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Information technology — Artificial intelligence — AI system life cycle processes

~~DIS stage~~

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ISO copyright office

CP 401 • Ch. de Blandonnet 8

CH-1214 Vernier, Geneva

Phone: +41 22 749 01 11

Fax: +41 22 749 09 47

Email: copyright@iso.org

Website: ~~www.iso.org~~www.iso.org

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 42, *Artificial intelligence*.

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Introduction

Artificial intelligence (AI) systems in the fields of computer vision and image recognition, natural language processing, fraud detection, automated vehicles, predictive maintenance and planning have achieved remarkable successes. To build and maintain an AI system, it is an efficient approach to extend the life cycle processes for a traditional software system to include AI-specific life cycle characteristics.

An example of such a specific characteristic of an AI system life cycle is where a system employs machine learning (ML) using training data and it becomes necessary to retrain the ML model using new training data that is more representative of current production data.

ISO/IEC/IEEE 12207 describes software life cycle processes and ISO/IEC/IEEE 15288 describes system life cycle processes. While these life cycle processes are broadly applicable to AI systems, they require the introduction of new processes and the modification of existing processes to accommodate the characteristics of AI systems. This document extends the current generic life cycle process International Standards to make them applicable for AI systems -so that the AI system life cycle can benefit from established models and existing practices. Some AI systems are in use in areas which are related to safety, such as health care or traffic control. Such safety critical AI systems need special attention and considerations as described in ISO/IEC TR 5469:—[1] [5].[5].

Integrating the AI system life cycle into existing processes delivers efficiency gains, better adoption of AI and mutual understanding among AI system stakeholders as defined in ISO/IEC 22989. Such an integrated life cycle approach embraces the fact that AI systems typically are a combination of AI-specific elements and traditional elements such as source code and databases. For AI systems in which software elements are of primary importance, an organization can apply ISO/IEC/IEEE 12207 in combination with this document. For each non-software element of the AI system, the organization can apply ISO/IEC/IEEE 15288 in combination with this document.

This document provides further details on AI system life cycle processes as discussed in ISO/IEC- 42001:—[2] [18].[18].

[1] Under preparation. Stage at the time of publication: ISO/IEC DTR 5469:20222023

[2] Under preparation. Stage at the time of publication: ISO/IEC DIS 42001:2023.

Information technology — Artificial intelligence — AI system life cycle processes

1 Scope

This document defines a set of processes and associated concepts for describing the life cycle of AI systems based on machine learning and heuristic systems. It is based on ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207 with modifications and additions of AI-specific processes from ISO/IEC 22989 and ISO/IEC 23053.

This document provides processes that support the definition, control, management, execution and improvement of the AI system in its life cycle stages. These processes can also be used within an organization or a project when developing or acquiring AI systems. When an element of an AI system is traditional software or a traditional system, the software life cycle processes in ISO/IEC/IEEE 12207 and the system life cycle processes in ISO/IEC/IEEE 15288 can be used to implement that element.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC/IEEE-_15288:2023, *Systems and software engineering — System life cycle processes*

ISO/IEC/IEEE-_12207:2017, *Systems and software engineering — Software life cycle processes*

ISO/IEC-_22989~~:2022,~~, *Information technology — Artificial intelligence — ~~Concepts~~Artificial intelligence concepts and terminology*

ISO/IEC-_23053:2022, *~~Artificial intelligence —~~ Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 22989, ISO/IEC 23053, ISO/IEC/IEEE 15288, ISO/IEC/IEEE 12207 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
knowledge acquisition
process of locating, collecting, and refining knowledge and converting it into a form that can be further processed by a knowledge-based system

Note 1 to entry: Knowledge acquisition normally implies the intervention of a knowledge engineer, but it is also an important component of machine learning.

[SOURCE: ISO/IEC 2382:2015, 2123777, modified — NoteNotes 2 to entry and Note 3 to entry have been deleted].]

