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Systems and software engineering — Guidelines for the utilization of ISO/IEC/IEEE 15288 in the context of system of systems (SoS)

Ingénierie des systèmes et du logiciel — Lignes directrices pour l'utilisation de l'ISO/IEC/IEEE 15288 dans le contexte d'un système de systèmes (SdS)

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Systems and software engineering*, in cooperation with the Systems and Software Engineering Standards Committee of the IEEE Computer Society, under the Partner Standards Development Organization cooperation agreement between ISO and IEEE.

This second edition cancels and replaces the first edition (ISO/IEC/IEEE 21840:2019), which has been technically revised.

The main changes are as follows:

— the text has been updated to be aligned with ISO/IEC/IEEE 15288:2023, ISO/IEC/IEEE 21839, ISO/IEC/IEEE 21841, ISO/IEC/IEEE 24748-1:2024, and ISO/IEC/IEEE 24748-2:2024.

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

Application of systems engineering (SE) to systems of systems (SoS) has become increasingly important for the realization and sustainability of large and persistent sociotechnical systems in domains as varied as healthcare, transportation, energy, and defence, and contexts such as corporations, cities, and government. This has been intensified in the last twenty years by the pervasiveness of information technology (IT), illustrated by new technologies and paradigms such as sensor networks, cloud computing, the internet of things, big data, smart devices and artificial intelligence. It is, for instance, the application of these technologies to cities that transform them into smarter cities.

This document provides guidance for the utilization of ISO/IEC/IEEE 15288 in the context of SoS. While ISO/IEC/IEEE 15288 applies to systems in general, including constituent systems (CS), this document provides guidance on the application of these processes to the special case of SoS. However, this document is not a self-contained SoS replacement for ISO/IEC/IEEE 15288. This document is intended to be used in conjunction with ISO/IEC/IEEE 15288, ISO/IEC/IEEE 21839 and ISO/IEC/IEEE 21841.

For example, ISO/IEC/IEEE 21841 provides a taxonomy for SoS, providing specific viewpoints that align with stakeholder concerns. Using a taxonomy in conjunction with this document facilitates better communications among the various stakeholders that are involved in activities like governance, engineering, operation, and management of these SoS. However, this document does not require the use of any specific taxa in ISO/IEC/IEEE 21841.

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Systems and software engineering — Guidelines for the utilization of ISO/IEC/IEEE 15288 in the context of system of systems (SoS)

1 Scope

This document provides guidance on the application of processes in ISO/IEC/IEEE 15288 to systems of systems (SoS).

This document also can be productively applied by users of ISO/IEC/IEEE 12207.

This document provides general guidance for each ISO/IEC/IEEE 15288 process and process outcome in the context of SoS, but it does not address specific activities, tasks, methods, or procedures. Additional processes and process outcomes unique to SoS can still be needed and are not covered by this document.

This document explores the similarities and differences between systems and SoS and, by extension, the similarities and differences between engineering of systems and SoS.

2 Normative References

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

— IEEE Standards Dictionary Online: available at: http://dictionary.ieee.org

NOTE For additional terms and definitions in the field of systems and software engineering, see ISO/IEC/IEEE 24765, which is published periodically as a "snapshot" of the SEVOCAB (Systems and software Engineering Vocabulary) database and which is publicly accessible at www.computer.org/sevocab.

3.1 General terms

3.1.1
capability
measure of capacity and the ability of an entity (*system* (3.1.11), person or *organization* (3.1.8)) to achieve its objectives

[SOURCE: ISO/IEC 19770-1:2017, 3.10, modified — Note 1 to entry has been removed.]

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3.1.2
constituent system
CS
independent *system* (3.1.11) that forms part of a *system of systems (SoS)* (3.1.13)

Note 1 to entry: Constituent systems (CS) can be part of one or more SoS. Each CS is a useful system by itself, having its own development, *management* (3.1.7), utilization, goals, and resources, but interacts within the SoS to provide the unique *capability* (3.1.1) of the SoS.

Note 2 to entry: While CS operate independently from each other for their own purposes, they also operate interdependently with each other and other *system elements* (3.1.12) to produce the SoS outputs. CS are never totally independent, since they work interdependently when operating as part of the SoS. However, they are never totally subservient to the SoS. CS have their own stakeholders and CS remain managerially and operationally independent; managers of CS or CS projects can be unaware, unable or unwilling to make adjustments to address SoS-desired *capabilities* (3.1.1).

3.1.3
emergence
principle that entities exhibit properties which are meaningful only when attributed to the whole, not to its parts

Note 1 to entry: These properties cannot be reduced or decomposed back down to the those of any individual *constituent system* (3.1.2).

3.1.4
governance
practice of establishing and enforcing strategic goals and objectives, organizational policies, and performance parameters

[SOURCE: ISO/IEC/IEEE 12207:—, 3.1.28]

3.1.5
interoperating system
system (3.1.11) that exchanges information with the *system of interest* (3.1.15) and uses the information that has been exchanged

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.20]

3.1.6
life cycle
evolution of a *system* (3.1.11), product, service, project or other human-made entity from conception through retirement

[SOURCE: ISO/IEC/IEEE 24748-1:2024, 3.24]

3.1.7
management
system (3.1.11) of controls and processes required to achieve the strategic objectives set by the *organization's* (3.1.8) governing body

Note 1 to entry: Management is subject to the policy guidance and monitoring set through corporate *governance* (3.1.4).

