



BSI Standards Publication

Systems and software engineering — Life cycle management

Part 2: Guidelines for the application of ISO/IEC/
IEEE 15288 (system life cycle processes)

National foreword

This British Standard is the UK implementation of ISO/IEC/IEEE 24748-2:2024. It supersedes BS ISO/IEC/IEEE 24748-2:2018, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee IST/15, Software and systems engineering.

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International
Standard

**ISO/IEC/IEEE
24748-2**

**Systems and software
engineering — Life cycle
management —**

**Part 2:
Guidelines for the application of
ISO/IEC/IEEE 15288 (system life
cycle processes)**

*Ingénierie des systèmes et du logiciel — Gestion du cycle de vie —
Partie 2: Lignes directrices pour l'application de l'ISO/IEC/IEEE
15288 (processus du cycle de vie du système)*

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Contents

Page

Foreword	v
Introduction	vii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Overview of ISO/IEC/IEEE 15288	1
4.1 General	1
4.2 Structure of ISO/IEC/IEEE 15288	2
4.3 Context of ISO/IEC/IEEE 15288	2
4.4 Comparison of ISO/IEC/IEEE 15288 to prior version	4
5 Application concepts	5
6 Applying ISO/IEC/IEEE 15288	5
6.1 Overview	5
6.2 Application strategy	5
6.2.1 Overview	5
6.2.2 Planning the application	7
6.2.3 Conduct pilot project(s)	7
6.2.4 Formalise the approach	8
6.2.5 Institutionalise the approach	8
6.3 Application of system concepts	8
6.3.1 General	8
6.3.2 Systems	8
6.3.3 System structure	9
6.3.4 Structure in systems and projects	9
6.3.5 Interfacing, enabling and interoperating systems	9
6.4 Application of life cycle concepts	10
6.4.1 Overview	10
6.4.2 Decision gates	11
6.4.3 Application approaches	12
6.5 Application of organizational concepts	17
6.5.1 Overview	17
6.5.2 Methods and tools	19
6.5.3 Considerations and techniques	19
6.5.4 Management commitment	20
6.5.5 Uses of ISO/IEC/IEEE 15288 within an organization	20
6.6 Application of project concepts	20
6.7 Application of process concepts	21
6.7.1 General	21
6.7.2 Application of agreement processes (ISO/IEC/IEEE 15288:2023, 6.1)	21
6.7.3 Application of organizational project-enabling processes (ISO/IEC/IEEE 15288:2023, 6.2)	24
6.7.4 Application of technical management processes (ISO/IEC/IEEE 15288:2023, 6.3)	25
6.7.5 Application of technical processes (ISO/IEC/IEEE 15288:2023, 6.4)	32
6.8 Application of conformance and adaptation concepts	47
6.8.1 Application of conformance concepts	47
6.8.2 Application of adaptation concepts	47
Annex A (informative) Summary of typical revised points in ISO/IEC/IEEE 15288:2023 from ISO/IEC/IEEE 15288:2015	50
Annex B (informative) Example for interfacing, enabling and interoperating systems	57
Annex C (informative) Model-based systems and software engineering (MBSSE)	59
Bibliography	62

IEEE notices and abstract.....64

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/JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering*, in cooperation with the IEEE Computer Society Systems and Software Engineering Standards Committee, under the Partner Standards Development Organization cooperation agreement between ISO and IEEE.

This second edition cancels and replaces the first edition (ISO/IEC/IEEE 24748-2:2018), which has been technically revised.

The main changes are as follows:

- updated [4.4](#) to reflect changes to ISO/IEC/IEEE 15288;
- reworked interfacing, enabling and interoperating systems;
- added considerations on agile and DevOps;
- reworked [6.5](#);
- reworked [6.7](#) to reflect changes to ISO/IEC/IEEE 15288;
- reworked [6.8](#) to reflect changes to ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 24748-1;

- removed the former [Annex A](#) (guide on transitioning from former version);
- added a new [Annex B](#) to include an example on interfacing, enabling and interoperating systems;
- removed the former [Annex C](#) (engineering views and the Vee);
- added a new [Annex C](#) on model-based systems engineering.

A list of all parts in the ISO/IEC/IEEE 24748 series can be found on the ISO and IEC websites.

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 and www.iec.ch/national-committees.