4 Abbreviated terms

AI artificial intelligence

ML machine learning

AI artificial intelligence

ML machine learning

5 Key concepts

5.1 General

AI system life cycle consists of three types of processes:

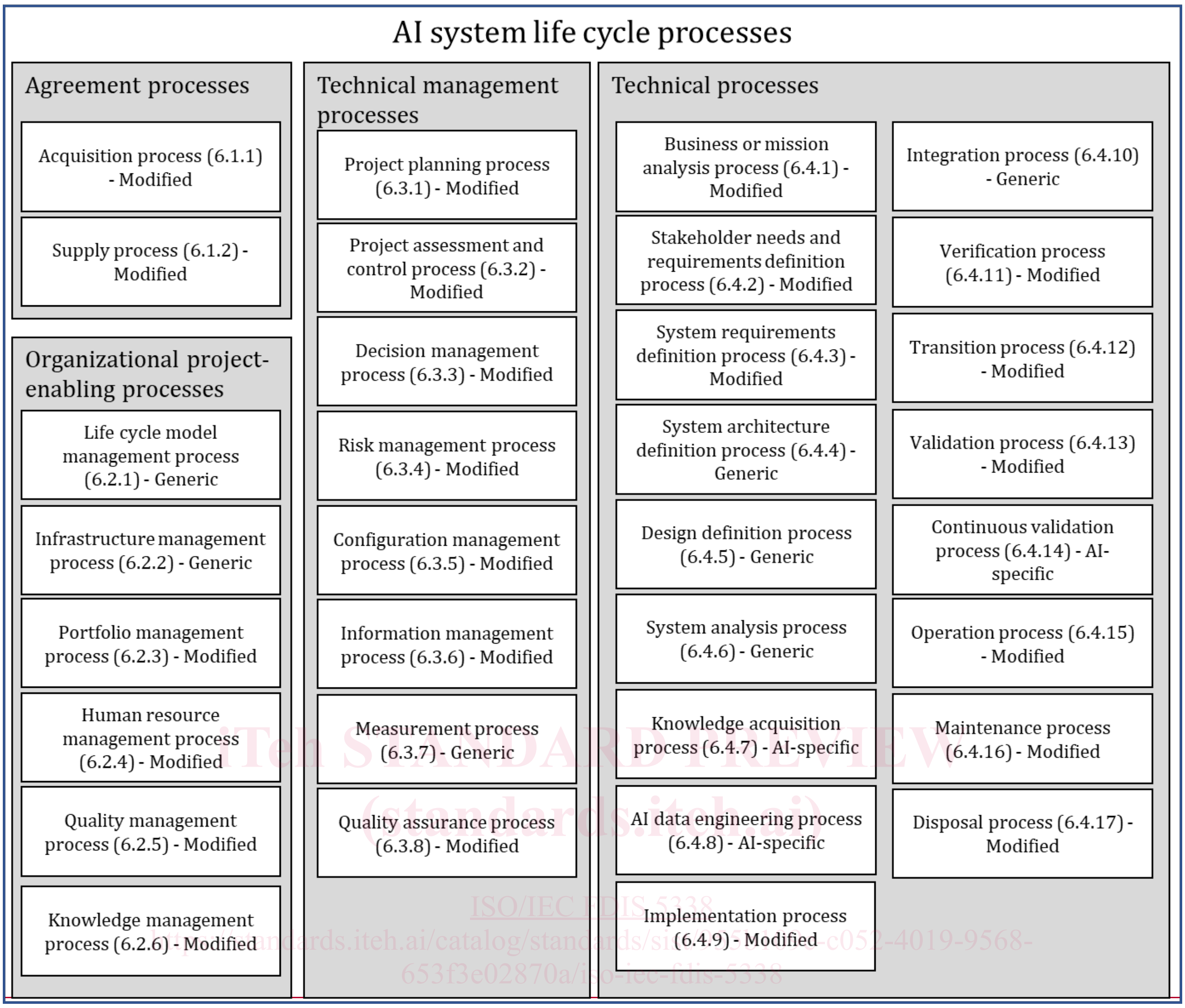
— Generic processes: Processes that are identical to the processes defined in ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207.

— Modified processes: Processes where elements are modified, added or removed from the ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207 definition.

NOTE 1 The Clause for each of these “Modified processes” contains a subclause of AI-specific particularities that provide guidance to adapt the process to AI systems.

— AI-specific processes: Processes that are specific to characteristics of AI systems but are not based directly on any processes in ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207.

AI system life cycle processes in Clause 6 are presented as generic, modified or AI-specific. Figure 1Figure 1 shows the life cycle processes of AI system, grouped by type, and compared to ISO/IEC/IEEE 15288:2023, Figure 4.


