Computer graphics, image processing and environmental data representation Extensible 3D (X3D) Part 1: Architecture and base components [see details]

Standard | ISO/IEC 9592-1:1997 Information technology Computer graphics and image processing Programmer's Hierarchical Interactive Graphics System (PHIGS) Part 1: Functional description [see details]

Standard | ISO 8805:1988 Information processing systems Computer graphics Graphical Kernel System for Three Dimensions (GKS-3D) functional description [see details]

Standard | ISO/IEC 10641:1993 Information technology Computer graphics and image processing Conformance testing of implementations of graphics standards [see details]

Standard | ISO/IEC 11072:1992 Information technology Computer graphics Computer Graphics Reference Model [see details]

Standard | ISO/IEC 12087-1:1995 Information technology Computer graphics and image processing Image Processing and Interchange (IPI) Functional specification Part 1: Common architecture for imaging [see details]

Standard | ISO/IEC 14478-1:1998 Information technology Computer graphics and image processing Presentation Environment for Multimedia Objects (PREMO) Part 1: Fundamentals of PREMO [see details]

Standard | ISO/IEC 15948:2004 Information technology Computer graphics and image processing Portable Network Graphics (PNG): Functional specification [see details]

Standard | ISO/IEC 7942-1:1994 Information technology Computer graphics and

image processing Graphical Kernel System (GKS) Part 1: Functional description [see details]

Standard | ISO/IEC 8632-1:1999 Information technology Computer graphics Metafile for the storage and transfer of picture description information Part 1: Functional specification [see details]

Standard | ISO/IEC 9636-1:1991 Information technology Computer graphics Interfacing techniques for dialogues with graphical devices (CGI) Functional specification Part 1: Overview, profiles, and conformance [see details]

Standard | ISO/IEC 9973:2013 Information technology Computer graphics, image processing and environmental data representation Procedures for registration of items [see details]

Technical specification | ISO/IEC TS 5147:2023 Information technology Computer graphics, image processing and environmental data representation Guidelines for representation and visualization of smart cities [see details]

Standard | 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) [see details]

Technical report | ETSI TR 102 794 V1.1.1 Media Content Distribution (MCD); 3D Gaming Graphics Delivery Overview [see details]

Standard | ISO/AWI 8000-220 Data quality Part 220: Sensor data: Quality measurement [see details]

Standard | ISO/CD 8000-210 Data quality Part 210: Sensor data: Data quality characteristics [see details]

Standard | ISO 8000-1:2022 Data quality Part 1: Overview [see details]

Standard | 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) [see details]

Standard | ISO/IEC 18026:2009 Information technology Spatial Reference Model (SRM) [see details]

Standard | ISO/IEC 18305:2016 Information technology Real time locating systems Test and evaluation of localization and tracking systems [see details]

Standard | ISO/IEC 23007-1:2010 Information technology Rich media user interfaces Part 1: Widgets [see details]

Standard | ISO/IEC 18025:2014 Information technology Environmental Data Coding Specification (EDCS) [see details]

Technical report | ETSI TR 126 998 V17.1.0 Support of 5G glass-type Augmented

Reality / Mixed Reality (AR/MR) devices (3GPP TR 26.998 version 17.1.0 Release 17) [see details]

Standard | ISO 12637-1:2006 Graphic technology Vocabulary Part 1: Fundamental terms [see details]

Standard | ISO 16760:2014 Graphic technology Prepress data exchange Preparation and visualization of RGB images to be used in RGB-based graphics arts workflows [see details]

Technical report | ISO/TR 24464:2020 Automation systems and integration Industrial data Visualization elements of digital twins [see details]

Standard | ISO 16757-2:2016 Data structures for electronic product catalogues for building services Part 2: Geometry [see details]

Standard | ISO 17506:2022 Industrial automation systems and integration COLLADA (TM) digital asset schema specification for 3D visualization of industrial data [see details]

Standard | ISO 10303-1:2021 Industrial automation systems and integration Product data representation and exchange Part 1: Overview and fundamental principles [see details]

Standard | ISO 10303-225:1999 Industrial automation systems and integration Product data representation and exchange Part 225: Application protocol: Building elements using explicit shape representation [see details]

Standard | ISO 10303-46:2022 Industrial automation systems and integration Product data representation and exchange Part 46: Integrated generic resource: Visual presentation [see details]

Standard | ISO 14306:2017 Industrial automation systems and integration JT file format specification for 3D visualization [see details]

Recommendation | ITU-T F.746.12 Requirements for a real-time interactive multimedia service under poor network conditions [see details]

