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| ITU logo | INTERNATIONAL TELECOMMUNICATION UNION  **TELECOMMUNICATION STANDARDIZATION SECTOR**  STUDY PERIOD 2017-2020 | | | SG13-TD688/WP2 | |
| **STUDY GROUP 13** | |
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| **Question(s):** | | | 17/13 | Virtual, 1-12 March 2021 | |
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| **Title:** | | | Draft Supplement ITU-T Y.sup.aisr: “Artificial Intelligence standardization roadmap” | | |
| **Purpose:** | | | Proposal | | |
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|  |  |
| --- | --- |
| **Keywords:** | Artificial Intelligence; Machine learning; Standardization Roadmap |
| **Abstract:** | This document is the updated draft supplement of Y.sup.aisr, “Artificial Intelligence standardization roadmap”. This document includes the results of discussion on the Q17/13 meeting which was held via virtual meeting in 1-12 March 2021. |

The following table shows discussion results for contributions and temporary documents.

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Source | Contribution title and Proposals | Agreements |
| TD 671 (WP2/13) | FG-AI4EE | LS/i/r on invitation to review Artificial Intelligence Standardization Roadmap and provide missing or updated information (reply to SG13-LS174) [from FG-AI4EE] | Accepted with modifications |
| C1227 | ETRI | Y.sup.aisr: Modification of gap analysis tables with analysis of academical and industrial categorizations of AI | Accepted with modifications |

During this meeting, it is agreed as follows:

* Update the information of AI standardization activities by reflecting LS from FG-AI4EE.
* Update the Table 8-1 which is standardization matrix of artificial intelligence.

It is recommended that future contributions cover following topics but not limited to:

* The **categorization criteria for standardization gap analysis** in the AI field.
* The allocation of the deliverables of ITU-T FG-AI4EE in standardization matrix
* The SDO's activities related with AI for further expansion and developing status.

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Artificial Intelligence Standardization Roadmap

AAP Summary

[To be provided before Approval]

Summary

This supplement provides the standards roadmap for artificial intelligence (AI) in the information technologies. This AI standards roadmap has been developed to assist in the development of AI standards in the IT fields by providing information about existing and under developing standards in key standards development organizations (SDOs). In addition, it describes the overviews of AI itself and AI related technical areas from standards perspective, AI related activities in standards development organizations (SDOs), and gap analysis.

Keywords

<Optional>

**CONTENTS**

| Page |
| --- |
| [1 Scope 4](#_Toc46426513)  [2 References 4](#_Toc46426514)  [3 Definitions 4](#_Toc46426515)  [3.1 Terms defined elsewhere 4](#_Toc46426516)  [3.2 Terms defined in this Recommendation 4](#_Toc46426517)  [4 Abbreviations and acronyms 4](#_Toc46426518)  [5 Conventions 5](#_Toc46426519)  [6 Overview of artificial intelligence standard development roadmap 5](#_Toc46426520)  [7 Developing Standards for Artificial Intelligence in SDO’s 6](#_Toc46426521)  [7.1 ITU-T SG13 6](#_Toc46426522)  [7.2 ITU-T SG16 9](#_Toc46426523)  [7.3 ITU-T SG5 12](#_Toc46426524)  [7.4 ITU-T SG12 12](#_Toc46426525)  [7.5 ITU-T SG17 15](#_Toc46426526)  [7.6 ITU-T SG20 15](#_Toc46426527)  [7.7 ITU-T SG9 16](#_Toc46426528)  [7.8 ITU-T SG11 17](#_Toc46426529)  [7.9 ITU-T SG2 18](#_Toc46426530)  [7.10 ITU-R SG6 19](#_Toc46426531)  [7.11 ISO/IEC JTC 1/SC 42 27](#_Toc46426532)  [7.12 ISO/IEC JTC 1/SC 29 30](#_Toc46426533)  [7.13 IEEE 32](#_Toc46426534)  [7.14 Khronos Group 35](#_Toc46426535)  [8 Gap analysis in artificial intelligence standardization 36](#_Toc46426536)  [Bibliography 42](#_Toc46426537) |

Draft Supplement ITU-T Y.sup.aisr

Artificial Intelligence Standardization Roadmap

# Scope

This Supplement provides the standardization roadmap for artificial intelligence (AI) area in the information technologies. It addresses the following subjects:

− overview of AI from the perspective of standards development;

− AI related activities in standards development organizations (SDOs);

− existing, approved, and under-developing standardization;

− standardization gap analysis.

# References

[ITU-T Y.3172] Recommendation ITU-T Y.3172 (2019), *Architectural framework for machine learning in future networks including IMT-2020*.

[ITU-T Y.3600] Recommendation ITU-T Y.3600 (2015), *Big data – Cloud computing based requirements and capabilities*.

# Definitions

## Terms defined elsewhere

This Supplement uses the following term defined elsewhere:

* + 1. **Artificial Intelligence (AI)** [ISO/IEC CD 22989] : capability of an engineered system to acquire, process and apply knowledge
    2. **Machine Learning (ML)** [ITU-T Y.3172]: processes that enable computational systems to understand data and gain knowledge from it without necessarily being explicitly programmed.

## Terms defined in this Recommendation

None.

# Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AI Artificial Intelligence

API Application Program Interface

ICT Information and Communications Technology

IEC International Engineering Consortium

ISO International Organization for Standardization

JTC 1 Joint Technical Committee 1

ML Machine Learning

NNEF Neural Network Exchange Format

SC Subcommittee

SDO Standards Development Organization

SG Study Group

TC Technical Committee

WG Working Group

# Conventions

None.

# Overview of artificial intelligence standard development roadmap

[Editor’s Note] In this clause 6, overview of the roadmap will be included with the description of general concepts of AI. It may include the landscape of AI from ITU-T perspectives if possible. In addition, it may include the potential standardization areas of AI that may be of interest to ITU-T.

In this supplement, the definition of artificial intelligence (AI) is referred as ‘capability of an engineered system to acquire, process and apply knowledge’ [ISO/IEC CD 22989]. This definition allows to restrict that the AI is a part of computer science without focusing on defining what the intelligence itself is.

NOTE – Defining the intelligence or knowledge itself is philosophical and paradoxical question which is hard to find the answers with technical approaches. [b-George F L.]

Since the definition of AI limits the its scope to information technologies (IT), the contents of this supplement only include AI techniques which are utilizing in the field of computer science. In computer science, the AI is implemented with the data structures for representing knowledge, the algorithms for applying the knowledge, and the languages and programming techniques for implementing knowledge. And the domain of AI includes technical topics such as computer vision, natural language processing, robotics, search engines, online advertising and etc.

Machine Learning is the one of programmable approach to building AI systems in the real-world. The machine learning achieves the goal by automatically improving its ability to solve problem with learning algorithm. The learning algorithm is explicitly programmed to enable computers to learn through experience. The example of machine learning is ‘deep learning’ which utilizing neural network algorithm. The machine learning shows high-performance in many tasks than the rule-based programming algorithms. Therefore, the machine learning algorithms are adopting in many fields of computer science such as speech recognition, natural language processing, customer relationship management, and etc.

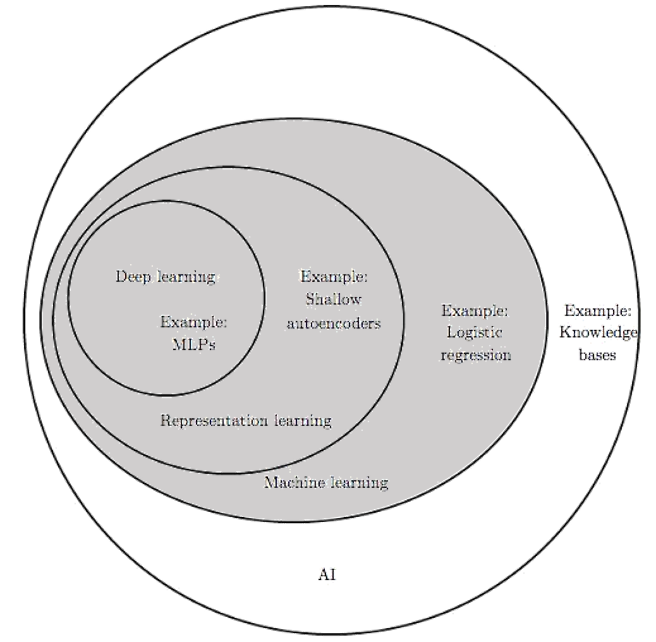


Figure 6-1 – A Venn diagram of AI technologies and the scope of this supplement

This supplement especially covers the AI techniques designed with machine learning including deep learning, neural network, and so on. The figure 6-1 shows the scope of this supplement in the fields of AI.

NOTE – The Venn diagram of AI technologies proposed in [b-Ian G.].

# Developing Standards for Artificial Intelligence in SDO’s

[Editor’s Note] Clause 7 will contain the list of key international AI standards development organizations and their work. The expected SDOs includes ITU-T, ISO/IEC, IEEE, and Khronos group. The contributions are invited for further expansion to other standard organizations with the information of their activities related with AI.

[Editor’s Note on 2019-06-26] It is needed the description of introduction to SDO related with AI/ML.

## ITU-T SG13

[Editor’s Note] It needs to discuss for how to handle the FG activities of ITU-T in the clause 7.

Table 7-1 lists the ITU‑T deliverables and work items related to artificial intelligence and machine learning.

Table 7-1 – ITU-T SG13 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG13 | [ITU-T Y.3170] | Requirements for machine learning-based quality of service assurance for the IMT-2020 network | Published 2018 |
| SG13 | [ITU-T Y.qos-ml-arc] | Architecture of machine learning based QoS assurance for IMT-2020 network | 4Q 2019 |
| SG13 | [ITU-T Y.MecTa-ML] | Mechanism of traffic awareness for application-descriptor-agnostic traffic based on machine learning | 4Q 2020 |
| SG13 | [ITU-T Y.MLaaS-reqts] | Cloud computing- functional requirements for machine learning as a service | 4Q 2019 |
| SG13 | [ITU-T Y.3172] | Architectural framework for machine learning in future networks including IMT-2020 | Consented 2019-03 |
| SG13 | [ITU-T Y.bDDN-MLMec] | Mechanisms of machine learning for big data driven networking | 4Q 2021 |
| SG13 | [ITU-T Y.ML-IMT2020-Data-Handling] | Mechanism of traffic awareness for application-descriptor-agnostic traffic based on machine learning | 4Q 2019 |
| SG13 | [ITU-T Y.Suppl to Y.317X series] | Machine learning in future networks including IMT-2020: use cases | 4Q 2019 |
| SG13 | [ITU-T Y.IMT2020-NSAA-reqts] | Requirements for network slicing with AI-assisted analysis in IMT-2020 networks | 2020-7 |
| SG13 | [Y.ML-IMT2020-MP] | ML marketplace integration in future networks including IMT-2020 | 2Q 2020 |
| SG13 | [Y.IMT2020-AIICDN-arch] | AI integrated cross-domain network architecture for future networks including IMT-2020 | 2021-12 |
| SG13 | [Y.ML-IMT2020-NA-RAFR] | Architecture framework of AI-based network automation for resource adaptation and failure recovery for future networks including IMT-2020 | 2020-Q2 |