Introduction

This document and its companion, ISO/IEC/IEEE 24748-3, specifically support the use of ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207, respectively. This document and ISO/IEC/IEEE 24748-3 reflect the alignment effort evident in ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207. Terminology, structure and content in this document and ISO/IEC/IEEE 24748-3 are aligned consistent with those in ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207. Consequently, the users of ISO/IEC/IEEE 12207 and ISO/IEC/IEEE 15288 benefit from having documents complementarily addressing all aspects of services or products over their life cycle.

This document is intended to be consistent with both ISO/IEC/IEEE 24748-1 and ISO/IEC/IEEE 15288 in its treatment of life cycle concepts and systems engineering processes.

NOTE Systems engineering for defence projects is addressed in ISO/IEC/IEEE 24748-7.

There is also increasing recognition of the importance of ensuring that all life cycle stages, and all aspects within each stage, are supported with thorough guidance enabling alignment with process documents that focus on areas besides systems and software. These can include hardware, humans, data, processes (e.g., review process), procedures (e.g., operator instructions), facilities and naturally occurring entities (e.g., water, organisms, minerals). The concept and structure of the ISO/IEC/IEEE 24748 series is intended to allow its extension to such additional domains where that will provide value to users.

Systems and software engineering — Life cycle management —

Part 2:

Guidelines for the application of ISO/IEC/IEEE 15288 (system life cycle processes)

1 Scope

This document provides guidance on the application of ISO/IEC/IEEE 15288. It addresses the application of system, life cycle, organizational, project, process, and conformance and adaption concepts, principally through references to ISO/IEC/IEEE 24748-1 and ISO/IEC/IEEE 15288. This document gives guidance on applying ISO/IEC/IEEE 15288 from the aspects of strategy, planning, application in organizations and application on projects. It also provides a comparison of the differences between ISO/IEC/IEEE 15288:2023 and ISO/IEC/IEEE 15288:2015.

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, *Systems and software engineering — System life cycle processes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC/IEEE 15288 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/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>
- IEEE Standards Dictionary Online: available at: <http://dictionary.ieee.org>

NOTE Definitions for other systems and software engineering terms typically can be found in ISO/IEC/IEEE 24765, available at www.computer.org/sevocab.

4 Overview of ISO/IEC/IEEE 15288

4.1 General

ISO/IEC/IEEE 15288 defines a set of processes to facilitate system development and information exchange among acquirers, suppliers and other stakeholders in the life cycle of a system. It applies to the acquisition of systems, which can be comprised of products, services or both, as well as to the supply, development, operation, maintenance and disposal of systems, whether performed internally or externally to an organization.

In the context of this document, ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207, there is a continuum of human-made systems from those that use little or no software to those in which software is the primary interest. When software is the predominant system or element of interest, ISO/IEC/IEEE 12207 should be used. Both documents have the same process model, share most activities and tasks and differ primarily in descriptive notes. The determination of the applicability of ISO/IEC/IEEE 15288 and ISO/IEC/IEEE 12207 should be decided by the nature of the system and its enabling systems. Often, a mixed tailoring of each standard can be appropriate.

The purpose of ISO/IEC/IEEE 15288 is to provide a defined set of processes to facilitate communication among acquirers, suppliers and other stakeholders in the life cycle of a system. ISO/IEC/IEEE 15288 is written for acquirers of systems and other stakeholders like suppliers, developers, operators, maintainers, managers, quality assurance managers and users of systems.

4.2 Structure of ISO/IEC/IEEE 15288

ISO/IEC/IEEE 15288 contains requirements in two clauses:

- a) ISO/IEC/IEEE 15288:2023, Clause 6 defines the requirements for the system life cycle processes;
- b) ISO/IEC/IEEE 15288:2023, Annex A provides requirements for tailoring of ISO/IEC/IEEE 15288.

See ISO/IEC/IEEE 15288:2023, Clause 5 for key concepts used in that International Standard.