Standard | ISO/IEC 23008-3:2022 Information technology High efficiency coding and media delivery in heterogeneous environments Part 3: 3D audio [see details]

## 5.3.2 Interoperability

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### OTHER

Technical specification | ETSI GS ARF 003 V1.1.1 Augmented Reality Framework (ARF); AR framework architecture [see details]

Technical specification | ETSI GS ARF 004-5 V1.1.1 Augmented Reality Framework (ARF); Interoperability Requirements for AR components, systems and services; Part 5: External Communications [see details]

Technical specification | ETSI GS ARF 005 V1.1.1 Augmented Reality Framework (ARF); Open APIs for the Creation and Management of the World Representation [see details]

Standard | ISO/IEC 18039:2019 Information technology Computer graphics, image processing and environmental data representation Mixed and augmented reality (MAR) reference model [see details]

Technical report | ISO/TR 23262:2021 GIS (geospatial) / BIM interoperability [see details]

Standard | ISO 29481-1:2016 Building information models Information delivery manual Part 1: Methodology and format [see details]

Standard | ISO 10303-21:2016 Industrial automation systems and integration Product data representation and exchange Part 21: Implementation methods: Clear text encoding of the exchange structure [see details]

Standard | ISO/IEC 14496-16:2011 Information technology Coding of audio-visual objects Part 16: Animation Framework eXtension (AFX) [see details]

Standard | ISO/IEC 14496-27:2009 Information technology Coding of audio-visual objects Part 27: 3D Graphics conformance [see details]

Standard | ISO/IEC 15938-5:2003 Information technology Multimedia content description interface Part 5: Multimedia description schemes [see details]

Standard | ISO/IEC 23090-14:2023 Information technology Coded representation of immersive media Part 14: Scene description [see details]

Technical report | ISO/IEC TR 15938-8:2002 Information technology Multimedia content description interface Part 8: Extraction and use of MPEG-7 descriptions [see details]

Standard | PWI JTC1-SC41-8 Internet of Things (IoT) Behavioral and policy interoperability [see details]

Guide | IEEE 2301-2020 Guide for Cloud Portability and Interoperability Profiles [see details]

Standard | IEEE 2302-2021 Standard for Intercloud Interoperability and Federation [see details]

Standard | IEEE P2304 Standard for Cloud Computing Shared Function Model [see details]



Standard | ISO/IEC 23000-13:2017 Information technology Multimedia application format (MPEG-A) Part 13: Augmented reality application format [see details]

Standard | ISO/IEC 21823-3:2021 Internet of Things (IoT) Interoperability for IoT systems Part 3: Semantic interoperability [see details]

Standard | IEEE 1857.9-2021 Standard for Immersive Visual Content Coding [see details]

Standard | ISO/IEC 23094-1:2020 Information technology General video coding Part 1: Essential video coding [see details]

Standard | ISO/IEC DIS 23094-21 Information technology Coded representation of immersive media Part 21: Reference Software for G-PCC [see details]

Technical report | MPAA-MMM Architecture Call for Technologies: MPAA-MMM – Architecture [see details]

Technical report | MPAA-MMM Functionalities Technical Report MPAA Metaverse Model (MPAA-MMM) – Functionalities [see details]

Technical report | MPAA-MMM Functionality Profiles Technical Report MPAA Metaverse Model (MPAA-MMM) Functionality Profiles [see details]

Standard | ISO 23247-4:2021 Automation systems and integration Digital twin framework for manufacturing Part 4: Information exchange [see details]

Standard | ISO/IEC 18038:2020 Information technology Computer graphics, image processing and environmental representation Sensor representation in mixed and augmented reality [see details]

Standard | ISO/IEC 23093-3:2022 Information technology Internet of media things Part 3: Media data formats and APIs [see details]

Standard | ISO/IEC 12113:2022 Information technology Runtime 3D asset delivery format Khronos glTF™ 2.0 [see details]

Standard | ISO 19444-1:2019 Document management XML Forms Data Format Part 1: Use of ISO 32000-2 (XFDF 3.0) [see details]

Technical specification | ISO/TS 23301:2021 STEP geometry visualization services [see details]

Technical specification | ISO/TS 24064:2023 Document management Portable document format RichMedia annotations conforming to the ISO 10303-242 (STEP AP 242) specification [see details]

Standard | ISO/IEC 19777-1:2006 Information technology Computer graphics and image processing Extensible 3D (X3D) language bindings Part 1: ECMAScript [see details]

Standard | ISO/IEC 19777-2:2006 Information technology Computer graphics and image processing Extensible 3D (X3D) language bindings Part 2: Java [see details]