* **ITU-T Y.3170**: This recommendation specifies requirements of machine learning based QoS assurance for the international mobile telecommunications 2020 (IMT-2020) network. This recommendation provides an overview of machine learning based QoS assurance for IMT-2020 network. It describes capabilities for QoS anomaly detection and prediction using machine learning. In addition, recommendation describes a functional model of machine learning based QoS assurance which includes functional components such as QoS data collection, data pre-processing, data storage, modelling and training, QoS anomaly detection and prediction, QoS policy decision making, enforcement and reporting. Based on the capabilities and functionalities described in the functional model, this recommendation specifies the high-level requirements and functional requirements of machine learning based QoS assurance for IMT-2020 network.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14278>

* **ITU-T Y.qos-ml-arc**: This recommendation specifies architecture of machine learning based QoS assurance for the international mobile telecommunications 2020 (IMT-2020) network. It provides an overview of unified architecture for ML in 5G and future networks. In addition, it describes the architecture of machine learning based QoS assurance. Based on the architecture, this recommendation specifies the procedures of machine learning based QoS assurance for IMT-2020 network.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14278>

* **ITU-T Y.MecTa-ml**: Application-descriptor-agnostic traffic is the traffic which cannot be identified by an application descriptor. On the one hand, traditional traffic awareness technologies such as deep packet inspection are not highly effective when they are applied to application-descriptor-agnostic traffic. On the other hand, with development of the artificial intelligence, many related technologies are emerging and applied in various areas. Compared to traditional traffic methods, traffic awareness method combining with machine learning based technologies will be more effective when it is used to process other application-descriptor-agnostic. Therefore, it is time to study mechanism and methods to implement application-descriptor-agnostic traffic awareness functions based on machine learning. This Recommendation specifies the mechanism of traffic awareness for application-descriptor-agnostic traffic based on machine learning.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14619>

* **ITU-T Y.MLaaS-reqts**: This Recommendation provides cloud computing requirements for machine learning as a service, which addresses requirements from use cases. Machine learning as a service (MLaaS) is a cloud service category to support the development and applications of machine learning in the cloud computing environments. On the perspective of cloud computing service provisioning, this Recommendation defines the functional requirements for MLaaS to identify functionalities such as data gathering, machine learning modelling and computing resources, etc. Also, this draft Recommendation aligned with the cloud computing reference architecture of ITU-T Y.3502. Developments of machine learning algorithms and methodology are out of the scope on this Recommendation.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14484>

* **ITU-T Y.3172**: This document specifies an architectural framework for machine learning (ML) in future networks including IMT-2020. A set of architectural requirements and specific architectural components needed to satisfy these requirements are presented. These components include, but are not limited to, ML pipeline and ML management and orchestration functionalities. The integration of such components into future networks including IMT-2020 and guidelines for applying this architectural framework in a variety of technology-specific underlying networks are also described.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15020>

* **ITU-T Y.bDDN-MLMec**: This Recommendation specifies the mechanisms of machine learning for big data driven networking, its scope includes the following aspects: o studying the procedures of machine learning applied in bDDN; o studying the general machine learning approach for bDDN; o studying the interfaces related to machine learning for bDDN; o studying the learning and control path based on machine learning for bDDN; o studying other aspects related to machine learning for bDDN.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15183>

* **ITU-T Y.ML-IMT2020-Data-Handling**: A framework of data handling to enable machine learning in future networks including IMT 2020 is described in this document. The requirements for ML data collection and ML processing mechanisms in various usage scenarios for ML in future networks are identified along with the requirements of corresponding targets for ML output in the network. Based on this, a generic framework of data handling and examples of its realisation on specific underlying networks are described.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15177>

* **ITU-T Y.Suppl to Y.317X series**: This Supplement describes the use cases of Machine Learning in future networks including IMT-2020. For each use case description, along with the benefits of the use case, the most relevant possible requirements related to the use case are provided. Classification of the use cases into categories is also provided.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15175>

* **ITU-T Y.IMT2020-NSAA-reqts**: Based on the future operation and maintenance management of network slicing and the purpose of satisfying users' SLA requirements, the objective of this document is to describe the requirements, architecture and function design of network slicing based on intelligent network analysis.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15061>

* **ITU-T Y.ML-IMT2020-MP**: This Recommendation provides the architecture for integration of ML marketplace in future networks including IMT-2020. The scope of this Recommendation includes ‘Challenges and motivations for ML marketplace integration’, ‘High level requirements of ML marketplace integration’, and ‘Architecture for integration of ML marketplace in networks’.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16345>

* **ITU-T Y.IMT2020-AIICDN-arch**: This Recommendation specifies the design principles and architecture of AI (including machine learning) integrated cross-domain network for future networks including IMT-2020.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16347>

* **ITU-T Y.ML-IMT2020-NA-RAFR**: This draft Recommendation specifies an architecture framework of artificial intelligence (AI)-based network automation for resource adaptation, failure detection and recovery for the purpose of improving network efficiency and maintaining QoS by continuously monitoring the network and promptly deciding about appropriate actions for resource adaptation and failure recovery with the help of AI including machine learning.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16343>

## ITU-T SG16

Table 7-2 lists the ITU‑T SG16 deliverables and work items related to artificial intelligence and machine learning.

[Editor’s Note] The Table 7-2 is updated to reflect the LS document from SG16 in SG13 meeting in 20-31 July 2020.

Table 7-2 – ITU-T SG16 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG16 | [ITU-T H.CUAV-AIF] | Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence | 2021 |
| SG16 | [ITU-T F.VS-AIMC] | Use cases and requirements for multimedia communication enabled vehicle systems using artificial intelligence | 2022 |
| SG16 | [ITU-T F.EMO-NN] | Emotion enabled multimodal user interface based on artificial neural network | 2021 |
| SG16 | [ITU-T F.AI-MLTF] | Technical framework for shared machine learning system | 2021 |
| SG16 | [ITU-T F.SCAI] | Requirements for smart class based on artificial intelligence | 2021 |
| SG16 | [ITU-T FSTP-ACC-AI] | Guideline on the use of AI for ICT accessibility | 2021 |
| SG16 | [ITU-T F.CDN-AINW] | Requirements and reference model for CDN services over AI network | 2023 |
| SG16 | [ITU-T FSTP-ACC-AI] | Guideline on the use of AI for ICT accessibility | 2020 |
| SG16 | [[F.748.11 (ex F.AI-DLPB)](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15295" \o "See more details)] | Metrics and evaluation methods for deep neural network processor benchmark | 2020-07 |
| SG16 | [[F.AI-DLFE](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15296)] | Deep Learning Software Framework Evaluation Methodology | 2021 |
| SG16 | [[F.AI-DMPC](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16634)] | Technical framework for Deep Neural Network model partition and collaborative execution | 2021 |
| SG16 | [[F.AI-FASD](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16636)] | Framework for audio structuralizing based on deep neural network | 2021 |
| SG16 | [[F.AI-ILICSS](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16639)] | Technical Requirements and Evaluation Methods of Intelligent Levels of Intelligent Customer Service System | 2021 |
| SG16 | [[F.AI-RMCDP](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16637)] | Requirements of multimedia composite data preprocessing | 2021 |
| SG16 | [[F.AI-SCS](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16381)] | Use cases and requirements for speech interaction of intelligent customer service | 2021 |
| SG16 | [[F.IMCS](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16633)] | Requirements for smart speaker based Intelligent Multimedia Communication System | 2021 |
| SG16 | [[F.Supp-OCAIB](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16631" \o "See more details)] | Overview of convergence of artificial intelligence and blockchain | 2021 |
| SG16 | [[F.746.11 (ex F.IQAS-INT)](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15015" \o "See more details)] | Interfaces for intelligent question answering system | 2020-07 |
| SG16 | [[H.AI-SaMD-Req](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16376)] | Requirements for artificial intelligence/machine learning (AI/ML)-based software as a medical device (SaMD) | 2021 |
| SG16 | [[HSTP.Med-AI-CCTA](http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16378" \o "See more details)] | Guidelines on development and application of artificial intelligence in coronary computed tomography angiography | 2022 |

* **ITU-T H.CUAV-AIF**: This recommendation provides framework and requirements for civilian unmanned aerial vehicle (CUAV) flight control using artificial intelligence. Currently, the CUAV has been widely used in indust ry and consumption areas, there are also problems in the development of CUAVs. In addition to the policy and legal supervision, the other problem is how CUAVs avoid obstacles during the flight, and how the CUAVs applied in a specific industry can automatically navigate, track or fly along a specific area according to the mission requirements. This draft Recommendation provides a framework of civilian unmanned aerial vehicle flight control using Artificial Intelligence, including the flight navigation control of a CUAV itself (including avoiding obstacles, normal take-off and landing) and the specific flight control (including automatic navigation, tracking, or along a regular direction or specific area) based on the specific industry application requirements. This framework is not a specific implementation case, but it provides a framework and capability requirements for each specific implementation, and the product and system integrators can design and produce specific products and systems according to this framework.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14760>

* **ITU-T F.VS-AIMC**: This recommendation specifies use cases and requirements of artificial intelligence for ICT-enabled autonomous vehicle systems. This draft Recommendation covers the followings:
  + Use cases: to identify the use cases of artificial intelligence applied to the ICT-based autonomous vehicle systems, e.g. situational awareness, route planning, driving behavior decision and human-computer interaction;
  + Requirements: to identify the service and network requirements, functional requirements and non-functional requirements of the ICT-based autonomous vehicle systems .

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14767>

* **ITU-T F.EMO-NN**: This Draft Recommendation provides UI functional entities and architecture for emotion enabled multimodal user interface based on artificial neural network.   
  As Emotion technology can give big improvement in HCI (Human Computer Interaction), many companies and researchers have been studying emotion technology. Various applications using multimodality and emotion analysis begin to be introduced these days with artificial intelligence technology. However, current many systems still did not infer human emotion properly yet, because some systems are too dependent to certain source, or too weak for real circumstances.   
  Therefore, the proposed system architecture is for multimodal UI based on emotion analysis with some properties and illustrations data with artificial neural network. The multimedia data is composed of text, speech, and image. And, for the unimodal emotion analysis, these data are pre-processed in each. For example, the text data can be pre-processed by data augmentation, person attributes recognition, topic cluster recognition, document summarization, named entity recognition, sentence splitter, keyword cluster, sentence to graph.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15026>

* **ITU-T F.AI-MLTF**: This Recommendation provides the architecture framework, technical requirements and application guidelines for Shared Machine Learning system.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15262>

* **ITU-T F.SCAI**: Smart class is designed to improve lecture preparation, enhance interaction between teachers and students and promote teaching quality via educational data analytics and advanced teaching equipment. This document describes application scenarios and requirements for smart class based on artificial intelligence.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15294>

* **ITU-T FSTP-ACC-AI**: This technical paper describes the use of AI for ICT accessibility. AI technologies such as automatic speech recognition for captioning are described, with their pros and cons. It also describes some parameters and criteria for objective, quantitative assessment and measurement the quality of service using these technologies.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15037>

* **ITU-T F.AI-DLFE**: With great desire in AI applications, Deep Learning Framework provide an easy and fast way for manufacturers to develop their own applications. However, different frameworks show different performance under different scenarios. It is a necessity to formulate a recommendation to evaluate the performance of Deep Learning Frameworks in order to help manufacturers take full advantages of certain framework and avoid disadvantages of others.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15037>

* **ITU-T F.AI-DLPB**: This Recommendation provides the benchmarking framework, evaluation metrics and methods, and a guideline of technical testing for deep learning processor while doing training and inference task. The edge computing market, where AI computation is done on the device, is expected to represent more than three-quarters of the total market opportunity, with the balance being in cloud/data center environments. Mobile phones will be a major driver of the edge market, and other prominent edge categories include automotive, smart cameras, robots, and drones.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15295>

## ITU-T SG5

Table 7-3 lists the ITU‑T SG5 deliverables and work items related to artificial intelligence and machine learning.

