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Automation systems and integration — Nuclear digital ecosystem —

Part 1: Overview and framework

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Foreword

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This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 4, *Industrial data*.

A list of all parts in the ISO 18136 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

The purpose of this document is to define the high-level concept of a nuclear digital ecosystem (NDE) for information integration and exchange.

ISO/TR 20123, which was published in 2023, deals with the concept of NDE. ISO/TR 20123 documents the state of standardization of information management (IM) of nuclear installations over their life cycle with national surveys. It also identifies the issues and needs to develop new standards, specifically for the nuclear industry.

In order to accomplish the vision described in ISO/TR 20123, a structured strategic roadmap is formulated. New NDE standards are grouped into three major categories: 1) a strong, simple and shared conceptual framework, 2) methodologies of application, and 3) the technological guidelines for practice.

This document is the first one to comprehend all relevant concepts and issues that facilitate a common understanding of the NDE. Based on the NDE framework proposed herein, a set of technical management methodologies, technical information methodologies, and feasibility assessment tools are further specified in the second category. Priority in identifying these methodologies is given to the most influencing business areas, to boost industry implementation. Finally, practical guidelines for implementing the methodologies are further specified in the third category. The guidelines may promote the practical implementation of NDE standards and other existing standards in a collective and harmonized manner.

In summary, this document helps:

a) identify and share a mutual understanding of the business objectives,

b) develop a methodology to apply this framework to the specific current contexts of the steps in the life cycles,

c) use practical guidelines for the practical implementation of the ISO standards.

The framework in this document aims to support the information integration and exchange based on unique managerial requirements of the NDE, to provide guidance for use of high-level standard identifiers for frequently and commonly used components in NDE, and to encompass all related disciplines of a nuclear facility.

This framework refers to and introduces the standards, guidance series and technical documents published by the International Atomic Energy Agency (IAEA).

Additionally, Annex A illustrates the structured representations of the NDE framework. Annex B presents examples of coding systems used in fictional nuclear projects incorporating NDE framework terms. Annex C presents relevant existing standards to help promote the actual implementation of the NDE standard. Annex D specifies a way to describe the context diagram of a system of interest to minimize interoperability issues. The relationship between ISO/TS 18101-1 and this document is defined in Annex E. Annex F describes configuration management and requirement management. Annex G discusses the viability of adopting this agreement to create a digital ecosystem. Finally, Annex H describes NDE structured data and provides several examples of structured data.

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Automation systems and integration — Nuclear digital ecosystem —

Part 1: Overview and framework

1 Scope

This document describes a shared conceptual framework for the nuclear digital ecosystem (NDE). In addition, this framework also serves as a systematic basis for a series of additional standards for management methods and technical guidelines for information integration and exchange, specifically in the nuclear industry.

The framework focuses on the nuclear industry-specifics with management requirements as well as information specifications to facilitate practical benefits from implementing ISO standards. It is viable because the industry scope is narrowed down to the nuclear sector, while the management concerns are expanded to cover the various disciplines throughout the entire life cycle.

The following are within the scope of this document:

— definition of the conceptual structure of the nuclear ecosystem with components and relationships in terms of facility type, life cycle (lifetime), and technical management methodology; the scope of this document exclusively addresses ‘all reactor-related facilities’;

— definition of the industry sectors involved within NDE, encompassing civil, architectural, mechanical, electrical, I&C, process engineering and ICT;

— list of high-level constituents for each component;

— instructions to guide the collective use of this document and existing standards to specify information requirements within the NDE for different functional purposes.

The following are outside the scope of this document:

— definition of detailed management methodologies or processes related to the standard data exchange;

— list of detailed properties and structures of the required information exchange (IE).