Technical report | ETSI TR 126 998 V17.1.0 Support of 5G glass-type Augmented Reality / Mixed Reality (AR/MR) devices (3GPP TR 26.998 version 17.1.0 Release 17)

[\[see details\]](#)

Standard | ISO 12637-1:2006 Graphic technology Vocabulary Part 1: Fundamental terms [\[see details\]](#)

Standard | ISO 16760:2014 Graphic technology Prepress data exchange Preparation and visualization of RGB images to be used in RGB-based graphics arts workflows [\[see details\]](#)

Technical report | ISO/TR 24464:2020 Automation systems and integration Industrial data Visualization elements of digital twins [\[see details\]](#)

Standard | ISO 16757-2:2016 Data structures for electronic product catalogues for building services Part 2: Geometry [\[see details\]](#)

Standard | ISO 17506:2022 Industrial automation systems and integration COLLADA (TM) digital asset schema specification for 3D visualization of industrial data [\[see details\]](#)

Standard | ISO 10303-1:2021 Industrial automation systems and integration Product data representation and exchange Part 1: Overview and fundamental principles [\[see details\]](#)

Standard | ISO 10303-225:1999 Industrial automation systems and integration Product data representation and exchange Part 225: Application protocol: Building elements using explicit shape representation [\[see details\]](#)

Standard | ISO 10303-46:2022 Industrial automation systems and integration Product data representation and exchange Part 46: Integrated generic resource: Visual presentation [\[see details\]](#)

Standard | ISO 14306:2017 Industrial automation systems and integration JT file format specification for 3D visualization [\[see details\]](#)

Standard | IEEE 7007 Ontological Standard for Ethically Driven Robotics and Automation Systems [\[see details\]](#)

Technical report | ETSI TR 126 999 V17.0.0 5G; LTE; Virtual Reality (VR) streaming interoperability and characterization [\[see details\]](#)

Standard | ISO/IEC 14496-25:2011 Information technology Coding of audio-visual objects Part 25: 3D Graphics Compression Model [\[see details\]](#)

Technical specification | ISO/IEC AWI TS 27115 Cybersecurity evaluation of complex systems Introduction and framework overview [\[see details\]](#)

## ■ 6. Conclusions

### ■ 6.1 Research recommendations

As CitiVerse is new, and many of the technologies it incorporates are also new (AI, blockchain, digital twin), much of the work on standards is ongoing, and research will influence future standards. Some recent research is worth mentioning:

- ▷ a taxonomy of the metaverse<sup>1</sup>,
- ▷ a survey on security and privacy in the metaverse<sup>2</sup>,
- ▷ the integration of AI in the metaverse<sup>3</sup>,
- ▷ the integration of the edge in the metaverse<sup>4</sup>,
- ▷ semantic communication in the metaverse<sup>5</sup>,
- ▷ semantic communication at the edge<sup>6</sup>.

In particular, the survey on security and privacy lists 5 challenges that we would like to cite:

- ▷ R1: Endogenous security empowered metaverse
- ▷ R2: Cloud-edge-end orchestrated secure metaverse
- ▷ R3: Cross-chain interoperable and regulatory metaverse
- ▷ R4: Energy-efficient and green metaverse
- ▷ R5: Content-centric and human-centric metaverse

### ■ 6.2 Recommendations from the landscape

The work carried out by the TWG-CitiVerse has led to the following conclusions:

- ▷ The main challenge is an integration challenge of technology bricks, organisation in ecosystems, standards structures, and standardisation process.
- ▷ The content of the landscape document will likely change to cope:
  1. with gaps and extensions, and
  2. a convergence towards a common taxonomy.

If we look at the statistics of standards collected:

- ▷ Some verticals / enablers have many references, e.g., geospatial systems (85 references), representation & modelling (67 references), data (65 references), security (61 references), trust (53

1 S.-M. Park and Y.-G. Kim, "A metaverse: Taxonomy, components, applications, and open challenges," IEEE Access, vol. 10, pp. 4209–4251, Jan. 2022.

2 Y. Wang et al., "A Survey on Metaverse: Fundamentals, Security, and Privacy," in IEEE Communications Surveys & Tutorials, vol. 25, no. 1, pp. 319–352, Firstquarter 2023, doi: [10.1109/COMST.2022.3202047](https://doi.org/10.1109/COMST.2022.3202047).