Table 7-3 – ITU-T SG5 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG5 | [ITU-T L.1305] | Data centre infrastructure management system based on big data and artificial intelligence technology | Consented 2019-09 |

* **ITU-T L.1305** : This Recommendation contains technical specifications of data centre infrastructure management system (DCIM), following aspects are covered: - Principles - management objects - Management system scheme - data collection function requirements - operational function requirements -- Energy saving management -- Capacity management for ICT and facilities -- Other operational Function requirements -- Intelligent controlling on system to maximize the green energy uses. Other items - maintenance function requirements -- Early Alarm and protection based on the big data analysis -- Intelligent controlling on system to decrease the cost for maintenance are also considered.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14873>

## ITU-T SG12

Table 7-4 lists the ITU‑T SG12 deliverables and work items related to artificial intelligence and machine learning.

[Editor’s Note] The Table 7-4 is updated to reflect the LS document from SG12 in SG13 meeting in 20-31 July 2020.Table 7-4 – ITU-T SG12 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG12 | [ITU-T P.MLGuide] | Guide for Development of Machine Learning Based Solutions | 2Q 2021 |
| SG12 | [ITU-T P.565 (ex P.VSQMTF)] | Framework for creation and performance testing of machine learning based models for the assessment of transmission network impact on speech quality for mobile packet-switched voice services | 2020 |
| SG12 | [ITU-T E.475 (ex E.FINAD)] | Guidelines for Intelligent Network Analytics and Diagnostics | 2020 |
| SG12 | E.AIQ | Artificial Intelligence Quotient (AI-Q) for indexing and rating AI algorithms used in conversational AI systems employed for customer service management, service optimization and management as part of service quality assessment methodologies | - |

* **ITU-T P.MLGuide**: The ML topic's imminence grew significantly in the telecom industry lately and mainly due to the fact that 5G networks must heavily rely on machine learning; from the intelligently adaptive RAN to real time network slicing adaptation to seamless context aware QoE service delivery and expected transformation of human's demands and perception. It is becoming impetuous for network operators to use machine learning to cost efficiently operate, control and manage their networks. Therefore, in order to remain relevant to the evolving telecom industry, SG 12 needs to adapt to and adopt case by case basis ML based approaches. ML approaches are to some extent use case specific, and these regard the conditions and assumptions within which ML techniques are applied, such as real time with continuous adaptive learning/tuning for non-supervised suited applications (e.g. network quality diagnosis, control and management) or off -line learning for supervised suited applications (e.g. QoE prediction). Regardless of the use case, the following aspects related to topics such as, but not limited to, are addressed in this recommendation guide: training/learning databases integrity and validity (data cleansing); training and validation data bases' split process; machine learning features' selection; ML algorithm's accuracy and consequently its suitability for a specific application; ML overfitting/underfitting test.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15114>

* **ITU-T P.565**: The output of the framework is a machine learning based speech quality prediction model, which predicts the impact on the speech quality from the IP transport and underlying transport, as well as the jitter buffer in the end client; thus providing a network centric view on the speech quality service delivered on mobile packet switched networks. This is expressed in terms of a MOS-LQO under the assumption of an otherwise clean transmission, without background noise, automatic gain control, voice enhancement devices, transcoding, bridging, frequency response, clock drift or any other impairment not caused by the IP transport and underlying transport. The models according to this framework use information on the temporal structure of the reference signal to identify the importance of individual sections of the bitstream with regard to speech quality. These models do not perform any perceptual analysis of the recorded speech signal. The framework specifies three modules required for the development of these kinds of metrics: the databases generator module, the machine learning module, and the validation module for the trained model. In addition, database content and the features used by the machine learning algorithm are described. The framework also provides a large set of test vectors, in the form of error (jitter and packet loss) patterns files for learning and validation. The recommendation specifies minimum required performance, as well as conditions and requirements for an independent additional validation for models developed based on the framework. The recommendation also specifies implementation requirements. The models developed based on the framework enable the assessment of transmission network impact on speech quality for mobile packet-switched voice services, and therefore benefit operators and regulators alike with a fast and easy speech quality trend monitoring / benchmarking and troubleshooting. In addition, if predictors according to this framework are used together with perceptual speech quality metrics like P.863, it is possible to identify if the source of problems resides inside or outside the transport network observed by the predictor according to this framework and thus a more detailed analysis of the situation can be achieved and consequently troubleshooting of less obvious degradations such as the ones occurring outside of the transport network (e.g. emerged from automatic gain control, voice enhancement devices, transcoding or analog processing) is enabled.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14353>

* **ITU-T E.475** : With the increased number of connected devices and the proliferation of web and multimedia services, cloud services and IoT applications, networks are subject to various network incidents and unregulated network changes which may be measured by network alerts and logs received from the underlying networks. Therefore, it is important for the networks to be aware of the services and applications they transport to optimize the operation and ensure that service quality meets user expectations. The absence of network alerts or network logs is generally interpreted as an indication of good network health, however this is not necessarily the case. Service quality problems may not be the result of network device failures, but instead due to issues that are not detected by traditional network monitoring tools such as configuration errors, insufficient network capacity, wireless access point issues (e.g., insufficient coverage, interference or overlapping channel), or third party network issues.   
  Typically, the manual network reconfiguration is time consuming and often error prone. In addition, service quality assessment methodologies need to further distinguish between network impairments and other causes of the performance degradation by considering application-specific factors (e.g., encoding/decoding, interaction between an application and a network) because the traditional assessment tools cannot provide accurate fault diagnosis, fault prediction, and root cause analysis. Furthermore, the reaction time of traditional assessment tools tends to be slow, responding after the service disruption occurs. In addition, the network performance metrics may contribute to QoS/QoE assessment, but many of existing network performance metrics may reflect only limited aspects of the network quality.   
  When the objectively-measured results indicate an unsatisfactory level of network performance or anomaly degree, it is desirable that the system performs necessary corrective actions automatically to resolve the identified quality problems.  
  This Recommendation specifies guidelines for intelligent network analytics and diagnostics for managing and troubleshooting networks. The Intelligent Network Analytics and Diagnostics (INAD) function is responsible for aggregating network data and setting up automatic tasks for network maintenance, providing the assurance of appropriate network performance, locating the service degradation area and service channels with poor performance, finding root causes of the detected network faults, probing network status, and predicting the possible network performance degradation at an early stage.   
  Specifically, this Recommendation describes the design considerations, functional architecture, network anomaly analysis models for network analytics and diagnostics. The network anomaly analysis model can be used to assess network anomaly degree, network performance, risk degree, to analyze the location and time of the network impairment and further to determine the root causes of the network impairments and to allow increased network visibility and network fault management automation.  
  This Recommendation also presents the concept of Network Health Indicator (NHI) which provides a numerical indication of the network anomaly degree based on Big Data Analytics. The NHI is not focused on specific multimedia application rating (e.g., rating of specific audio application, video conferencing application) and application layer monitoring. Instead, it aims at network monitoring and evaluation of specific networks (e.g., LAN, WAN, Storage Network, Data Centre Network) and further triggers Network Diagnosis using Big Data based fault diagnosis algorithms and determine the root causes of the network anomaly events.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14037>

* **ITU-T E.AIQ**: Artificial Intelligence (AI) is advanced computing that enables a machine to interact with its environment in an intelligent way. With perpetual advancements in technologies pertaining to Neural Networks, Natural Language Processing, Facial Recognition and Sentiments and Gesture Analysis, AI is going to have potential uses of serving as front desk support for consumer interfaces. AI assisted applications / virtual assistants can be used as conversational AI for customer service management, public grievance management, service optimization and quality of service management and can add tremendous value in customer service relations, quality of service and overall quality of experiences. AI systems will be used to better serve the human and their intelligence is mainly reflected in the process of serving. The higher the intelligence level is, the better service to the consumer will be offered by such system. Before putting such AI based systems in the network, if capabilities of AI algorithms are adjudged based on some predefined Key Performance Indicators (KPIs), it will help network managers in doing cost benefit analysis. The proposed Recommendation defines these Key Performance Indicators (KPIs) serving as basis for an A-IQ (Artificial Intelligence Quotient), which can be used for indexing and rating AI algorithms for their capabilities in quality of service and quality of experience improvement, as part of service quality assessment methodologies. This will be under mandate of SG12 for operational aspects of performance, QoS and QoE of such services and development of quality assessment methodologies, both subjective and objective.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16788>

## ITU-T SG17

Table 7-5 lists the ITU‑T SG17 deliverables and work items related to artificial intelligence and machine learning.

Table 7-5 – ITU-T SG17 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG17 | [ITU-T TR.cs-ml] | Technical Report: Countering spam based on machine learning | 3Q 2020 |

* **ITU-T TR.cs-ml**: The purpose of this work item is to define a technical framework for countering spam based on machine learning. It may help some relevant persons and companies in spam management, reduce the benefit loss of users and providers, improve user experience and promote the healthy development of telecommunication business.  
  This technical report provides some general scenarios, characteristics of spam, and define general technical framework, work flows, to help some companies and users to counter spam.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=15246>

## ITU-T SG20

Table 7-6 lists the ITU‑T SG20 deliverables and work items related to artificial intelligence and machine learning.