3.1.8
organization
person or group of people that has its own functions with responsibilities, authorities, and relationships to achieve its objectives

EXAMPLE Company, corporation, firm, enterprise, manufacturer, institution, charity, sole trader, association, or parts or combination thereof.

[SOURCE: ISO 9000:2015, 3.2.1, modified — Notes to entry have been removed; EXAMPLE has been added.]

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3.1.9
satisficing
decision-making strategy or selection approach that prioritizes sufficiency over optimization

3.1.10
stage
period within the *life cycle* (3.1.6) of an entity that relates to the state of its description or realization

Note 1 to entry: As used in this document, stages relate to major progress and achievement milestones of the entity through its life cycle.

Note 2 to entry: Stages often overlap.

[SOURCE: ISO/IEC/IEEE 24748-1:2024, 3.48]

3.1.11
system
arrangement of parts or elements that together exhibit a stated behaviour or meaning that the individual constituents do not

Note 1 to entry: A system is sometimes considered as a product or as the services it provides.

Note 2 to entry: In practice, the interpretation of its meaning is frequently clarified by the use of an associative noun, e.g. aircraft system. Alternatively, the word "system" is substituted simply by a context-dependent synonym (e.g. aircraft), though this potentially obscures a system principles perspective.

Note 3 to entry: A complete system includes all of the associated equipment, facilities, material, computer programs, firmware, technical documentation, services, and personnel required for operations and support to the degree necessary for self-sufficient use in its intended environment.

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.46]

3.1.12
system element
discrete part of a *system* (3.1.11) that can be implemented to fulfil specified requirements

EXAMPLE Hardware, software, data, humans, processes [e.g. processes for providing service to users, procedures [e.g., operator instructions], facilities, materials, and naturally occurring entities or any combination.

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.47]

3.1.13
system of systems
SoS
set of *systems* (3.1.11) and *system elements* (3.1.12) that interact to provide a unique *capability* (3.1.1) that none of the *constituent systems* (3.1.2) can accomplish on its own

Note 1 to entry: System elements can be necessary to facilitate interaction of the constituent systems in the system of systems.

Note 2 to entry: A collection of systems is not always an SoS. The differences between a system and an SoS are not in the structure of the parts, but rather in the managerial and operational independence of those parts. There is no distinct boundary that separates systems from SoS, as the transition between the two is often gradual and context dependent.

3.1.14
system of systems engineering
SoSE
process of planning, analysing, organizing, developing and integrating the *capabilities* (3.1.1) of a mix of existing and new *systems* (3.1.11), including inter-system infrastructure, facilities, and overarching processes into a *system of systems (SoS)* (3.1.13) capability that is greater than the sum of the capabilities of the *constituent systems* (3.1.2)

Note 1 to entry: SoSE also includes testing, modification, maintenance and other post-integration activities.

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3.1.15
system of interest
SoI
system (3.1.11) whose *life cycle* (3.1.6) is under consideration

[SOURCE: ISO/IEC/IEEE 15288:2023, 3.48.]

3.1.16
systems engineering
transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered *systems* (3.1.11) using systems principles and concepts and scientific, technological and *management* (3.1.7) methods

[SOURCE: INCOSE-TP-2020-002-06]

3.1.17
taxonomy
scheme that partitions a body of knowledge and defines the relationships among the parts

[SOURCE: ISO/IEC/IEEE 26531:2023, 3.1.30]

3.2 SoS types

3.2.1
acknowledged SoS
acknowledged system of systems
SoS (3.1.13) with recognized objectives, a designated manager, and resources

Note 1 to entry: *Constituent systems* (3.1.2) retain their independent ownership, objectives, funding, and development and sustainment approaches. Changes in the *systems* (3.1.11) are based on cooperative agreements between the managers of the SoS and the managers of the CS.

3.2.2
collaborative SoS
collaborative system of systems
SoS (3.1.13) in which *constituent systems(CS)* (3.1.2) operationally interact more or less voluntarily to fulfil agreed-upon central purposes

Note 1 to entry: Managers of CS or CS projects collaboratively decide how to provide or deny service, thereby providing means of enforcing and maintaining consistency.

3.2.3
directed SoS
directed system of systems
SoS (3.1.13) created and managed to fulfil specific purposes, with *constituent systems* (3.1.2) that are subordinated to the SoS

Note 1 to entry: Constituent systems maintain an ability to operate independently; however, their normal operational mode is subordinated to the central managed purpose.

3.2.4
virtual SoS
virtual system of systems
SoS (3.1.13) that lacks a central *management* (3.1.7) authority and a centrally-agreed-upon purpose

Note 1 to entry: Large-scale behaviour emerges – and can be desirable – but this type of SoS relies on relatively invisible mechanisms to maintain it.

Note 2 to entry: Virtual SoS are typically self-organizing.

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