3 T. Huynh-The, Q.-V. Pham, X.-Q. Pham, T. T. Nguyen, Z. Han, and D.-S. Kim, "Artificial intelligence for the metaverse: A survey," arXiv preprint arXiv:2202.10336, 2022

4 M. Xu, W. C. Ng, W. Y. B. Lim, J. Kang, Z. Xiong, D. Niyato, Q. Yang, X. Shen, and C. Miao, "A full dive into realizing the edge-enabled metaverse: Visions, enabling technologies, and challenges," IEEE Communications Surveys & Tutorials, vol. 25, no. 1, pp. 656–700, Firstquarter 2023, doi: [10.1109/COMST.2022.3221119](https://doi.org/10.1109/COMST.2022.3221119).

5 Z. Qin, X. Tao, J. Lu, and G. Y. Li, "Semantic communications: Principles and challenges," arXiv preprint arXiv:2201.01389, Dec. 2021. [Online]. Available: <https://arxiv.org/abs/2201.01389>.

6 W. Yang, Z. Q. Liew, W. Y. B. Lim, Z. Xiong, D. Niyato, X. Chi, X. Cao, and K. B. Letaief, "Semantic communication meets edge intelligence," arXiv preprint arXiv:2202.06471, Feb. 2022. [Online]. Available: <https://arxiv.org/abs/2202.06471>.

references), blockchain (51 references), extended reality (48 references), and interoperability (47 references). There could be a need in the future to further refine these categories.

- ▶ other categories lack standards references for CitiVerse, such as in: 6G (3 references), edge & cloud computing (3 references), inclusivity (2 references), networks (2 references), openness (1 reference), safety (2 references), sustainability (1 reference), and usability (2 references). This may also be evidence of gaps in standards for CitiVerse.

During the last JTC 1/SC 27/WG 5 plenary in Seoul, South Korea in October 2023, a workshop took place on privacy protection in the Metaverse. We would like to quote Nat Sakimura, Japanese privacy and identification management expert:

- ▶ Metaverse can bring the threat of pervasive monitoring by everyone.
- ▶ Identification management, anonymisation and pseudonymisation is going to be substantially more difficult in the Metaverse.

We consequently would like to add the following recommendations:

- ▶ R6: address the problem of integration at all levels:
  - ▶ guidance on how to integrate technologies
  - ▶ guidance on how to integrate organisations in a metaverse ecosystem
  - ▶ guidance on how to match standards to the technologies and organisations
  - ▶ guidance on how to implement a standardisation process
- ▶ R7: improve the current landscape to uncover further gaps
- ▶ R8: address the privacy threat of pervasive monitoring by everyone
- ▶ R9: ensure the scaling of Identification management, anonymisation and pseudonymisation to the granularity of the CitiVerse

## ■ 6.3 Outlook

Acting as a digital representation of the physical ecosystem of a “municipality”, the Local Digital Twin, may support municipalities in their decision-making, both strategic as well as operational, e.g., visualisations, predictions, or simulations. Eventually also to steer certain use cases autonomously. The vision of CitiVerse goes beyond this “hybrid” approach, providing a complete digital “movie” or “game” like representation.

It is very important to achieve acceptance and a substantial overall positive appearance of “CitiVerse”, aside from the technical standards it requires. Therefore, the need for standardised “design principles” in the social, ecological, economic, and technological domains are apparent. It is important to develop those parallel to further developing the technology domain. That way we can avoid rebound effects by trying to keep all four areas of the sustainability rhombus in balance. Therefore, it is vital to use existing or investigate and establish new ethical standards. For example, standards regarding all kinds of analytics or modelling, ecological standards regarding the overall ecological footprint of digital technologies (“twin transition”). That is, besides economic carrying capacity and technological interoperability, regarding “CitiVerse”. This implies the opening “of the world of standards” to these “governance / taxonomy” questions. It can be accomplished by harvesting demands, needs, and concerns from the municipality ecosystem early on, to achieve with “CitiVerse” a measurable positive impact for their inhabitants.

# ■ Annex A CitiVerse and Metaverse

## ■ Introduction

Metaverse has been a topic of great interest for some time now. There are many ideas about what Metaverse is and should be. The discussions and work regarding CitiVerse has begun more recently. There is however no clear definition yet of neither Metaverse nor CitiVerse. It is therefore easy to mix these two emerging technologies up with each other, seeing them as the same thing. They do have a lot in common, but there are also a lot of specific demands and challenges we encounter when a digital 3D world is based on and are a copy of the social physical real world that need to be taken in to account. Therefore, these two technologies most likely need to be dealt with separately, but in parallel.

Some people might think of CitiVerse is a special kind of Metaverse or an instantiation of Metaverse. Other people might claim they are different constructions. For now, and for the purpose of this annex, that doesn't really matter. Things will most likely be clearer to all of us in the future as we proceed with initiatives and standardization regarding both Metaverse and CitiVerse. As stated in the beginning of this document, in the Landscape Report and this Annex we consider CitiVerse as being a copy of the social physical real world. In the introduction section and in this Annex, we use the term Metaverse for a virtual 3D world more freely designed and NOT being a copy of a specific physical area in the real world or even look like something from the real world.