Table 7-6 – ITU-T SG20 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG20 | [ITU-T  Y.SSC-AISE-arc] | Reference architecture of artificial intelligence service exposure for smart sustainable cities | 4Q 2019 |
| SG20 | [ITU-T  Y.Sup.AI4IoT] | Unlocking Internet of things with artificial intelligence | 4Q 2019 |

* **ITU-T Y.SSC-AISE-arc**: This recommendation introduces the artificial intelligence service exposure (AISE) for smart sustainable cities (SSC), analyses common characteristics and high-level requirements of AISE, brings a reference architecture of AISE and relevant common capabilities. The AISE is one of the bases, supporting functional entities for smart sustainable cities, with which the SSC services can use the uniform interfaces (exposed by the AISE) to integrate and access the AI capabilities (functionalities) of AI services (e.g., machine learning services for video/audio/picture recognition, natural language processing services, traffic prediction services etc.). The AISE can leverage the AI capabilities developed and exposed by AI service providers for SSC services, and can support the SSC service providers to integrate and access the exposed AI capabilities. The AISE can provide security and privacy mechanism on the SSC data. The AISE can support the AI service providers to design and train AI capabilities with local SSC data on AISE in SSCs, and can support the SSC services to integrate and access AI capabilities.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14503>

* **ITU-T Y.Sup.AI4IoT**: As the IoT system seeks to spread within the urban realm in keeping with smart and sustainable city aspirations, the need to manage the burgeoning big data and establishing a self-sustaining urban ecosystem is at the fore-front. Accordingly, this Technical Report examines how artificial intelligence could step in as the saviour and bolster the intent of urban stakeholders to deploy IoT technologies and eventually transition to smart cities. This Technical Report includes:
  + The various technologies from AI which will help cater to urbanization and facilitate smart city transformations;
  + The role played by AI in managing the data generated within the IoT realm;
  + The main benefits of adopting AI and delving into how this technology could be leveraged to attain the targets stipulated in the recently established Sustainable Development Goals (SDGs).

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14103>

## ITU-T SG9

Table 7-7 lists the ITU‑T SG9 deliverables and work items related to artificial intelligence and machine learning.

[Editor’s Note] The Table 7-7 is updated to reflect the LS document from SG9 in SG13 meeting in 20-31 July 2020.

Table 7-7 – ITU-T SG9 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG9 | ITU-T J.1600 | [Premium cable network platform – Framework](https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13977) | In force |
| SG9 | ITU-T J.pcnp-char | E2E network characteristics requirement for video services | Under Study |
| SG9 | ITU-T J.pcnp-smgw | Functional requirements for Smart Home Gateway | Under Study |

* **ITU-T J.1600**: Recommendation ITU-T J.1600 specifies the framework of the premium cable network platform (PCNP) for cable TV and broadband network that exploit cloud based artificial intelligence (AI) and network data to optimize network and TV services, thus enabling the high satisfaction of user's experience of perceptual aspects of services.

URI: <https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13977>

* **ITU-T J.pcnp-char**: Different video services (4K, 8K, VR, AR, etc.) have different requirements of the network performance which evaluated by network key performance indicators (KPI). Also different video services for user experience have different quality requirements to be evaluated by service key quality indicators (KQI). This recommendation will specify the E2E network characteristics (KPI and KQI) especially for their appropriate values or ranges for characterizing a very good delivery and user experience of advanced videos, includes TV and OTT videos (4K, 8K, VR, AR, etc.).

URI: TBD

* **ITU-T J.pcnp-smgw**: In a Smart Home solution, a smart home gateway is incorporated to connect various smart home appliances, and an IoT connection management platform is required to enable various applications. These applicable solutions include: home health, entertainment, security, and home automation, which promotes a safer, happier, and more comfortable and convenient lifestyle. The proposal aims to define the functional requirement and specification for a smart home gateway, from both hardware and software point of views, ensuring secure interoperability for consumers, businesses and industries by delivering a standardized communications platform to allowing devices to communicate cross operating system, service provider, transport technology or ecosystem.

URI: https://www.itu.int/itu-t/workprog/wp\_item.aspx?isn=14926

## ITU-T SG11

Table 7-8 lists the ITU‑T SG10 deliverables and work items related to artificial intelligence and machine learning.

[Editor’s Note] The Table 7-8 is updated to reflect the LS document from SG10 in SG13 meeting in 20-31 July 2020.

Table 7-8 – ITU-T SG11 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG11 | [ITU-T Q.5001] | Signalling requirements and architecture of intelligent edge computing | Published 2018 |
| SG11 | [ITU-T Q.INS-PM] | Protocol for managing Intelligent Network Slicing with AI-assisted analysis in IMT-2020 network | 1Q 2021 |
| SG11 | [ITU-T Q.IMT2020-PIAS] | Protocol for providing intelligent analysis services in IMT-2020 network | 4Q 2021 |
| SG11 | [ITU-T Q.VoLTE-SAO-FP] | Framework and protocols for signalling network analyses and optimization in VoLTE | 4Q 2021 |

* **ITU-T Q.5001**: A large volume of data have been generated from the use of various types of smart things. The related smart services have been working based on cloud systems. However, various issues have occurred as a result of the network bottleneck between terminals and a cloud system (e.g., data loss, network delay, etc.). An edge computing technology between the user equipment and a cloud server system is envisaged to solve these problems. In addition, applying the intelligent data processing functions by providing artificial intelligence (AI) technologies will provide enhanced networking capabilities for new emerging services and applications.  
  Regarding these emerging environments, Recommendation ITU-T Q.5001 defines the intelligent edge computing (IEC). It is applicable to collect, store, and process data reliably in the intelligent edge computing, especially to support mission critical services. Thus, the main functionality of intelligent edge computing is collecting, processing, analysing the data and providing the values based on intelligent data processing.  
  This Recommendation specifies use cases, signalling requirements and an architecture of intelligent edge computing.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=14276>

* **ITU-T Q.INS-PM**: This recommendation specifies APIs, API management, message format and procedures related of intelligent network slice with AI-assisted in IMT-2020 networks.  
  Intelligent network slicing with AI-assisted functions is capable of allocating limited resources to meet the SLA of slicing users in real time dynamically. It is necessary to develop an intelligent network slicing API framework which makes the IMT-2020 network more efficient and flexible. The framework includes common aspects and some functional APIs which provide AI-assisted functions

URI: <https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=15152>

* **ITU-T Q.IMT2020-PIAS**: This recommendation specifies architecture for supporting intelligent analysis services in IMT-2020 network, and intelligent analysis services offered by Data Analysis Function (DAF) including load balancing, network functions fault location and advance warning, device on/off analysis, mobility analysis ,etc. It includes signalling flows for network functions (NFs) event exposure to DAF and DAF analytics exposure to NFs, message format, and security considerations.  
  Data analysis function (DAF) is defined in ITU-T Q.INS-PM, and DAF introduced in IMT-2020 network [ITU-T Y.3104] can provide intelligent analysis services. Intelligent analysis services offered by DAF include load balancing, NF fault location and warning, device on/off analysis, mobility analysis, energy saving, etc. It is necessary to enable network automation and intelligence.

URI: <https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=16387>

* **ITU-T Q.VoLTE-SAO-FP**: This draft Recommendation defines the framework of signalling network analyses and optimization for VoLTE network, specifies the interfaces and protocols between signalling network analyses and optimization system and VoLTE network, specifies the service procedures of signalling network analyses and optimization, and specifies the AI-assisted functions and security issues of the proposed system.  
  The proposed signalling network analyses and optimization system is a network management system with the characteristics of high efficiency, real time reaction, reliability and intelligence, designed for VoLTE network.

URI: <https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=16385>

## ITU-T SG2

Table 7-9 lists the ITU‑T SG2 deliverables and work items related to artificial intelligence and machine learning.

Table 7-9 – ITU-T SG2 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG2 | [M.resm-AI] | Requirements for energy saving management of 5G RAN system with AI | 2022-12 |
| SG2 | [M.AI-TOM] | Framework of AI enhanced Telecom Operation and Management (AITOM) | 2020 |
| SG2 | [M.rwop-AI] | Requirements for work orders processing in telecom management with AI | 2022 |

* **ITU-T M.resm-AI**: This draft Recommendation provides requirements for energy saving management of 5G RAN system with AI. This draft targets for proving requirement of energy saving management for communication units and virtualized hardware resources of base station via OMC and open interfaces provided by vendors, from OSS perspective. As a necessary technology, AI is applied to the energy saving management of 5G RAN system across vendors and communication systems, such as 4G and 5G. In addition, this draft Recommendation includes sending intelligent energy saving strategies from OSS to OMC and then to wireless equipment.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16435>

* **ITU-T M.AI-TOM**: This Recommendation provides framework of Artificial Intelligence (AI) enhanced Telecom Operation and Management (AITOM). It describes functional architecture of AITOM to support telecom operation management for efficiency improvement, quality assurance, cost management, and security assurance. It also describes AI pipeline and information model on how to enable AITOM using AI technology.

URI: <https://www.itu.int/itu-t/workprog/wp_item.aspx?isn=16432>

* **ITU-T M.rwop-AI**: This Recommendation focuses on work orders processing in telecom management with AI. This Recommendation provides the function requirement, typical scenario and feature extraction process of work orders.   
  URI：<https://www.itu.int/ITU-T/workprog/wp_item.aspx?isn=16615>

## ITU-R SG6

Table 7-10 lists the ITU‑R SG6 deliverables and work items related to artificial intelligence and machine learning.

[Editor’s Note] The Table 7-10 is updated to reflect the LS document from ITU-R SG6 in SG13 meeting in 20-31 July 2020.

Table 7-10 – ITU-R SG6 deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| SG 6 | Question ITU-R 144/6 | Use of Artificial Intelligence (AI) for broadcasting | 2019 |
| SG 6 | Report ITU-R BT.2447 | Artificial intelligence systems for programme production and exchange | 2019 |

* **Question ITU-R 144/6**: Question ITU-R 144/6 acknowledges that Artificial Intelligence technologies are increasingly used in many areas of society including broadcasting and asks what is the impact of AI technology and how can it be deployed to increase efficiency in the areas of programme production, quality evaluation, programme assembly (including content scheduling and archive mining) and for broadcast emission.

URI: https://www.itu.int/pub/R-QUE-SG06.144

* **Report ITU-R BT.2447**: Report ITU-R Report ITU-R BT. 2447 “Artificial intelligence systems for programme production and exchange”, discusses current applications and efforts underway and evaluated that are relevant to the near-term broadcast programme and production pathway. Relevant applications and efforts are categorized into the following topical descriptions for areas of technological benefit: Workflow Optimization, Bandwidth Optimization, Automated Content Creation, Content Creation from Legacy Archives, Content Selection for Targeting Audience Demographics, Optimization of Asset Selection – Metadata Creation, Dynamic Product Placement and Advertising for Broadcast and Content Personalization.

URI: https://www.itu.int/pub/R-REP-BT.2447

## ITU-T FG-AI4AD

Table 7-11 lists the ITU‑T FG-AI4AD deliverables and work items related to artificial intelligence and machine learning.

[Editor’s Note] The Table 7-11 is updated to reflect the LS document from ITU-T FG-AI4AD in SG13 meeting in 7-17 December 2020.