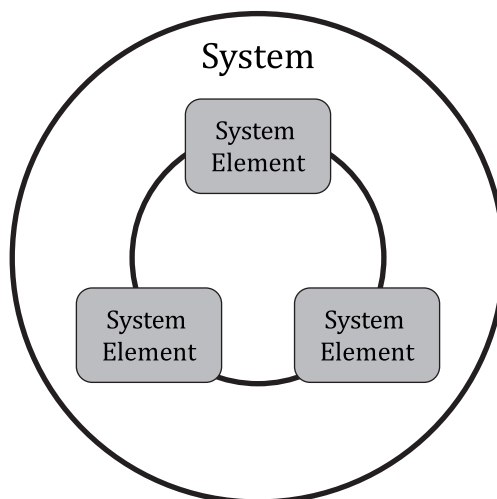
Three informative annexes support the use of ISO/IEC/IEEE 15288:

- ISO/IEC/IEEE 15288:2023, Annex B provides information on possible information items that can be associated with each process in ISO/IEC/IEEE 15288;
- ISO/IEC/IEEE 15288:2023, Annex C provides information about use of the ISO/IEC/IEEE 15288 system life cycle processes as a process reference model to support process assessment;
- ISO/IEC/IEEE 15288:2023, Annex D provides an informative description of the implementation of system life cycle processes in an MBSE approach.

4.3 Context of ISO/IEC/IEEE 15288

ISO/IEC/IEEE 15288 focuses on the processes that are used by or for a project that exists in a defined relationship with the organization, other projects and enabling systems. Typically, a project is assigned responsibility that encompasses one or more life cycle stages of the system-of-interest (SoI). ISO/IEC/IEEE 15288 is applicable to organizations and projects whether they act as the acquirer or the supplier of a system and whether the system is comprised of products, services or a combination of both.

The ISO/IEC/IEEE 15288 processes are described in relation to a system, see [Figure 1](#). As shown in [Figure 1](#), a system is composed of a set of interacting system elements. System elements may include software elements, hardware elements, services, and utilization and support resources.



NOTE See ISO/IEC/IEEE 15288:2023, Figure 1.

Figure 1 — System and system element relationship

When an organization applies ISO/IEC/IEEE 15288 to a particular system that system becomes the SoI. The SoI has a life cycle that consists of multiple stages through which the system passes during its lifetime. These stages are not necessarily sequential and their execution can be completely or partially in parallel, as well as iterative or recursive. Examples of typical stages are:

- concept;
- development;
- production;
- utilization;
- support;
- retirement.

NOTE 1 Stages are described in ISO/IEC/IEEE 15288:2023, 5.5.2 and in ISO/IEC/IEEE 24748-1:2024, 4.3.2 and Clause 5.

NOTE 2 The management of the transition from one stage to another is not necessarily a linear, sequential, progression and engineering activities are associated with providing appropriate work products and decision-making information in each stage.

A number of enabling systems are deployed throughout the system life cycle to provide the SoI with support as needed. Each life cycle stage can require one or more enabling systems. An enabling system has its own life cycle and when ISO/IEC/IEEE 15288 is applied to it, it then becomes an SoI.

NOTE 3 The role and use of enabling systems are described in [6.3.5](#).

NOTE 4 For related material on enabling systems, see also ISO/IEC/IEEE 15288:2023, 5.2.3 and ISO/IEC/IEEE 24748-1:2024, 4.2.4.

ISO/IEC/IEEE 15288 is applicable at any level of the structure associated with an SoI. As a system is decomposed recursively into its system elements, the processes of ISO/IEC/IEEE 15288 may be used for each system and system element in the system structure, including enabling systems. Each system and system element has a life cycle of its own and its own set of enabling systems.

NOTE 5 For related material on system structure, see ISO/IEC/IEEE 15288:2023, 5.2.2 and ISO/IEC/IEEE 24748-1:2024, 4.2.3.

In order to perform needed operations and transformations upon systems during their life cycles, the organization creates and monitors projects. Projects have a defined scope, resources (including time) and focus. The scope can involve managing all of the stages of the life cycle, a subset of the stages, one or more defined processes or one or more process activities. The time scale can be of varying duration, for example a few weeks or tens of years. The focus of the project is related to the SoI and its systems and system elements in some form of system structure or stage partitioning.

NOTE 6 System life cycle concepts are described in ISO/IEC/IEEE 24748-1:2024, 4.3.

Organizations focus on systems that are created or transformed by projects within the organization or in conjunction with other organizations. Projects have a span of interest that includes the SoI and its related enabling systems. Some enabling systems are under direct control of the project. The SoI and those enabling systems make up the project span of control.