AI system life cycle processes
Agreement processes
Acquisition process (6.1.1) - Modified
Supply process (6.1.2) - Modified
Organizational project-enabling processes
Life cycle model management process (6.2.1) - Generic
Infrastructure management process (6.2.2) - Generic
Portfolio management process (6.2.3) - Modified
Human resource management process (6.2.4) - Modified
Quality management process (6.2.5) - Modified
Knowledge management process (6.2.6) - Modified
Technical management processes
Project planning process (6.3.1) - Modified
Project assessment and control process (6.3.2) - Modified
Decision management process (6.3.3) - Modified
Risk management process (6.3.4) - Modified
Configuration management process (6.3.5) - Modified
Information management process (6.3.6) - Modified
Measurement process (6.3.7) - Generic
Quality assurance process (6.3.8) - Modified
Technical processes
Business or mission analysis process (6.4.1) - Modified
Stakeholder needs and requirements definition process (6.4.2) - Modified
System requirements definition process (6.4.3) - Modified
System architecture definition process (6.4.4) - Generic
Design definition process (6.4.5) - Generic
System analysis process (6.4.6) - Generic
Knowledge acquisition process (6.4.7) - AI-specific
AI data engineering process (6.4.8) - AI-specific
Implementation process (6.4.9) - Modified
Integration process (6.4.10) - Generic
Verification process (6.4.11) - Modified
Transition process (6.4.12) - Modified
Validation process (6.4.13) - Modified
Continuous validation process (6.4.14) - AI-specific
Operation process (6.4.15) - Modified
Maintenance process (6.4.16) - Modified
Disposal process (6.4.17) - Modified