Regardless of our interpretation of the terms CitiVerse and Metaverse, this Annex try to provide some clarification between these two worlds, although it by no means claims to cover all aspects of similarities or differences between the two. We are at the beginning of a long journey with these technologies, where ongoing work and collaboration in sharing thoughts and ideas will continue to form the future for both the Metaverse and CitiVerse. As there are many different opinions about both these worlds, there will certainly be a need for other aspects to consider, with other ideas and interpretations of the terms which are assumed and covered below.

It is our intention that the thoughts expressed in this Annex may serve as a starting point for further discussion or debate on the subject.

## ■ Similarities

Both CitiVerse and a more fictional Metaverse are virtual 3D worlds. As such, much of what applies for a more fictional Metaverses is also valid for CitiVerses, at least regarding the realisation of a 3D world.

The idea, of both a more fictional Metaverse and CitiVerse, is to be able to use those worlds as an alternate reality that you may visit in some manner: using an avatar, with Virtual Reality or Augmented Reality technologies, and so on.

Both kinds of digital worlds can offer the possibility for people to meet and interact with each other.

Most technologies for building Metaverses are likely be useful for CitiVerses as well, provided the alignment of the two worlds is ensured with each other and same standards are applied, where and as possible.

Important examples of such similarities can be seen in human interactions with the virtual worlds:

- ▷ The creation and usage of avatars may be used in CitiVerse, as used already in Metaverse.
- ▷ 3D-visualisation technologies used in Metaverse could eventually be similar for CitiVerse (although there may be a need to differentiate between the tools).
- ▷ The same AR and VR solutions will most likely be adaptable to be used in both worlds (although a CitiVerse world may be more useful for such applications).

- ▷ Virtually, imaginary objects, may be placed in both worlds (although probably more carefully and for specific purposes in a CitiVerse).
- ▷ Hardware used for input could most likely be the same or at least similar for both worlds, e.g., camera sensors, wearables, eye and voice commands or even brain computer interfaces.
- ▷ And so on...

As in the gaming industry, both Metaverse and CitiVerse will most likely be populated by so called “Nonplaying characters” (NPCs) or “Synthetic Humans” for gaming experiences, education, or simulation purposes, and so on. Characters may be managed by AI algorithms, where it would be beneficial if the same standards could be used for these in both kinds of virtual worlds.

Both worlds can also serve as Digital Twins for real-world objects, via digital representations, where IoT technologies offer user interaction, with sensors gathering object information and actuators that control and change the state of these real-world objects in the virtual world.

Many legal and ethical aspects of using both the Metaverse and CitiVerse will probably be similar too. However, as CitiVerses will contain data collected from the real-world, there are likely to be many more challenges relating to security, integrity, and data classification in the CitiVerse environment, compared to more fictional Metaverses. On the other hand, the risk of cyber harassment and bullying are challenges involving social components that need to be addressed in both kinds of virtual worlds.

With regards to the use of Artificial Intelligence, for both worlds the rules, algorithms, and technologies may be similar, even if it is likely that CitiVerses will contain larger datasets.

The gaming industry will, in all likelihood, make use of both more fictional Metaverse and CitiVerse. The more standards that align these two virtual worlds, the easier will it be for the game developers to produce interesting content for both. Possibly the imaginary worlds of Metaverses will be used more for action and adventure games, whilst educational and training games will be more the focus of CitiVerse. However, it is currently hard to clearly foresee the exact directions that may be taken by the gaming industry.

For military purposes, there will most likely be a strong interest in CitiVerses, but, at the same time, a continuing use of fictive Metaverses in training and education.

## ■ Differences

Metaverses, as we use the term in this Annex, are fictional, providing developers with a large degree of freedom when creating these worlds. For example, some worlds or parts of worlds may be highly fantastical compared to the world we live in, i.e., the real world, whilst other worlds or parts of worlds of a fictional Metaverse will try to mirror real-life objects and environments. Even fictive Metaverses may wish to copy or look like famous places in the real world, making it possible to travel there virtually, without being obliged to provide an exact copy of the real world itself. It may be modified or even enhanced, depending on its purpose.

CitiVerses on the other hand may not be fictional. Instead, to the best of their capabilities, they must attempt to reflect a corresponding real-world environment, as similar, detailed, and as accurately as is possible.