The work performed by projects is on or with the SoI within one or more life cycle stages. ISO/IEC/IEEE 15288 includes the requirement to define an appropriate life cycle for a system, the selection of processes to be applied throughout the life cycle and the application of these processes to fulfil agreements and achieve customer satisfaction.

ISO/IEC/IEEE 15288 can be applied to all types of product- or service-focused systems and system elements consisting of one or more of the following: hardware, software, humans, processes, procedures, facilities and naturally occurring entities. The use of ISO/IEC/IEEE 15288 for systems within this broad scope is one of its main advantages.

The use of the standard may be adapted to accommodate the varying project requirements in treating system life cycles.

NOTE 7 This can be performed by adapting the life cycle as described in ISO/IEC/IEEE 24748-1:2024, Clause 5 and tailoring described in ISO/IEC/IEEE 15288:2023, Annex A.

4.4 Comparison of ISO/IEC/IEEE 15288 to prior version

This subclause compares ISO/IEC/IEEE 15288:2023 with ISO/IEC/IEEE 15288:2015. For a more detailed comparison, see [Annex A](#). The main changes are:

- improvements to selected technical processes including business or mission analysis process, system architecture definition process (renamed from architecture definition process), design definition process, implementation process, integration process and maintenance process;
- improvements to selected technical management processes, including risk management process and configuration management process;
- except for these changes, the process groups and life cycle processes are the same as the prior version;
- emphasized importance of system of systems (SoS), moved content from ISO/IEC/IEEE 15288:2015, Annex G to ISO/IEC/IEEE 15288:2023, 5.4 and added several notes throughout the document;
- addition of ISO/IEC/IEEE 15288:2034, Annex D addressing model-based systems engineering (MBSE);
- updates to ISO/IEC/IEEE 15288:2015, Clause 5, including a better description of iteration and recursion and expanded content on process application and system concepts;
- new content in ISO/IEC/IEEE 15288:2023, Clause 5 on collaborative activities, concept and system definition, assurance and quality characteristics;
- updates to the terms and definitions;
- removed ISO/IEC/IEEE 15288:2015, Annex D “Process integration and process constructs”, Annex E “Process views”, Annex F “Architecture modelling” and Annex G “Application of system life cycle processes to a system of systems”.

5 Application concepts

This document provides guidelines for life cycle management in the field of systems. This clause lists essential concepts on which this document is based and provides references for further reading and applying. Essential concepts are:

- life cycle management: ISO/IEC/IEEE 24748-1 provides more information on concepts related to life cycle management in general;
- system concepts: system concepts for systems that are any mix of products and services are introduced in ISO/IEC/IEEE 15288:2023, 5.2; additional discussion is in ISO/IEC/IEEE 24748-1:2024, 4.2;
- organizational concepts: organizational concepts are introduced in ISO/IEC/IEEE 15288:2023, 5.3; additional discussion is in ISO/IEC/IEEE 24748-1:2024, Annex B;
- system of systems concepts: SoS concepts are introduced in ISO/IEC/IEEE 15288:2023, 5.4; additional discussion is in ISO/IEC/IEEE 21839, ISO/IEC/IEEE 21840 and ISO/IEC/IEEE 21841;
- life cycle concepts: life cycle concepts are introduced in ISO/IEC/IEEE 15288:2023, 5.5; additional discussion is in ISO/IEC/IEEE 24748-1:2024, 4.3;
- process concepts: process concepts are introduced in ISO/IEC/IEEE 15288:2023, 5.6; additional discussion is in ISO/IEC/IEEE 24748-1:2024, Annex A;
- project concepts: project concepts are introduced in ISO/IEC/IEEE 15288:2023, 5.3.2; additional discussion is in ISO/IEC/IEEE 24748-1:2024, Annex C.

6 Applying ISO/IEC/IEEE 15288

6.1 Overview

Throughout ISO/IEC/IEEE 15288, “shall” is used to express a provision that is binding between two or more parties, “should” to express a recommendation among possibilities and “may” to indicate a course of action permissible within the limits of ISO/IEC/IEEE 15288. This document provides guidance to assist in understanding how the provisions of ISO/IEC/IEEE 15288 apply. No new requirements are introduced in the guidance text (no “shall”). Where “should” is used, it is a recommendation of a requirement of ISO/IEC/IEEE 15288.