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For this document, the following terms and definitions 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

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

3.1.1
stakeholder
person, group, or organization that has interests in, or can affect, be affected by, or perceive itself to be affected by, any aspect of the project, programme, or portfolio

[SOURCE: ISO 21506:2024, 3.86]

3.1.2
breakdown structure
hierarchical structure tool used to structure facility *information* (3.1.12) and management control

Note 1 to entry: The term breakdown structures may represent different types of breakdown structures such as work breakdown structure (WBS), physical breakdown structure (PBS), functional breakdown structure (FBS), location breakdown structure (LBS), product breakdown structure (PBS) in Reference [25] and organizational breakdown structure (OBS).

3.1.3
classification
process of assigning objects to classes according to criteria

[SOURCE: ISO 22274:2013, 3.5]

3.1.4
cyber value creation
creation of value for the business by providing, through a *governance* (3.1.11) structure and *framework* (3.1.10), cyber capabilities to share *knowledge* (3.1.16) and *information* (3.1.12) feedback to support business processes by taking improved collective decisions in the activities of the users and thus create increased value of the business

Note 1 to entry: Cyber capabilities include information technologies such as digital twin, linked data, AI, and other ICT innovations, supporting business across the supply chain and across the *nuclear digital ecosystem* (3.1.18).

3.1.5
data
representation of *information* (3.1.12) in a formal manner suitable for communication, interpretation, or processing by human beings or computers

[SOURCE: ISO 10303-2:2024, 3.1.207]

3.1.6
digital ecosystem
distributed, adaptive, open socio-technical system with properties of self-organization, scalability, and sustainability inspired from natural ecosystems

[SOURCE: ISO/TS 18101-1:2019, 3.26]

3.1.7
disposal facility
special unit that is permitted to store waste

[SOURCE: ISO 24161:2022, 3.1.3.4, modified — Note 1 to entry has been removed.]

3.1.8
effectiveness
extent to which planned activities are realized and planned results are achieved

[SOURCE: ISO 30401:2018, 3.6]

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3.1.9
facility
physical structure or installation, including related site, works, servicing one or more main purposes

[SOURCE: ISO/TS 12911:2012, 3.9]

3.1.10
framework
structure expressed in diagrams, texts, and formal rules, which relates the components of a conceptual entity to each other

[SOURCE: ISO 19439:2006, 3.31]

3.1.11
governance
principles, policies, and *framework* (3.1.10) by which an organization is directed and controlled

[SOURCE: ISO 21505:2017, 3.1]

3.1.12
information
knowledge (3.1.16) concerning objects, such as facts, events, things, processes, or ideas, including concepts that within a certain context has a particular meaning

[SOURCE: ISO/IEC 2382:2015, 2121271]

3.1.13
information requirement
specification for what, when, how, and for whom *information* (3.1.12) is to be produced

[SOURCE: ISO 19650-1:2018, 3.3.2]

3.1.14
interoperability
capability of two or more entities to exchange items in accordance with a set of rules and mechanisms implemented by an interface in each entity in order to perform their specific tasks

[SOURCE: ISO/TS 18101-1:2019, 3.1, modified — Notes 1, 2 and 3 to entry were removed.]

3.1.15
IT infrastructure
all the technical components, system, software, databases, and data files and deployed application software, technical procedures, and technical documentation used to make the *information* (3.1.12) available

[SOURCE: ISO/IEC 16350:2015, 4.22]

3.1.16
knowledge
human or organizational asset enabling effective decisions and action in the context

Note 1 to entry: Knowledge in *a nuclear digital ecosystem (NDE)* (3.1.18) can be individual or organizational and be in the form of *structured data* (3.1.26) or *unstructured data* (3.1.29). The explicit knowledge can be transferred in a systemized format, while the tacit knowledge is intricate to be converted to formal expertise. Knowledge systems enable automated reasoning for decision-making in a collective manner.

[SOURCE: ISO 30401:2018, 3.25, modified — Notes 1, 2 and 3 to entry were removed and a new Note 1 to entry was added.]