Table 7-11 – ITU-T FG-AI4AD deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| FG- AI4AD | TR01 | Draft Technical Report on automated driving safety data protocol – Specification | - |
| FG- AI4AD | TR02 | Draft Technical Report on automated driving safety data protocol – Public safety benefits of continual monitoring | - |
| FG- AI4AD | TR03 | Draft Technical Report on automated driving safety data protocol – Practical demonstrators | - |

* **TR01**: The scope of the document covers the definition of the minimum data required from the autonomous or assisted driving system for the purposes of a safety evaluation of behavioural performance. It will describe the data model and communication protocol to be implemented by the automated driving software to publish key performance metrics in a standardised format. The subscriber of the data will be a safety evaluation software module that will use these metrics within a standardised behavioural performance algorithm. The technical report will describe the implementation of the protocol within different software and hardware environments as well as communication across local, private and public networks. The algorithms of the safety evaluation software module are out of scope and will be covered by a separate technical report.
* **TR02**: The scope of this Technical Report covers the public safety benefits of Automated Driving Safety Data Protocol and the specific approach to the continual monitoring of driving behaviour exhibited by autonomous and assisted driving systems in the real-world. It will describe the public’s justified expectations of performance of these systems, the benefits of risk-based evaluation and the expected impact on public liability.
* **TR03**: The scope of the document covers the practical application of Automated Driving Safety Data Protocol. It will describe the demonstrator architectures, system configurations and results of practical testing in both physical and virtual environments. It will highlight any performance limitations when processing locally onboard the vehicle. It will highlight any performance limitations when communicating data remotely for edge or cloud processing. It will include reference to the algorithms of the safety evaluation software module used within the practical demonstrator. However, the detail of the algorithms of the safety evaluation software module are out of scope and will be covered by a separate technical report.

## ITU-T FG-AI4EE

Table 7-12 lists the ITU‑T FG-AI4EE deliverables and work items related to artificial intelligence and machine learning.

[Editor’s Note] The Table 7-12 is updated to reflect the LS document from ITU-T FG-AI4EE in SG13 meeting in 1-12 March 2021.

Table 7-12 – ITU-T FG AI4AD deliverables and work items

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| FG- AI4AD  WG1 | D.WG1-01 | Standardized Glossary of Terms | - |
| FG- AI4AD  WG1 | D.WG1-02 | Scorecard to identify enhanced eco-friendly business processes | - |
| FG- AI4AD  WG1 | D.WG1-03 | Solution scorecard on environmental behavioral influencers | - |
| FG- AI4AD  WG1 | D.WG1-04 | List of KPIs/metrics | - |
| FG- AI4AD  WG1 | D.WG1-05 | Reporting templates on AI, AR and ML | - |
| FG- AI4AD  WG1 | D.WG1-06 | High-Level Qualitative Impact Matrix of Artificial Intelligence and Blockchain on Sustainable Development Goals and on environmental efficiency | - |
| FG- AI4AD  WG1 | D.WG1-07 | Visions of Best Practices on Artificial Intelligence and Blockchain in 2025 | - |
| FG- AI4AD  WG1 | D.WG1-08 | Connecting Environmental Efficiency of Digital Technologies to the Sustainable Development Goals (SDGs) | - |
| FG- AI4AD  WG1 | D.WG1-09 | A method for Intuitive Human interaction with data model (ML & AI etc.) | - |
| FG- AI4AD  WG1 | D.WG1-10 | Guidelines on applying U4SSC KPIs in a digital twin city using ML, AR & AI for better climate mitigation solutions | - |
| FG- AI4AD  WG1 | D.WG1-11 | Best practices on how AI & ML for data processing can scale and be used in different locations globally | - |
| FG- AI4AD  WG2 | D.WG2-01 | Environmental Impact self-check assessment | - |
| FG- AI4AD  WG2 | D.WG2-02 | Computer processing, data management and energy perspective | - |
| FG- AI4AD  WG2 | D.WG2-03 | Requirements on energy efficiency measurement models and the role of AI and big data | - |
| FG- AI4AD  WG2 | D.WG2-04 | Guidelines on Evaluating and Measuring the Impacts of Artificial Intelligence and Blockchain on Environmental Efficiency | - |
| FG- AI4AD  WG2 | D.WG2-05 | Guidelines on Energy Efficient Blockchain Systems | - |
| FG- AI4AD  WG2 | D.WG2-06 | Assessment of Environmentally Efficient Data Centre and Cloud Computing in the framework of the Sustainable Development Goals (SDGs) | - |
| FG- AI4AD  WG3 | D.WG3-01 | Guidelines on the implementation of eco-friendly criterias for AI and other emerging technologies | - |
| FG- AI4AD  WG3 | D.WG3-02 | Smart Energy Saving of 5G Base Station: Based on AI and other emerging technologies to forecast and optimize the management of 5G wireless network energy consumption | - |
| FG- AI4AD  WG3 | D.WG3-03 | Application of AI technology in improving energy efficiency of telecom equipment rooms and IDC infrastructure | - |
| FG- AI4AD  WG3 | D.WG3-04 | Methodology for Supporting the Implementation of Artificial Intelligence and Blockchain Solutions at the Government Level | - |
| FG- AI4AD  WG3 | D.WG3-05 | Best Practice Catalogue on Environmentally Efficient Artificial Intelligence and Blockchain Application | - |
| FG- AI4AD  WG3 | D.WG3-06 | Guidelines on the Environmental Efficiency of 5G Usage in Smart Water Management | - |
| FG- AI4AD  WG3 | D.WG3-07 | Guidelines on the Environmental Efficiency of Machine Learning Processes in Supply Chain Management | - |

* **D.WG1-01**: This document will contain a dictionary of common terms and phrases used in the Focus Group's deliverables that will help readers to have common definitions and frames of reference.
* **D.WG1-02**: This document will provide the following:  
  – Impact assessment document to help organizations quantify their environmental impact on how they conduct work;  
  – Rating system so that organizations can self-assess how much positive or negative impact they are creating;  
  – Guidelines on finding more environmentally friendly practices as substitutes for a business process/function.
* **D.WG1-03**: This document will provide a scoring system for organizations to measure how much positive impact they have created (internally and/or externally) on individuals who have incorporated more eco-friendly behaviors and practices in their regular activities.
* **D.WG1-04**: The document will define how environmentally sensitive issues could benefit from Artificial Intelligence (AI), Machine Learning (ML), and other emerging technologies, by providing a set of standard measurements and definitions in the form of a list of Key Performance Indicators (KPIs)/metrics. This KPIs system will focus on finding indicators which are easy to measure and give a broad range of coverage. This system will be designed for easy and simple use by Small and Medium-Sized Businesses (SMBs) and other smaller organizations. Therefore, a set of maximum 50 indicators will be defined. Whenever possible, solutions will rely on existing best practices and globally respected sources.
* **D.WG1-05**: This document will generate a set of standard reporting templates/dashboards to visualize data produced from technology solutions such as AI, Augmented Reality (AR) and ML, that employ defined eco-friendly practices. This document will aim to display the results gained from D.WG1-04 in an instinctive way. The graphical interface will share a design language with D.WG1-09 and results may be used in D.WG1-10 and D.WG1-11.
* **D.WG1-06**: This document will contain a set of high-level impact matrix that supports policymakers, operators and other relevant stakeholders in assessing the implication of different AI and blockchain solutions. The objective of the matrix is to provide:  
  – The necessary tools for relevant stakeholders to determine the AI and blockchain solutions with the highest impacts, allowing them to prioritize solutions and design possibilities that are aligned closest to the values of the Sustainable Development Goals;  
  – The necessary tools for relevant stakeholders to determine the AI and blockchain solutions with the highest impacts, allowing them to prioritize solutions and design possibilities necessary to improve the environmental performance of AI and blockchain.
* **D.WG1-07**: This document will discuss the vision of best practices on artificial intelligence and blockchain in 2025. AI and blockchain are revolutionizing every aspects of society. The capability and performance of these technologies will substantially be improved and expanded in the next decades, from enhanced AI prediction, rising AI assistant and automation in all aspects of operation, boosting transparency, further decentralized networks, further blending between physical and digital computing, further security concerns and more. It is crucial to anticipate the policy, procedure and environmental frameworks needed to ensure the sustainability and accessibility of these technologies.
* **D.WG1-08**: This document is intended to raise awareness on the growing concern over the environmental impacts of digital technologies. The double-edged sword nature of digital technologies on the one hand offer promising solutions to resolve the most pressing global issues from climate change, social equality, preserving biodiversity and more. Yet, more and more data centres are being built to process data. In order to achieve the SDGs, it is crucial to start reducing the carbon footprint of these technologies. This document will highlight the 5 ways environmental efficiency of digital technologies are directly connected to the SDGs and will consider the policy needs of environmental efficiency of digital technologies. This document will not consider the energy consumption of digital technologies.
* **D.WG1-09**: This document will demonstrate a method for elegantly connecting complex data, including (ML & AI) into a system level solution designed for humans, allowing communication between man and machine which cultivates mutual enhancement. Interfacing humans to data is key to using its power to accelerate the speed with which we can solve our environmental problems. Machines are very powerful at working with data including ML & AI. Humans need to interact effectively with this information. This means building it into an interface which is manageable and allows comparison between data sources. The aim is to create a system for adding many data sets and being able to compare these with one another in a way machines and humans can understand. This could have a measurement score system based on a “traffic light” concept covering environmental factors, for example:  
  – Heating/cooling & energy consumption  
  – Impact on plant and animal life  
  – Carbon & other air-based emissions  
  – Waste & water management  
  Increasing amounts of the world’s population live in cities. This is also the source of many of our environmental key pressures for climate change. This group will therefore use cities as a model for this report.
* **D.WG1-10**: This document will provide guidelines on how to use the United Nations ''United for Smart Sustainable Cities” (U4SSC) Key Performance Indicator (KPI) system in a digital twin city, to identify high impact climate mitigation solutions. It will include a set of case studies showing examples of projects where emerging technology, such as ML, AR & AI, has or could have been used to reduce the negative impact of climate change in cities. It will contain a set of online video and testimonials to illustrate those examples.
* **D.WG1-11**: This report-based example will focus on how emerging technology solutions can have most impact on environmental issues within cities. The data used will be based on information gained from the United Nations ''United for Smart Sustainable Cities” (U4SSC) reports. The focus will be on comparing results from different cities and looking at the areas where cities gained low results. What are the emerging technologies that could improve these results? How should the data be structured to improve results?
* **D.WG2-01**: This document will contain a scorecard for an organization to grade itself on how well they have built a product or service based upon environmental impacts. It will define a set of standard areas to be scored (e.g. power consumption, water consumption, etc.) as well as standardized scoring criteria so that scoring is measured the same across industries and products/services.
* **D.WG2-02**: We live in an era that is defined the “Cambrian explosion of data”, and advanced data analytics (Deep and Machine Learning, mainly) is ready to drive us in this world. The volume of data produced hourly and daily is enormous and is intended to dramatically increase in the next years –just consider the IoT revolution. Data centers of the future will be data driven. A clear limiting factor is their energy consumption. Presently, data centers consume more power than several European Union Member States, producing a larger footprint than all aircrafts. For these reasons, innovative strategies and technological solutions are needed to allow a scalability that is essential to enable and support the AI revolution. The document aims at recognizing important areas of innovation addressing this issue and facilitating the AI uptake by our Society.
* **D.WG2-03**: This document will provide an overview of existing evaluation metrics and methodologies for energy efficiency and the role of Information and Communications Technologies (ICTs), based on a gap analysis of existing relative standards and on a detailed and systematic literature review on corresponding assessment models:   
  – Resources: scientific databases (e.g., sciencedirect, scopus, etc.)  
  – Keywords: "energy efficiency" AND "assessment" AND "model" AND "big data" AND "AI"
* **D.WG2-04**: This document will contain a framework for evaluating and measuring the impacts of AI and blockchain on environmental efficiency. The objective of the framework is to support operators and other related stakeholders in assessing the environmental impacts of AI and blockchain. The results aim to inform them to make better environmental decisions, improve the operational quality and efficiency of the two technologies, and identify a clear pathway for AI and blockchain stakeholders to align their values with the visions of the United Nations Sustainable Development Goals.
* **D.WG2-05**: This document will describe the rationale, principles on transitioning from Proof of Work to Proof of Stake in blockchain systems. In contrast to Proof of Work, the Proof of Stake model introduces ‘validators’ to add the next block, effectively eliminating the incentive to compete to be the first miner to solve the puzzle that is given to them in order to obtain the rewards. This document will consider also a comparison of traditional implementation of algorithm with respect to the new proposed implementation.
* **D.WG2-06**: This document will conduct a more comprehensive environmental sustainability assessment with a multi-impact and life cycle approach. It includes the following aspects:  
  – An assessment of environmental impacts of data centre and cloud computing through a life cycle approach  
  – An assessment of the current sustainability matrixes of data centre and cloud computing  
  – An analysis on the links to the 17 SDGs with breakdown indicators being evaluated  
  – A gap analysis of policies that facilitating the development of environmentally efficient data centre and cloud in support of the achievement of the Paris agreement and the UN SDGs  
  – Policy recommendations  
  – A section of a gap analysis on existing standards (e.g., [ITU-T L.1302] Assessment of energy efficiency on infrastructure in data centres and telecom centres, [ITU-T L.1351] Energy efficiency measurement methodology for base station sites, [ITU-T L.1502] Adapting information and communication technology infrastructure to the effects of climate change etc.) could be developed upon the availability of expertise, with potential adoption by ITU as sector standards.
* **D.WG3-01**: This document will define a set of guidelines for organizations to review their implementation and build process to assess the technological impact to environmental factors like:  
   – Materials used;  
   – Energy consumed;  
   – Water consumed;  
   – Waste generated.  
  These guidelines will serve as common factors, not a comprehensive list, for technologists to consider as they design and build any piece of technology.
* **D.WG3-02**: The energy consumption of 5G base stations is three to four times that of 4G. With the help of AI, intelligent pattern recognition, deep learning prediction, and automatic hierarchical control of energy-saving scenarios could be achieved, the customer-oriented cross-network 5G base station intelligent energy-saving capability could be established. This document will establish model algorithms for intelligent identification of base station energy saving scenarios, business load forecasting, etc.; It will set up the basic framework scheme of perception-oriented hierarchical base station energy saving strategy; develop basic functions of 5G base station smart energy-saving experimental system.
* **D.WG3-03**: Most of the existing equipment rooms do not have the full ability to identify indoor temperature distribution. Therefore, they are unable to analyze power consumption in real-time and make appropriate and timely adjustments. As a result, it causes energy to be wasted. This document will cover how AI-based power management capabilities can:  
  – Collect data in telecom equipment rooms and IDC infrastructure;  
  – Analyze the historical power consumption and real-time parameters of the target equipment room;  
  – Train an intelligent model; and   
  – Make reasonable adjustments to the equipment room air- conditioning and temperature, so as to achieve energy saving in the equipment rooms and IDC infrastructure.
* **D.WG3-04**: This document will contain a four-step methodology for supporting policymakers and other government entities in implementing artificial intelligence and blockchain solutions. Policymakers play a decisive role in shaping the environment in which AI and blockchain applications operate in. This four-step methodology will contain a set of guidelines that allow governments to take the initiative in determining the environmental efficiency aspect of AI and blockchain application. It will consider the global market needs of these technologies in the coming decades, and in particular the way in which they can be aligned with visions and values of the Sustainable Development Goals (SDGs). The outcome will allow policymakers to foster the development of AI and blockchain related applications in a more sustainable and efficient manner. The results will also allow government entities to develop a strategic vision on their application, serving as the foundation for collaboration with other stakeholders.
* **D.WG3-05**: This document will contain a list of best practices on artificial intelligence and blockchain applications that have taken environmental efficiency into full consideration. The growing energy demands of AI and blockchain is directly contributing to carbon emissions. The best practices contained in this specification will support relevant stakeholders in making better environmental decisions and reduce the environmental footprint of these technologies. The best practices also act as benchmarking tools that allow operators and service providers to assess their own operation, improve process management and learn from the industry leaders.
* **D.WG3-06**: This guidance document is intended to support researchers and practitioners in measuring and improving the environmental efficiency of IoT technologies, in particular 5G connectivity in water management systems. The requirements, recommended processes, best practices and other considerations regarding the measurement and verification of environmental impact/efficiency contained in this document are developed based on inputs from leading academic experts and industry leaders. These requirements provide general guidelines applicable to the use of IoT connectivity of 5G. Other stakeholders may also utilize this guidance to gain new understanding on the environmental impacts from the use of IoT and 5G to connect and enable further networked sensors and applications to manage water supplies and reduce water loss.
* **D.WG3-07**: This guidance document is intended to support ML researchers and operators to measure and improve the environmental efficiency of ML use in supply chain management. The requirements, recommended processes, best practices and other considerations regarding the measurement and verification of environmental impact/efficiency contained in this document are developed based on inputs from leading academic experts and industry leaders. These requirements provide general guidelines applicable to the use of ML in supply chain management. Other stakeholders may also utilize this guidance to gain new understanding on the environmental impacts of ML use in supply chain management. Big data impact will also be considered as well Blockchain and the circular economy.