Understanding concepts does not give the ability to immediately apply them without further thought and work. [6.2](#) to [6.8](#) give guidance on what should be done to bridge the gap between concept and practical use in different organizational, life cycle and project environments, starting with planning the application of ISO/IEC/IEEE 15288.

Modern organizations strive to develop a robust set of life cycle processes that are applied repeatedly to the projects of the organization. To accommodate that need, ISO/IEC/IEEE 15288 is intended to be useful for application at either the organization level or at the project level. An organization should adopt the standard and supplement it with appropriate policies, life cycle processes, life cycle models and procedures. A project of the organization should typically conform to the organization's processes rather than conform directly to ISO/IEC/IEEE 15288.

In some cases, projects can be executed by an organization that does not have an appropriate set of processes adopted at the organizational level. Such a project may directly adopt the provisions of ISO/IEC/IEEE 15288.

6.2 Application strategy

6.2.1 Overview

ISO/IEC/IEEE 15288 can be applied for a variety of reasons, such as to:

- a) define the processes, activities and tasks required for use on a specific project;

- b) improve processes used by an organization across multiple projects;
- c) provide guidance on system life cycle processes usable within a larger process, such as an organization's acquisition process or maintenance process.

Whatever the reason for application of ISO/IEC/IEEE 15288 is, a suggested application strategy consists of the following:

- plan the application;
- adapt ISO/IEC/IEEE 15288, if applicable;
- conduct pilot project(s);
- formalise the approach;
- institutionalise the approach.

This strategy is typical of the approach that should be followed when introducing changes into an organization or project. The application strategy can be repeated several times across an organization or within a project as additional processes are addressed or improved.

Whether the basis for the existing system life cycle processes is ISO/IEC 15288:2015 or some other reference point, the fundamental starting point is to identify all the changes to go from that basis to ISO/IEC/IEEE 15288.

Coordinating with stakeholders in this effort is critical: even one area left out that should have been in the planning can materially disrupt applying the new basis. One way of proceeding is for a small group to develop a high-level list of items that should be considered and changed in applying ISO/IEC/IEEE 15288. This may include, and possibly will not be limited to:

- process and procedure changes, including flow and nomenclature;
- staff training needs;
- responsibility changes, including need for new or modified agreements;
- impacts on procedures and tools;
- an approach applied across the organization
- improved processes.

A more detailed set of changes should then be developed by a wide group of affected stakeholders.

Once there is a detailed listing of the changes, the time and cost impacts of each should be assessed and adjusted for the risks of each change and various groupings of change. Changes should be phased to minimise cost, project disruption and the potential for adverse human reactions. Readiness criteria should be developed for the phase-in, as well as checks for successful completion of the changes. Quantitative and qualitative measures should be developed and used.

Throughout, a core group should be maintained to oversee the change from one basis to another, with periodic coordination with the entire group of stakeholders. This coordination is very important to repeatedly communicate the goals of the change, to show progress and to recognise progress.

When an organization or project already has established processes that have been institutionalised, then the implementation strategy can be shortened and should probably include the following:

- plan the application;
- adapt ISO/IEC/IEEE 15288, if applicable (for the risk level of the work);
- conduct the project(s).

6.2.2 Planning the application

Applying ISO/IEC/IEEE 15288 should be considered as a specific project and planned as such.

The following are examples of items to consider while planning the application project:

- a) Define the scope of the application project. Possibilities include the following.
 - 1) A single project that is either internal to an organization or as part of a two-party agreement.
 - 2) Concentration on some key processes or even a single process where there is expected to be some gain for an organization. This approach can be used where a weakness has been detected previously. It can lead to a full application of ISO/IEC/IEEE 15288 at some future point. Conversely, the approach can be of benefit where significant process refinements or additions have been made, so that in depth revisions of a single process are necessary.
 - 3) Adoption of ISO/IEC/IEEE 15288 within an organization or across a range of projects. This generally involves a staged introduction. This generally occurs when an organization has multiple processes that are not aligned with ISO/IEC/IEEE 15288.
 - 4) Adoption of ISO/IEC/IEEE 15288 across all projects and within all parts of the organization. This sometimes occurs with a new subsidiary of an existing organization that has previously adopted ISO/IEC/IEEE 15288.
- b) Identify the 15288 application project goals and determine how they fit into the organization-wide business goals. If no obvious link is established between this application project and the organization's business focus, then lasting commitment to achieve the application project goals will be difficult if not impossible to maintain.
- c) Identify roles and responsibilities of the application project team, assigning a point of responsibility for each process.
- d) Identify the resources available for the application of ISO/IEC/IEEE 15288, such as time, funding, people and enabling systems and services. Also estimate the resources and infrastructure needed to sustain the process development and improvement process once the initial processes are institutionalized.
- e) Create and record the application project management strategy for applying ISO/IEC/IEEE 15288.
- f) Plan for regular coordination with stakeholders involved in the application project. It is key to every application project to communicate with stakeholders, in particular those that are supposed to apply the updated set of processes.
- g) Identify the impact of process tailoring on certifications and the impact of certifications on process tailoring.