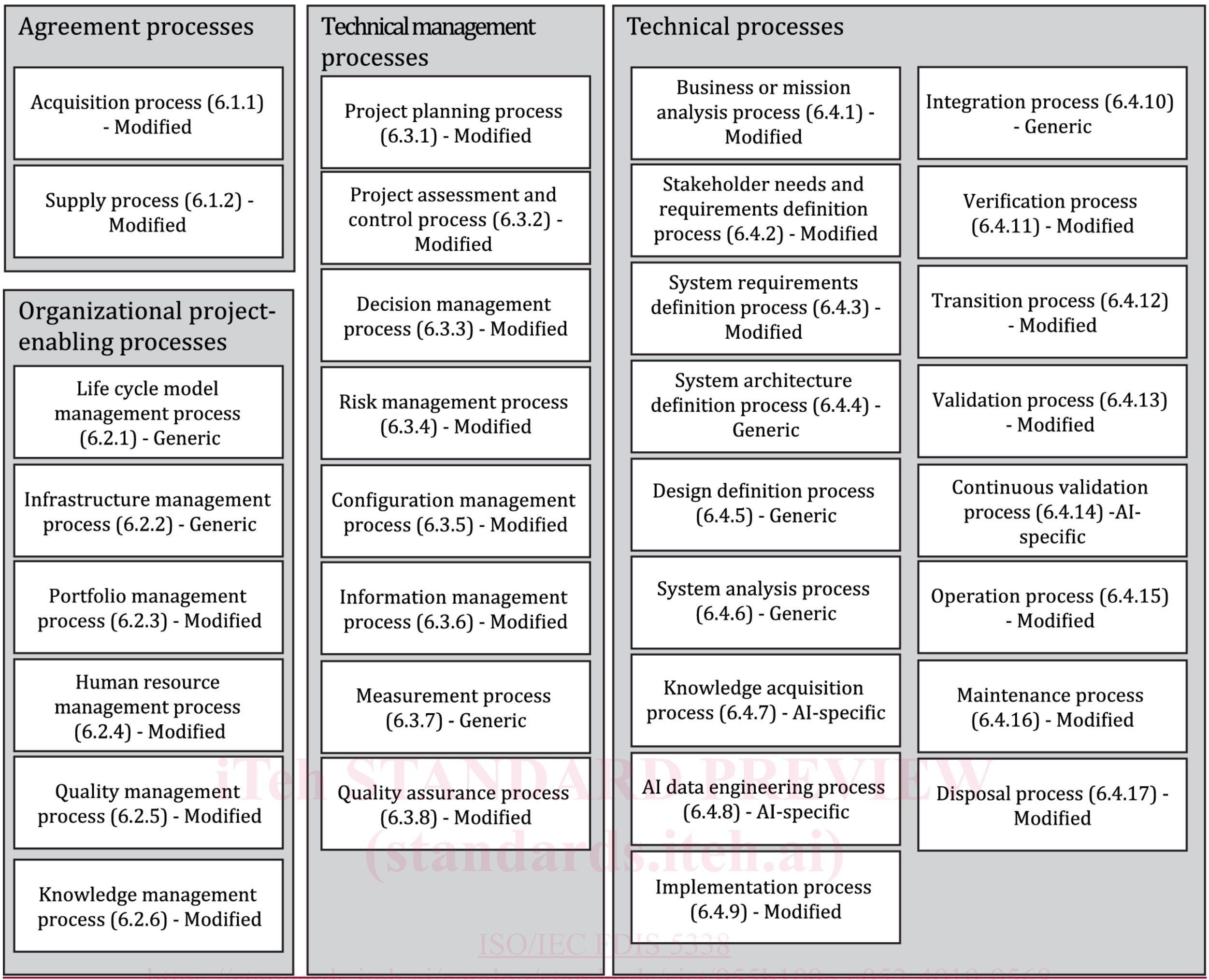


Figure ~~1~~ 1 — AI system life cycle processes relative to ISO/IEC/IEEE 15288:2023, Figure 4

The following aspects of AI systems are key factors that differentiate the life cycle processes from those that are traditional systems:

— Measurable potential decay: Since AI models aim to model a desired behaviour which can change over time, measuring and monitoring any deviations of the production data (data drift) or deviations towards the desired output (concept drift) can be required. The changing of desired behaviour is not restricted to AI systems only, but for AI models this is uniquely measurable by validating input and output.

— Potentially autonomous: AI system's ability to make automated, complex and fast decisions creates the potential to replace actions or processes otherwise executed by humans. Consequently, AI systems can require extra attention to ensure fairness, security, safety, privacy, reliability, transparency and explainability, accountability, availability, integrity and maintainability. The more likely an AI system is able to do harm, the more important this extra attention becomes. See ISO/IEC TR 24368 ~~[14]~~[14] for an overview of ethical and societal concerns in the development and deployment of AI systems. See ISO/IEC 23894 ~~[11]~~[11] for more information of risk management of AI systems.

— Iterative in requirements and behaviour specification: AI systems can be based on iterative, agile requirements specification, knowledge specification, behaviour modelling and usability design. AI system development can take place through cycles of requirements specification, prototype demonstration and requirements refinement. This aspect differs from traditional software applications based on fixed, well-defined requirements. Further, as AI systems are used, the requirements can also evolve as unseen situations arise and refined requirements, specifications and gaps are identified.

— Probabilistic: Decisions made by AI systems based on machine learning are inherently probabilistic. Therefore, it is important for stakeholders to recognize that decisions made by AI systems are not always correct. Formally testing the correctness of models has inherent limitations and uncertainties when it comes to guarantees.

— Reliant on data: AI systems based on machine learning rely on sufficient, representative data to train, test, and validate models. The behaviour of machine learning models is not programmed but is instead learned from the data. Because of this, it is important that particular consideration be given to the data (e.g. data quality) that are required for an AI system for training, testing, verification and validation.

— Knowledge intensive: For heuristic models, knowledge acquisition is of relatively high importance, since the knowledge is coded explicitly in the model and determines its correctness.

— Novel: New knowledge and skills can be required for organizations designing, developing or using AI systems. Other stakeholders, such as AI system users, can be unfamiliar with AI. This can cause trust and adoption challenges. The novelty of AI can cause overconfidence and enthusiasm without fully accounting for AI system risks. The perception that AI systems can eventually replace humans or demonstrate intelligence can also impact how stakeholders view AI systems.

— Incomprehensible: In case of heuristic models or machine learning, model behaviour is emergent in the sense that it is not explicitly programmed but is instead the indirect result of knowledge engineering or derived from the training data. Stakeholders can find AI systems to be less predictable, explainable, transparent, robust and understandable than explicitly programmed systems. This can reduce trust in AI systems.

NOTE 2 A high-level overview of AI ethical and societal concerns can be found in ISO/IEC TR 24368 ~~[14].~~.[14] More information on addressing ethical concerns during system design can be found in IEEE 7000-2021 ~~[20].~~[20].

5.2 AI system concepts

~~ISO/IEC 22989 defines an AI system as an “engineered system that generates outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives”. In other words, models that perform actions that require a form of intelligence.~~

A model can be a machine learning model which has learned how to compute based on data, or it can be a heuristic model engineered based on human knowledge. In a heuristic model, the computations are engineered explicitly (procedural), implicitly by specifying rules or probabilities (declarative), or both.

In the case of machine learning, the data are the primary input for the model. For a heuristic model, the primary input is knowledge. Regardless, both data and knowledge are required in either case. Data are needed to test heuristic models, and to perform analysis to build the knowledge. Knowledge is required