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3.1.17
nuclear power plant
NPP
nuclear reactor installation that produces electrical and/or heat energy

Note 1 to entry: A nuclear power plant is a collection of single or multiple installed nuclear reactors with the supporting structures, systems, and components necessary to produce power, i.e. heat or electricity.

[SOURCE: ISO 12749-5:2018, 3.2.5, modified — Note 1 to entry was replaced.]

3.1.18
nuclear digital ecosystem
NDE
digital ecosystem (3.1.6) specialized for application for nuclear facilities and related activities

Note 1 to entry: The objective is to provide principles, methodologies, and technologies to enable sharing of shared resources across nuclear industry and beyond, and their specialization in each specific domain and discipline.

Note 2 to entry: There is a trend to name these shared resources 'commons'.

[SOURCE: ISO/TR 20123:2023, 3.1.12]

3.1.19
nuclear fuel cycle
operations associated with the production of nuclear energy

Note 1 to entry: The nuclear fuel cycle includes the following stages:

a) mining and processing of uranium or thorium ores;

b) conversion;

c) enrichment of uranium;

d) manufacturing of nuclear fuel;

e) uses of the nuclear fuel;

f) reprocessing and recycling of spent nuclear fuel;

g) temporary radioactive material storage of spent nuclear fuel and radioactive waste from fuel fabrication and reprocessing and disposal of spent nuclear fuel (open fuel cycle) or high-level waste (closed fuel cycle);

h) any related research and development activities;

i) transport of radioactive material;

j) all waste management activities (including decommissioning relating to operations associated with the production of nuclear energy).

Note 2 to entry: Reactor operation and other activities at a reactor site are not addressed in this document, but are addressed in ISO 12749-5.

[SOURCE: ISO 12749-1:2020, 3.2.6]

3.1.20
ontology
formal statement of an understanding of the world

Note 1 to entry: An ontology can be represented in any language. It need not be represented in a language specifically designed for ontologies, such as OWL. An ontology can have different representations.

Note 2 to entry: An ontology does not specify what *data* (3.1.5) needs to be recorded about the world.

Note 3 to entry: The ontology defined by this document is principally concerned with the world outside a computer system.

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[SOURCE: ISO/TS 15926-12:2018, 3.1.3]

3.1.21
process engineering
branch of engineering that is concerned with industrial processes, especially continuous ones such as the production of petrochemicals, including power generation

[SOURCE: Reference [71]]

3.1.22
regulator
regulatory body
authority or a system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating the nuclear, radiation, radioactive waste and transport safety

[SOURCE: Reference [52], p. 177, definition 1, modified — The supplementary information has been removed.]

3.1.23
research reactor
type of nuclear reactor engineered to use its neutron flux and ionizing radiation for scientific research in different fields

[SOURCE: ISO 12749-5:2018, 3.5.1.2, modified — Notes 1 and 2 to entry have been removed.]

3.1.24
referential integrity
property of a set of relations such that the attribute values of foreign keys are null values or are identical to the values of primary keys of other relations

Note 1 to entry: Referential integrity: term and definition standardized by ISO/IEC [ISO/IEC 2382-17:1999].

Note 2 to entry: 17.04.13 (2382).

[SOURCE: ISO/IEC 2382:2015, 2121478]

3.1.25
structure
person, group, or organization that has interests in, or can affect, be affected by, or perceive itself to be affected by, any aspect of the project

3.1.26
structured data
data (3.1.5) which are organized based on a predefined (applicable) set of rules

Note 1 to entry: The predefined set of rules governing the basis on which the data are structured needs to be clearly stated and made known.

Note 2 to entry: A predefined data model is often used to govern the structuring of data.

[SOURCE: ISO/IEC 20546:2019, 3.1.35]

3.1.27
technical information methodology
techniques that support the *technical management methodology* (3.1.28)

Note 1 to entry: Technical information methodology in the *nuclear digital ecosystem (NDE)* (3.1.18) includes *breakdown structure* (3.1.2), *ontology* (3.1.20), numbering system (coding system), equipment designation systems, etc.