6.2.3 Conduct pilot project(s)

When introducing ISO/IEC/IEEE 15288 in an organization across many projects, employing some pilot usage in key areas and processes helps remove emotional barriers, facilitate adoptions and limit the risk exposure of the organization. A successful introduction should usually include such approaches as the following.

- a) Identify pilot projects that can use the selected processes. These pilot projects should be chosen on the basis of high priority work that will result in significant improvements, with a high probability of success, or that can be expected to provide quick, visible results.
- b) Select a team of early adopters to conduct the pilot projects then publicise and reward their efforts.
- c) Plan the pilot projects and identify critical success factors and measures of success.
- d) Train everybody involved. Awareness can be aided by regular communication of progress in the implementation process, in addition to formal training classes.

- e) For each pilot project, incorporate the selected adapted process or processes into the application project management strategy. Reference or include as appropriate, the necessary records, including the adaptation decisions and rationale.
- f) Execute the pilot project(s). Track and record performance against the critical success factors.
- g) Capture knowledge gained from each pilot project in the knowledge management process, including lessons learned throughout the pilot project(s). Incorporate the lessons learned into revised processes.

6.2.4 Formalise the approach

Formalizing involves the introduction of a new process across the organization or across several projects. This includes the development of training, procedures, provision of enabling systems and services, such as tools for the processes, and the tracking and oversight of the new processes use and acceptance. Planning for the transition to the new processes should be addressed for any project that is already up and running.

NOTE Improvements can be made within a project by monitoring at the project level. They can also be made by comparing one project against another to determine approaches which were successful and which can be applicable and to be incorporated into future projects.

6.2.5 Institutionalise the approach

Institutionalisation involves the introduction of new processes across any areas and remaining projects of the organization. It includes a focus on ensuring that processes are used consistently and automatically throughout the organization or project. This also involves measuring performance of the process, and continuing to implement process improvement as necessary. These can be instituted using process work product review and approval such as decision gates as described in [6.4.2](#).

6.3 Application of system concepts

6.3.1 General

ISO/IEC/IEEE 15288 defines a set of processes to facilitate system development and information exchange among acquirers, suppliers and other stakeholders in the life cycle of a system. It applies to the full life cycle of systems, including concept, development, production, utilization, support and retirement of systems, and to the acquisition and supply of systems, whether performed internally or externally to an organization. This subclause focuses on those processes that most directly apply the system concepts stated in ISO/IEC/IEEE 15288:2023, 5.2 and expanded in ISO/IEC/IEEE 24748-1:2024, 4.2.

6.3.2 Systems

To determine how to provide products or services for the benefit of users and other stakeholders, the starting point should be to define the purpose of the system, its boundaries (including human interactions) and those who should be its stakeholders. The same idea should be followed in case the task is to upgrade or add capabilities to an existing system. In many cases, the structure or the composition of the final system are not known, and are not the focus of interest. For those reasons, users of ISO/IEC/IEEE 15288 should start with an analysis of the business or mission of the proposed system, applying the process defined in ISO/IEC/IEEE 15288:2023, 6.4.1, then use this as a bounding framework to define stakeholder needs and requirements, applying the process defined in ISO/IEC/IEEE 15288:2023, 6.4.2. These processes can be applied iteratively, or recursively and can be applied to new systems, existing systems where changes are being considered and enabling systems. This work focuses on purpose, scenarios, use cases and user stories. It is critical to identify and meaningfully involve all who will be stakeholders over the systems life cycle.