## ISO/IEC JTC 1/SC 42

[Editor’s Note on 2019-06-26] It is needed to enhance the description of introduction to SDO related with AI/ML.

[Editor’s Note on 2020-12-14] The big data related standards of WG2 are removed. Those items are considered in the big data standardization roadmap.

JTC 1/SC 42 focuses on the area of "Artificial Intelligence". JTC1/SC 42 is developing AI standards by operating 5 WGs and 1 JWG. Table 7-12 lists the JTC 1 deliverables and work items related to artificial intelligence.

| Table 7-13 – JTC 1/SC 42 deliverables and work items | | | |
| --- | --- | --- | --- |
| Sub group | Reference  (Note) | Name/Title | Status |
| WG1 | ISO/IEC 22989 | Artificial intelligence - Concepts and terminology | CD2 |
| WG1 | ISO/IEC  23053 | Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML) | CD2 |
| WG1 | ISO/IEC 42001 | Artificial intelligence – Management System | WD |
| WG2 | ISO/IEC  24668 | Information technology — Artificial intelligence —Process management framework for Big data analytics | WD |
| WG2 | ISO/IEC 5259-1 | Data quality for analytics and ML — Part 1: Overview, terminology, and examples | WD |
| WG2 | ISO/IEC 5259-3 | Data quality for analytics and ML — Part 3: Data Quality Management Requirements and Guidelines | WD |
| WG2 | ISO/IEC 5259-4 | Data quality for analytics and ML — Part 4: Data quality process framework | WD |
| WG3 | ISO/IEC  23894 | Information Technology - Artificial Intelligence - Risk Management | CD |
| WG3 | ISO/IEC  TR 24027 | Information technology - Artificial Intelligence (AI) - Bias in AI systems and AI aided decision making | WD |
| WG3 | ISO/IEC  TR 24028:2020 | Information technology - Artificial Intelligence (AI) - Overview of trustworthiness in Artificial Intelligence | Published |
| WG3 | ISO/IEC  TR 24029-1 | Artificial Intelligence (AI) - Assessment of the robustness of neural networks - Part 1: Overview | FDIS |
| WG3 | ISO/IEC  TR 24368 | Information technology — Artificial intelligence — Overview of ethical and societal concerns | WD |
| WG3 | ISO/IEC 25059 | Software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality Model for AI systems | WD |
| WG3 | ISO/IEC TR 5469 | Artificial intelligence — Functional safety and AI systems | WD |
| WG4 | ISO/IEC  TR 24030 | Information technology - Artificial Intelligence (AI) - Use cases | FDIS |
| WG4 | ISO/IEC 5338 | Information technology — Artificial intelligence — AI system life cycle processes | WD |
| WG4 | ISO/IEC 5339 | Information Technology — Artificial Intelligence — Guidelines for AI applications | WD |
| WG5 | ISO/IEC  TR 24372 | Information technology — Artificial intelligence (AI) — Overview of computational approaches for AI systems | WD |
| WG5 | ISO/IEC TS 4213 | Information technology — Artificial Intelligence — Assessment of machine learning classification performance | WD |
| WG5 | ISO/IEC 5392 | Information technology — Artificial intelligence — Reference architecture of knowledge engineering | WD |
| JWG1 | ISO/IEC  38507 | Information technology - Governance of IT - Governance implications of the use of artificial intelligence by organizations | CD |

* **ISO/IEC 22989**: This document establishes terminology for Artificial Intelligence (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/stakeholders. This document is applicable to all types of organizations (e.g., commercial enterprises, government agencies, not-for-profit organizations).

URI: [https://www.iso.org/standard/74296.html](https://www.iso.org/standard/74296.html?browse=tc)

* **ISO/IEC 23053**: This document establishes an Artificial Intelligence (AI) and Machine Learning (ML) framework for describing a generic AI system using ML technology. The framework describes the system components and their functions in the AI ecosystem. 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 implementing or using AI systems.

URI: [https://www.iso.org/standard/74438.html](https://www.iso.org/standard/74438.html?browse=tc)

* **ISO/IEC 42001**: TBD

URI: [https://www.iso.org/standard/81230.html](https://www.iso.org/standard/81230.html?browse=tc)

* **ISO/IEC 24668**: The standard provides a framework for developing processes to effectively leverage big data analytics across the organization irrespective of the industries/sectors. This standard specifies process management for big data analytics with its various process groups taken into account along with their interconnectivities. These process groups are: Organization Stakeholder Processes, Competency Development Processes, Data Management Processes, Analytics Development Processes and Technology Integration Processes. This standard describes processes to acquire, describe, store and process data at an organization level which provides Big Data analytics services.

URI: <https://www.iso.org/standard/78368.html>

* **ISO/IEC 5259-1**: TBD

URI: <https://www.iso.org/standard/81088.html>

* **ISO/IEC 5259-3**: TBD

URI: <https://www.iso.org/standard/81092.html>

* **ISO/IEC 5259-4**: TBD

URI: <https://www.iso.org/standard/81093.html>

* **ISO/IEC 23894**: This document provides guidelines on managing risk faced by organizations during the development and application of Artificial Intelligence (AI) techniques and systems. The guidelines also aim 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 these guidelines can be customized to any organization and its context. This document uses the guidelines described in the International Standard ISO 31000 (Risk management – Guidelines) and in addition provides additional guidance that arises by the application of AI to existing processes in any organization or when an organization provides an AI system for use by others.

URI: [https://www.iso.org/standard/77304.html](https://www.iso.org/standard/77304.html?browse=tc)

* **ISO/IEC 24027**: This document addresses bias in relation to AI systems, especially with regards to AI aided decision making. Measurement techniques and methods for assessing bias are described, with the aim to address bias related vulnerabilities, and mitigation thereof. All AI system lifecycle phases are in scope, including but not limited to data collection, training, continual learning, design, testing, evaluation, and use.