Where more fictional Metaverses will probably continue to be created by designers and game constructors, CitiVerses will be created by collecting data from the real world, e.g., photographs of buildings, maps, aerial photographs, with greater quantities of information required from the real world. In short, CitiVerses will most likely start from Local Digital Twins – with what today are also called Urban Digital Twins, City Information Modelling, and similar technologies.

A specific challenge with a CitiVerse is that most probably its environment will be built on multiple real-world Digital Twins, both vertically and horizontally. For verticals, we can foresee a multitude of Digital Twins being built on the same sector, like Energy or Public Transport, by different organisations leading to issues of interoperability, waste of resources, and general incohesion. All these “copies” will need to fit together somehow. Furthermore, the Digital Twin of one municipality, will need to integrate with their neighbouring municipalities, horizontally. This creates increased challenges and demands on the CitiVerses which are quite diverse from more fictive Metaverses.

Another important difference is that unlike a more fictive Metaverse, the most likely use of CitiVerses will be as Digital Twins for the real-world, with real-world objects. As CitiVerses will provide a much

better environment for visualising real-life objects and data.

The large data sets collected with Internet of Things need to be visualised in suitable environments. A Local Digital Twin provides such environment. Yet, a CitiVerse, built on such Local Digital Twins, will provide improved and far greater possibilities to visualize and experience the collected data to visit and interact with.

## Transitions from CitiVerses to fictive Metaverses

One aspect of CitiVerses that will require far more in-depth contemplation are the characteristics of its Digital Twins. Where other types of Digital Twins, such as those in industry, are commonly used for simulations and predictions, the Digital Twins of CitiVerses will, most certainly, be used for urban and rural planning, as well as for simulations of strategic and operational scenarios.

When a Digital Twin is manipulated and no longer corresponds to a real-world object, the result is a fictive digital object. The same will be true for CitiVerses. Once we start manipulating a copy of a CitiVerse, then it will no longer be an exact copy of a real world, and, instead, become fictive world. If such modifications to a CitiVerse become extensive, the result becomes a hybrid of CitiVerse and fictive Metaverse, or eventually a fully fictive Metaverse.

This transition from CitiVerse to a fictive Metaverse may be a useful one for the gaming industry, using the “real world” as a starting point, and where gaming elements turn it into a fictional Metaverse or CitiVerse / Metaverse hybrid.

## Additional challenges with CitiVerses

Whereas the creator of a fictive Metaverse is free to design their world, the greater challenge to the creator of a CitiVerse is that instead they must carry out extensive data collection to create their virtual world, to make it mirror the real world. For the creation of a CitiVerse, unlike for a fictive Metaverse, it is probable that the creator will have to gather and incorporate data from public sectors, such as real estate information, traffic information, demographics, and so on. Furthermore, real time data from sensors will probably be required to keep the world “alive”. Sensorial data that may be gathered from water and flood levels, air pollution, weather, water consumption, waste, and so on. All data that enriches the virtual world of the CitiVerse. The gathering of such real-time data provides important challenges on multiple and complex political, social, economic and technical levels. To achieve a CitiVerse that provides decision support or even semi-autonomous or autonomous management of urban ecosystems, the technologies that will be required are beyond the scope or needs of a purely fictive Metaverse.

Another challenge may be scalability. A fictive Metaverse can be created to be functional on a specific detailed level – a zoom level. The creator is only required to work with a specific zoom level when creating details for their virtual world. On the other hand, as a copy of a real world, a CitiVerse must be able to deal with a wide range of scales.

A further challenge will be interoperability. Several of the most engaged Metaverse experts might want the Metaverse to be one single large seamless virtual world where all Metaverse parts can fit together, and where objects and information can be interchanged between different instances of that single world. This would place heavy demands on the need for interoperability between these implementations of the Metaverse. In the case of a CitiVerse, interoperability becomes an even greater challenge, as real-life objects will probably have much more metadata and information attached to them, making them hard to transfer and incorporate interoperability. If we choose to see the CitiVerse as a part of, a specific kind of, or a specific instance of Metaverse we will most likely have even higher demand on integrating CitiVerse with the fictive parts of Metaverse.



## ■ Advantages of the two kinds of worlds

So, when would we want to use a fictive Metaverse and when would a realistic CitiVerse be more suitable? Although answers to this question are likely to be revealed in the coming years, here are some initial thoughts on this discussion.

A freely designed fictive Metaverse may create thrilling environments and experiences that are more exciting than the ordinary real world, and therefore far more entertaining to visit. For example, the creation of “new” places to visit and go on “virtual vacations”. On the other hand, a CitiVerse may offer those that cannot afford to travel with the possibility to carry out virtual visits to digital copies of real historic attractions in any part of the real world, or experience wildlife nature without negative impact on flora and fauna. And so on.