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3.1.28
technical management methodology
rules, techniques and standards that support an organization and improve their performance by adopting ways to manage product, process, people, activity, and resources throughout the life cycle (lifetime)

Note 1 to entry: Technical management methodology in *a nuclear digital ecosystem (NDE)* (3.1.18) includes, but is not limited to, requirement management, configuration management, systems engineering, performance management, operation management, information management, knowledge management, safety management.

3.1.29
unstructured data
data (3.1.5) which are characterized by not having any structure apart from that record or file level

Note 1 to entry: On the whole, unstructured data are not composed of data elements.

EXAMPLE Free text.

[SOURCE: ISO/IEC 20546:2019, 3.1.37]

3.2 Abbreviated terms

BWR	boiling water reactor
CFM	configuration management
CMR	construction management at risk
DBB	design-bid-build
DBM	design-build-maintain
EPC	engineering-procurement-construction
EPCC	engineering-procurement-construction-commissioning
FBR	fast breeder reactor
FCF	fuel cycle facility
GCR	gas-cooled, graphite-moderated reactor
GDM	graph data model
GML	geography markup language
HTGR	high-temperature gas-cooled reactor
HVAC	heating, ventilation and air conditioning
IAEA	International Atomic Energy Agency
I&C	instrumentation and control
ICT	information and communication technology
IE	information exchange
IFC	industry foundation classes
IM	information management
LWGR	light-water cooled, graphite-moderated reactor

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MSR	molten salt reactor
NDE	nuclear digital ecosystem
NPP	nuclear power plant
OO	owner and operator
PDS	project delivery system
PHWR	pressurized heavy water reactor
PRIS	power reactor information system
PWR	pressurized light-water moderated and cooled reactor
RQM	requirements management
NRR	research reactor
NWD	waste disposal facility

4 Nuclear digital ecosystem (NDE) framework

4.1 Concept of an NDE

The NDE is a cyber value creation community of related stakeholders (see 5.2.4) in the nuclear facilities (see 5.2.2) through the entire facility life cycle (lifetime) (see 5.2.5) under global governance (see 5.2.3), as depicted in Figure 1.

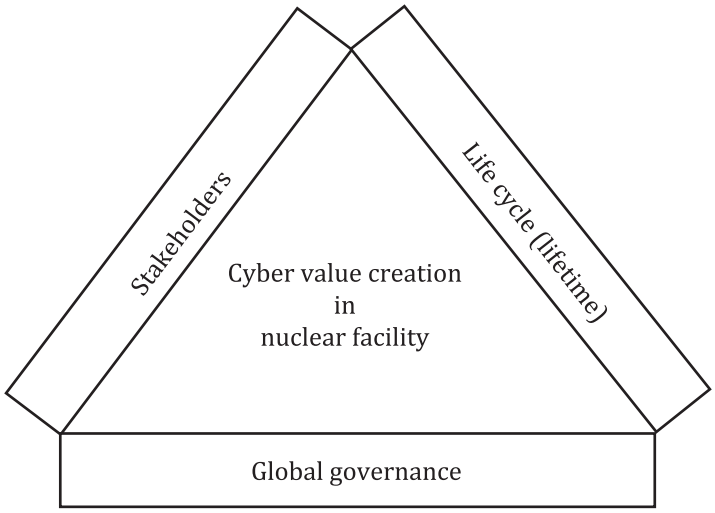


Figure 1 — Concepts of an NDE

The NDE cyber value creation is enabled by integration (see 5.4) of information (see 5.5) based on business requirements (see 5.3) using information and communication technology (ICT) and infrastructure (see 5.6).

Information integration and exchange within the NDE is crucial for cyber value creation. This is accomplished by the technical management methodology (see 5.3.2) supported by appropriate technical information methodology (see 5.3.3), which is evolving to improve practicability and is continuously evaluated by feasibility measures (see 5.3.4), as illustrated in Figure 2.

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