URI: [https://www.iso.org/standard/77607.html](https://www.iso.org/standard/77607.html?browse=tc)

* **ISO/IEC 24028:2020**: This document surveys topics related to trustworthiness in AI systems, including the following:   
  - approaches to establish trust in AI systems through transparency, explainability, controllability, etc.;  
  - engineering pitfalls and typical associated threats and risks to AI systems, along with possible mitigation techniques and methods; and   
  - approaches to assess and achieve availability, resiliency, reliability, accuracy, safety, security, privacy, maintainability, and durability of AI systems.

URI: [https://www.iso.org/standard/77608.html](https://www.iso.org/standard/77608.html?browse=tc)

* **ISO/IEC 24029-1**: The present document provides background about the existing methods to assess the robustness of neural networks.

URI: [https://www.iso.org/standard/77609.html](https://www.iso.org/standard/77609.html?browse=tc)

* **ISO/IEC 24368**: This document provides a high-level overview of the programme of work in SC 42 in the area of ethics and societal concerns relative to Artificial Intelligence (AI) systems and applications. This document provides information in relation to principles, processes and methods in this area. This document is intended for technologists, regulators, interest groups, and the society at large. This document is not intended to advocate for any specific set of values (value systems).

URI: [https://www.iso.org/standard/78507.html](https://www.iso.org/standard/78507.html?browse=tc)

* **ISO/IEC 25059**: TBD

URI: <https://www.iso.org/standard/80655.html>

* **ISO/IEC TR 5469**: TBD

URI: <https://www.iso.org/standard/81283.html>

* **ISO/IEC 24030**: This document provides a collection of representative use cases of AI applications in a variety of domains.

URI: [https://www.iso.org/standard/77610.html](https://www.iso.org/standard/77610.html?browse=tc)

* **ISO/IEC 5338**: TBD

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

* **ISO/IEC 5339**: TBD

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

* **ISO/IEC 24372**: This document provides an overview of the state of the art of computational approaches for AI systems, by describing: a) main computational characteristics of AI systems; b) main algorithms and approaches used in AI systems, referencing use cases contained in ISO/IEC TR 24030.

URI: [https://www.iso.org/standard/78508.html](https://www.iso.org/standard/78508.html?browse=tc)

* **ISO/IEC TS 4213**: TBD

URI: <https://www.iso.org/standard/79799.html>

* **ISO/IEC 5392**: TBD

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

* **ISO/IEC 38507**: Governance, as an organisation-wide discipline and responsibility, is generally more stable than the systems subject to their direction, accountability, and oversight. Technologies and their related processes constantly change and evolve. Governance processes do not. This document gives only a summary overview of artificial intelligence (AI) and AI technologies. It does not describe or offer any guidance on technical implementation details. This document provides guidance for members of the governing bodies of organizations (which can comprise owners, directors, partners, executive managers, or similar) to ask the right questions regarding AI and thus determine the effective, efficient, and acceptable uses of AI technologies within their organizations.

URI: [https://www.iso.org/standard/56641.html](https://www.iso.org/standard/56641.html?browse=tc)

## ISO/IEC JTC 1/SC 29

[Editor’s Note] The other related activities should be studied such as SC29’s work which is related with neural network in MPEG.

JTC 1/SC 29 focuses on utilization of AI/ML in multimedia information compression, compressed representations of neural networks for efficient storage and distribution, video coding for computer vision tasks and AI/ML based media processing aspects and systems via network-based media processing.

| Table 7-14 – JTC 1/SC 29 deliverables and work items | | | |
| --- | --- | --- | --- |
| Sub group | Reference  (Note) | Name/Title | Status |
| WG4 | ISO/IEC 15938-13 | Information technology — Multimedia content description interface — Part 13: Compact descriptors for visual search | Published  2015 |
| WG4 | ISO/IEC 15938-15 | Information technology — Multimedia content description interface — Part 15: Compact descriptors for video analysis | Published  2019 |
| WG4 | ISO/IEC 15938-17 | Information technology — Multimedia content description interface — Part 17: Compression of neural networks for multimedia content description and analysis | CD |
| WG4 | ISO/IEC 23090-8 | Information technology — Coded representation of immersive media — Part 8: Network based media processing | Published  2020 |

* **ISO/IEC 15938-13:** This standard specifies an image description tool designed to enable efficient and interoperable visual search applications, allowing visual content matching in images. Visual content matching includes matching of views of objects, landmarks, and printed documents, while being robust to partial occlusions as well as changes in viewpoint, camera parameters, and lighting conditions.

URI: <https://www.iso.org/standard/65393.html>

* **ISO/IEC 15938-15**: This standard specifies descriptor technology for search and retrieval applications, i.e. for visual content matching in video. Visual content matching includes matching of views of large and small objects and scenes, with robustness to partial occlusions as well as changes in vantage point, camera parameters and lighting conditions. The objects of interest comprise planar or non-planar, rigid or partially rigid, textured or partially textured objects, but exclude the identification of people and faces. The databases can be large, for example broadcast archives or videos available on the internet. Such applications thus require video descriptors that enable matching with smaller descriptor sizes and shorter runtimes as compared to application enabled by single-frame (still image) descriptors (e.g. CVDS, ISO/IEC 15938-13) in the video domain.

URI: <https://www.iso.org/standard/75399.html>

* **ISO/IEC 15938-17**: This standard specifies compressed representation of the parameters/weights of a trained neural network, complementing the description of the network topology in existing (exchange) formats for neural networks. The standard is specified as a toolbox of compression methods, specifying (where applicable) the resulting elements of the compressed bitstream. This standard does not aim to define a custom exchange format, but to propose compressed representations that can be added to existing exchange formats. Hence, the standard also defines a high-level syntax that specifies required metadata elements and the semantics of components of the file. The compression tools described in this standard have been selected and evaluated for neural networks used in applications for multimedia description, analysis and processing. However, they may be useful for the compression of neural networks used in other applications and applied to other types of data.

URI: <https://www.iso.org/standard/78480.html>

* **ISO/IEC 23090-8**: The Network-Based Media Processing specification defines the interfaces including both data formats and APIs among the entities connected through the digital networks for media processing. Media processing may refer to AI/ML based media analysis and information extraction, computer vision for media augmentation or any other media processing algorithm and functionality which is deployable at a processing system and having well-defined input/output interfaces. Users can access and configure their operations remotely for efficient processing. The framework describes and manages workflows to be applied to the media data. This process includes uploading of media data to the network, instantiation of the media processing tasks, and configuration of the tasks. The framework enables dynamic creation of media processing pipelines, access of processed media data and metadata in real-time or in a deferred way. The media and metadata formats used between the Media Source, Workflow Manager and Media Processing Entities in a media processing pipeline are also within the scope.

URI: <https://www.iso.org/standard/77839.html>

## IEEE

[TBD]

[Editor’s Note on 2019-10-25] It needs to survey the definition of autonomous system, and discuss whether the scope of this document covers the autonomous system. After the discussion the related deliverables of P7007, P7008, and P7009 should be updated on Table 8-1.

[Editor’s Note on 2019-10-25] Further discussions and contributions are invited for updating Table 8-1 about P2755.2, P2807, P7012, P7013, P7014.

Table 7-15 – IEEE deliverables and work items related to AI and ML

|  |  |  |  |
| --- | --- | --- | --- |
| *Sub  group* | Reference  (Note) | Name/Title | Status |
| IEEE | P7006 | Standard for Personal Data Artificial Intelligence (AI) Agent | PAR Approval  2017-03-23 |
| IEEE | P7007 | Ontological Standard for Ethically Driven Robotics and Automation Systems | PAR Approval  2017-03-23 |
| IEEE | P7008 | Standard for Ethically Driven Nudging for Robotic, Intelligent and Autonomous Systems | PAR Approval  2017-06-15 |
| IEEE | P7009 | Standard for Fail-Safe Design of Autonomous and Semi-Autonomous Systems | PAR Approval  2017-06-15 |
| IEEE | P7010 | Wellbeing Metrics Standard for Ethical Artificial Intelligence and Autonomous Systems | PAR Approval  2017-06-15 |
| IEEE | P7012 | Standard for Machine Readable Personal Privacy Terms | PAR Approval  2017-12-06 |
| IEEE | P7013 | Inclusion and Application Standards for Automated Facial Analysis Technology | PAR Approval  2018-05-14 |
| IEEE | P7014 | Standard for Ethical considerations in Emulated Empathy in Autonomous and Intelligent Systems | PAR Approval  2019-06-13 |
| IEEE | P2755.2 | Recommended Practice for Implementation and Management Methodology for Software Based Intelligent Process Automation (SBIPA) | PAR Approval  2019-05-21 |
| IEEE | P2801 | Recommended Practice for the Quality Management of Datasets for Medical Artificial Intelligence | PAR Approval  2018-12-05 |
| IEEE | P2802 | Standard for the Performance and Safety Evaluation of Artificial Intelligence Based Medical Device: Terminology | PAR Approval  2018-12-05 |
| IEEE | P2807 | Framework of Knowledge Graphs | PAR Approval  2017-03-23 |
| IEEE | P2841 | Framework and Process for Deep Learning Evaluation | PAR Approval  2019-09-05 |
| IEEE | P2805.3 | Cloud-Edge Collaboration Protocols for Machine Learning | PAR Approval  2019-02-08 |
| IEEE | P3333.1.3 | Standard for the Deep Learning-Based Assessment of Visual Experience Based on Human Factors | PAR Approval  2017-09-28 |
| IEEE | P3652.1 | Guide for Architectural Framework and Application of Federated Machine Learning | PAR Approval  2018-12-05 |

* **IEEE P7006**: This standard describes the technical elements required to create and grant access to a personalized Artificial Intelligence (AI) that will comprise inputs, learning, ethics, rules and values controlled by individuals.

URI: <https://standards.ieee.org/project/7006.html>

* **IEEE P7007**: The standard establishes a set of ontologies with different abstraction levels that contain concepts, definitions and axioms which are necessary to establish ethically driven methodologies for the design of Robots and Automation Systems.

URI: <https://standards.ieee.org/project/7007.html>

* **IEEE P7008**: "Nudges" 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.

URI: <https://standards.ieee.org/project/7008.html>

* **IEEE P7009**: 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.

URI: <https://standards.ieee.org/project/7009.html>

* **IEEE P7010**: IEEE Project 7010 Well-being Metrics for Autonomous and intelligent Systems is a standard for measuring the impact of artificial intelligence or autonomous and intelligent systems (A/IS) on humans. The overall intent of IEEE P7010 is to supports the outcome of A/IS having positive impacts on human well-being. It is the tenth of a series of standards in the P70xx series, all of which emerged from the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems. The standard is grounded in scientifically valid well-being indices currently in use and based on a stakeholder engagement process. The intent of the standard is to guide product development, identify areas for improvement, manage risks, assess performance and identify intended and unintended users, uses and impacts on human well-being of A/IS products, services, and systems.

URI: <https://standards.ieee.org/project/7010.html>

* **IEEE P7012**: The standard identifies/addresses the manner in which personal privacy terms are proffered and how they can be read and agreed to by machines.