In the future, where will people want to meet their friends? In a fictional world, or at a favourite coffee shop where they live, going along in person and meeting friends virtually using VR or AR glasses?

When companies advertise, will they prefer to use virtual worlds, or to offer their potential clients a realistic experience of their products or services in a real-world environment of shops, restaurants, theatres, and so on, using VR and AR glasses?

Already in today's world of gaming, we see the use of reconstructed sites and environments from the real world, such as famous racetracks, cities, or historical places for battles. Games that are already attempting to benefit from the hybrid worlds of Metaverse and CitiVerse. CitiVerses may provide edutainment through their realistic 3D worlds, utilised by the gaming industry, where players can experience fun and learn at the same time.

## ■ The need for standardisation

Although there is already extensive work initiated and ongoing regarding standardisation for Metaverses, this is not yet the case for CitiVerses.

Although, of course, we may not be certain, it does seem that in time CitiVerses could end up offering far greater possibilities than purely fictive Metaverse. For both public and private sectors, this may be manifested in terms of better ways to develop strategies and operate highly complex urban ecosystems in the face of delivering on sustainable and inclusive solution for society and the environment. It may well also provide enhanced human experiences and a wealth of new commercial opportunities. We therefore need to decide how best to build such CitiVerses, in a structured manner. Understanding what standards may be used jointly between Metaverses and CitiVerses is a first critical step forward. At the same time, we must determine how CitiVerses are aligned with Local Digital Twins, Urban Digital twins, and City Information Modelling.

By investing in CitiVerses without structured coordination and core standards in place, we run the likely risk of creating technologies and building blocks that will never fit together, thereby wasting public resources and losing precious time in taking advantage of the incredible opportunities that CitiVerses can bring. Furthermore, without “interoperability by design” through the use of standards, we risk creating (unmanaged) data silos, wasting energy and thereby creating negative climate impact.

Along this CitiVerses journey ahead, there will be many challenges and great discussions that will require agreements to achieve common ground, but with an adventure that can bring incredible opportunities for the good of society, humankind and our world.



# Visualisation of the standardisation landscape for CitiVerse and Metaverse

The three illustrations below provide one way to visualise the standardisation landscape for the CitiVerse and Metaverse.

- ▶ **Illustration 1** shows the combined standardisation landscape for CitiVerse. In the current version of this Landscape Report no standards for “application areas” have been included for CitiVerse standardisation. The application areas are displayed in the illustration as the green objects at the top.
- ▶ **Illustration 2** shows the standards & techniques in common between CitiVerse and Metaverse. The greyed-out objects are standards that may be used for both worlds, in certain cases.
- ▶ **Illustration 3** shows standards, techniques, and challenges specific to CitiVerse. This illustration indicates the large number of standards needed for a CitiVerse, compared to those needed for a pure fictive Metaverse. The greyed-out objects are standards that may be used for both worlds, in certain cases.

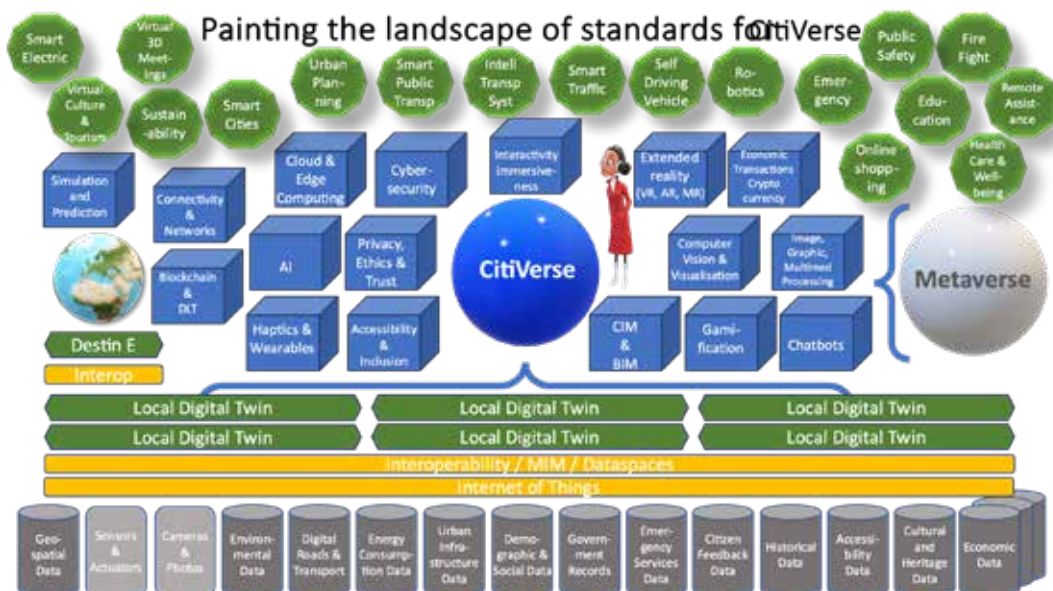


Illustration 1. The combined standardisation landscape for CitiVerse

## Similarities CitiVerse Metaverse

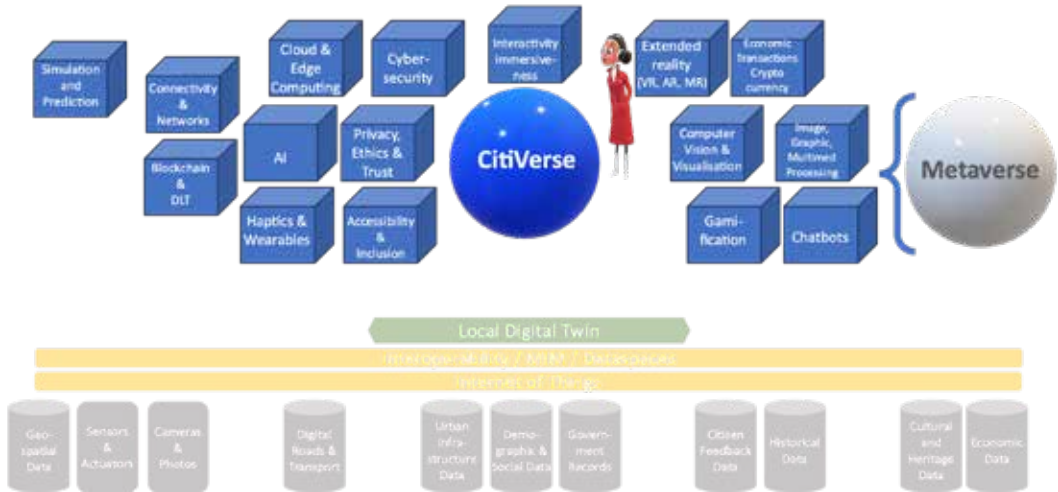


Illustration 2. Standards & techniques in common between CitiVerse and Metaverse

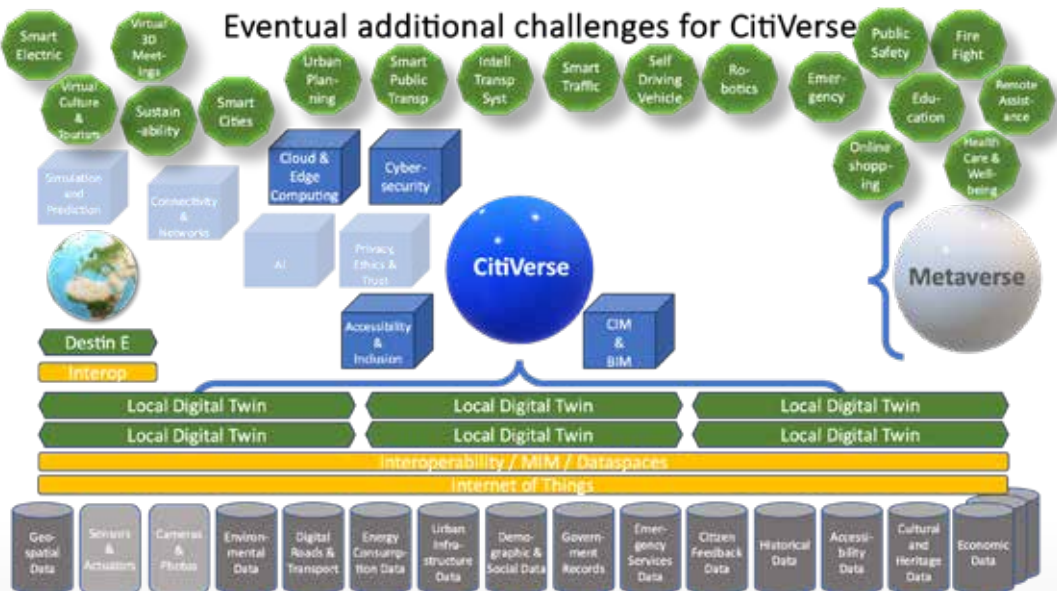


Illustration 3. Standards, techniques, and challenges that might be specific to CitiVerse









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