URI: <https://standards.ieee.org/project/7012.html>

* **IEEE P7013**: The standard provides phenotypic and demographic definitions that technologists and auditors can use to assess the diversity of face data used for training and benchmarking algorithmic performance, establishes accuracy reporting and data diversity protocols/rubrics for automated facial analysis, and outlines a rating system to determine contexts in which automated facial analysis technology should not be used.

URI: <https://standards.ieee.org/project/7013.html>

* **IEEE P7014**: 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.

URI: <https://standards.ieee.org/project/7014.html>

* **IEEE P2755.2**: This recommended practice describes implementation and management approaches and methods for enterprise implementation of Software Based Intelligent Process Automation (SBIPA) technologies. The recommended practice includes the exploration of technology capabilities, development of strategy, product evaluation, platform implementation, management and governance for service providers and end users.

URI: <https://standards.ieee.org/project/2755_2.html>

* **IEEE P2801**: The recommended practice identifies best practices for establishing a quality management system for datasets used for artificial intelligence medical device. The recommended practice covers a full cycle of dataset management, including items such as but not limited to data collection, transfer, utilization, storage, maintenance and update. The recommended practice recommends a list of critical factors that impact the quality of datasets, such as but not limited to data sources, data quality, annotation, privacy protection, personnel qualification/training/evaluation, tools, equipment, environment, process control and documentation.

URI: <https://standards.ieee.org/project/2801.html>

* **IEEE P2802**: The standard establishes terminology used in artificial intelligence medical device, including definitions of fundamental concepts and methodology that describe the safety, effectiveness, risks and quality management of artificial intelligence medical device. The standard provides definitions using the following forms, such as but not limited to literal description, equations, tables, figures and legends. The standard also establishes a vocabulary for the development of future standards for artificial intelligence medical device.

URI: <https://standards.ieee.org/project/2802.html>

* **IEEE P2807**: This standard defines the framework of knowledge graphs (KGs). The framework describes the input requirement of KG, construction process of KG, i.e., extraction, storage, fusion and understanding, performance metrics, applications of KG, verticals, KG related artificial intelligence (AI) technologies and other required digital infrastructure.

URI: <https://standards.ieee.org/project/2807.html>

* **IEEE P2841**: This document defines best practices for developing and implementing deep learning algorithms and defines a framework and criteria for evaluating algorithm reliability and quality of the resulting software systems.

URI: <https://standards.ieee.org/project/2841.html>

* **IEEE P2805.3**: This standard specifies the collaboration protocols of enabling machine learning on the edge computing node with support from industrial clouds. This standard provides implementation reference of machine learning upon lower powered, cheaper, embedded devices, a specific hardware-based method of accepting the introduced machine learning models and then online optimization, i.e. comparing the models with incoming live data.

URI: <https://standards.ieee.org/project/2805_3.html>

* **IEEE P3333.1.3**: This standard defines deep learning-based metrics of content analysis and quality of experience (QoE) assessment for visual contents, which is an extension of Standard for the Quality of Experience (QoE) and Visual-Comfort Assessments of Three-Dimensional (3D) Contents Based on Psychophysical Studies (IEEE STD 3333.1.1)) and Standard for the Perceptual Quality Assessment of Three Dimensional (3D) and Ultra High Definition (UHD) Contents (IEEE 3333.1.2). The scope covers the following. \* Deep learning models for QoE assessment (multilayer perceptrons, convolutional neural networks, deep generative models) \* Deep metrics of visual experience from High Definition (HD), UHD, 3D, High Dynamic Range (HDR), Virtual Reality (VR) and Mixed Reality (MR) contents \* Deep analysis of clinical (electroencephalogram (EEG), electrocardiogram (ECG), electrooculography (EOG), and so on) and psychophysical (subjective test and simulator sickness questionnaire (SSQ)) data for QoE assessment \* Deep personalized preference assessment of visual contents \* Building image and video databases for performance benchmarking purpose if necessary

URI: <https://standards.ieee.org/project/3333_1_3.html>

* **IEEE P3652.1**: Federated learning defines a machine learning framework that allows a collective model to be constructed from data that is distributed across data owners. This guide provides a blueprint for data usage and model building across organizations while meeting applicable privacy, security and regulatory requirements. It defines the architectural framework and application guidelines for federated machine learning, including: 1) description and definition of federated learning, 2) the types of federated learning and the application scenarios to which each type applies, 3) performance evaluation of federated learning, and 4) associated regulatory requirements.

URI: <https://standards.ieee.org/project/3652_1.html>

## Khronos Group

The Khronos group is the organization that develops open standards for software and hardware in areas of graphics, parallel computing, and etc. In December 2017, the Khronos Group announced the Neural Network Exchange Format (NNEF) standard for artificial intelligence.  Currently, the NNEF 1.0 standard document is available on the Khronos website with providing open source tools related to NNEF.

Table 7-16 – Khronous Group deliverables and work items related to AI and ML

|  |  |  |  |
| --- | --- | --- | --- |
| Study group | **Reference** | Title | Status |
| NNEF | NNEF 1.0 | Neural Network Exchange Format (NNEF) | Published 2018-08 |

* **NNEF 1.0.2**: NNEF is a data format for exchanging information about (trained) neural networks. Exchanging such information in a standardized format has become inevitable with the spreading of deep learning, as neural networks found their way from academic research to real-world industrial applications. With the proliferation of open-source deep learning frameworks and hardware support emerging for the acceleration of neural networks, the field faces the problem of fragmentation, as different accelerators are compatible with different frameworks. The goal of NNEF is to provide a standard platform for connecting accelerated neural network execution engines and available deep learning tools. Ideally, neural networks trained in deep learning frameworks would be exported to NNEF, and neural network accelerator libraries could consume it without worrying about compatibility with all deep learning frameworks.

URI: <https://www.khronos.org/registry/NNEF/>

# Gap analysis in artificial intelligence standardization

This clause provides a matrix for gap analysis and the related standardization activities with artificial intelligence in order to identify standardization gaps.

The matrix is composed of two axes. The horizontal axis describes document categories which cover the subject of applications as follows:

− **General, definition**: the standard which provides general descriptions or terms and definitions of the technology;

− **Common requirements, use cases**: the standard which provides use cases and derived general/functional requirements;

− **Architecture**: the standard which provides reference architecture;

− **API, interface, profile**: the standard which provides common interface, API and/or its profile;

− **Data model, format, schema**: the standard which provides data model or protocol including scheme and/or its encoding format;

− **Others** (e.g., guidelines, technical reports).

The vertical axis describes the related technologies for supporting artificial intelligence as follows.

[Editor’s Note] The vertical axis represents the technical areas related with AI, which are very related with under developing standards. It may implicate the suggestions of categorization in AI fields. Currently, the AI technique is widely spanning into enormous technical areas, so it is hard to clarify the categorization of AI exactly in this moment. For developing this document, AI related technologies should be categorized for the purpose of giving information of developing fields in key SDOs. The initial draft supplementary includes initial categorizations which can be modified with discussion.

[Editor’s Note] The contributions are invited for further expansion to other fields and applications. In addition, the contributions are highly welcome for the categorization of AI fields with clear and logical criteria.

[Editor’s Note] The descriptions will be updated after the discussions.

− **Fundamental**:

− **Trustworthiness**:

− **Governance**:

− **Data**:

− **Cloud Computing**:

− **Network optimization with AI**:

− **Smart City:**

− **Healthcare with AI**:

− **Security/privacy**:

− **Ethical/Societal Concerns**:

− **Autonomous Vehicle**:

− **Multimedia**:

NOTE – The items on the horizontal axis are not subordinated to the different technologies.

NOTE – The items on the vertical axis can be modified with technology change.

NOTE – A standard has more than one location on the matrix. In the case that one standard is included in multiple document categories (horizontal axis) or related technologies (vertical axis), it can be mapped several times.

Table 8-1 shows the standardization matrix related to artificial intelligence.



| Table 8-1 – Standardization matrix of artificial intelligence | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
|  | General/ Definition | Common requirement/ Use case | Architecture | API, Interface and its profile | Data model, format, schema | Others (e.g., guideline) |
| **Fundamental** | ISO/IEC CD 22989.2  ISO/IEC CD 23053.2  ISO/IEC WD 5338 | ISO/IEC CD TR 24030 | ISO/IEC WD 23053  ISO/IEC WD 5392 |  | NNEF, ONNX | ISO/IEC WD 42001,  ISO/IEC WD 5059,  ISO/IEC AWI TR 24372  ISO/IEC WD TS 4213  ISO/IEC WD 5339 |
| **Trustworthiness** | ISO/IEC CD 23894,  ISO/IEC AWI TR 24027,  ISO/IEC TR 24028:2020,  ISO/IEC DTR 24029-1 | ISO/IEC AWI 24029-2 | ISO/IEC AWI TR 5469 |  |  |  |
| **Governance** | ISO/IEC NP 38507 |  |  |  |  |  |
| **Data** | ISO/IEC WD 5259-1 | ISO/IEC WD 5259-3 |  |  | ISO/IEC WD 5259-4 | ISO/IEC AWI 24668 |
| **Cloud/edge computing** | F.AI-MLTF | Y.3531 | P3652.1, P.MLGuide, F.AI-DMPC | IEEE P2841, F.748.11, F.AI-DLFE | IEEE P2805.3 | IEEE P3652.1 |
| **Network optimization with AI** | Y.MecTa-ML, Y.ML-IMT2020-Data-Handling, Y.ML-IMT2020-MP | M.resm-AI, Y.3170, Y.Suppl to Y.317X series | Y.qos-ml-arc, Y.IMT2020-AIICDN-arch, Y.ML-IMT2020-NA-RAFR, F.CDN-AINW | Q.INS-PM, Q.IMT2020-PIAS, Q.VoLTE-SAO-FP, E.475 |  | Y.MecTa-ML |
| **Smart City & IoT** |  |  | Y.SSC-AISE-arc |  |  | Y.Sup.AI4IoT |
| **Healthcare with AI** | IEEE P2802 | P2801, H.AI-SaMD-Req | HSTP.Med-AI-CCTA |  |  | P2801, P2802, P3333.1.3 |
| **Security/Privacy** | ISO/IEC AWI TR 5469, P2807, M.AI-TOM, F.Supp-OCAIB | TR.cs-ml | L.1305 | IEEE P7012 | IEEE P7013 |  |
| **Ethical/Societal Concerns** | ISO/IEC  NP TR 24368 |  | IEEE P7006, |  |  | IEEE P7010,  IEEE P7014 |
| **Autonomous vehicle & robot** | IEEE P7007,  IEEE P7008 | H.CUAV-AIF,  F.VS-AIMC | Y.SSC-AISE-arc | IEEE P7009 |  |  |
| **Multimedia** |  | P7014, F.SCAI, F.AI-RMCDP, F.AI-SCS, F.IMCS | FSTP-ACC-AI, F.AI-FASD | IEEE P3333.1.3, IEEE P7013, IEEE P.565, F.EMO-NN, F.AI-ILICSS, F.746.11 |  |  |

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