Applying a systems concept should mean that the analysis and determination are then used to define the requirements of some collection of interacting elements. This collection should satisfy the analysis and determination by applying the system requirements definition process defined in ISO/IEC/IEEE 15288:2023, 6.4.3. The specific structure of the system is not known at this point, nor is the manner in which that structure will be implemented (i.e. hardware, software, humans, processes, procedures, facilities or naturally occurring entities). The user should determine, possibly iteratively or recursively, the functional,

logical, timing, thermal, mass and other properties of the SoI and its enabling systems. Model-based systems engineering (MBSE), see [Annex C](#), can help understand and specify these properties. Maintaining stakeholder involvement throughout is still critical. Depending on the results, revision of the work described in [6.3.2](#) can be required.

For any of this work, the system analysis process defined in ISO/IEC/IEEE 15288:2023, 6.4.6 can be useful to apply.

6.3.3 System structure

With a thorough understanding of the purpose and benefits of the SoI, its boundaries and stakeholders, as well as their needs and requirements, plus the resulting system requirements that have been derived from these, the user of ISO/IEC/IEEE 15288 should apply the technical processes for system definition (see [6.7.5.3](#)) to progressively define the structure of the system (its architecture) and the specific ways in which that architecture can be realised.

More specifically, the user of ISO/IEC/IEEE 15288 should apply the system architecture definition process (ISO/IEC/IEEE 15288:2023, 6.4.4) and the design definition process (ISO/IEC/IEEE 15288:2023, 6.4.5). In applying these processes, probably iteratively and recursively, characteristic properties at a system's boundary arise from the interactions between system elements and external systems. What this means in practice is that the interfaces between parts of the system should be understood first, then the parts themselves should be architected and then designed to respond to the requirements imposed by the interface. This process should be continued from the most general understanding of the system structure progressively to the most detailed level. Due to the huge amount of information that is gathered when applying the processes, model-based approaches (MBSE) should be taken to help keeping the artefacts consistent, also see [Annex C](#).

Briefly stated, the user of ISO/IEC/IEEE 15288 should work from the interfaces inward, and from the most general to the most specific and detailed aspects of the requirements, architecture and design. This applies to the SoI and its enabling systems, whether new or under consideration for change. Accordingly, the application of the processes can be done at any stage of a system's life cycle.

For any of this work, the systems analysis process defined in ISO/IEC/IEEE 15288:2023, 6.4.6 can be useful to apply.

6.3.4 Structure in systems and projects

The user of ISO/IEC/IEEE 15288 should determine the project scope, or the scopes of the set of projects, that best supports definition, realization and use of the SoI and its enabling systems. To do this, the user of ISO/IEC/IEEE 15288 should draw on the results of applying, directly or with adaptation, the agreement processes (ISO/IEC/IEEE 15288:2023, 6.1), organizational project-enabling processes (ISO/IEC/IEEE 15288:2023, 6.2) and technical management processes (ISO/IEC/IEEE 15288:2023, 6.3) that are already in place for the organization within which the projects will be executed. For example, the possible need to define a new system should result in reconsideration of the organization's infrastructure, portfolio, human resource, quality and knowledge management capabilities under various possible project structures to find the best relationship of the set of projects versus the possible scope of the SoI and its enabling systems.

6.3.5 Interfacing, enabling and interoperating systems

Typically, systems break at the interfaces because of lack of quality or maturity of these interfaces. When developing an SoI, it is not only the interfaces that this SoI has in operation that should be taken into account. There are other interfaces to be considered along the entire life cycle. Therefore, it is important to understand the concept of interfacing, enabling and interoperating systems.

When teams begin to identify the external interfaces of the SoI, they often start with the systems that the SoI interacts with in operation. Often, a system boundary diagram is used to document data or information, energy, material and physical flows. Immediately thereafter, other life cycle stages should be considered to identify all systems that interact with the SoI to perform a function. This almost always occurs in an SoS environment where constituent systems interact with each other to realise SoS functions. Also included are

cases where external systems exchange data or information with the SoI for further processing. The total set of these external systems is referred to as the interoperating systems associated with the SoI.

These interoperating systems are a subset of the interfacing systems. The interfacing systems also include those external systems having purely physical interfaces with the SoI, in which no data or information is exchanged to support any system functionality, neither on the part of the SoI nor on the external system. In most cases, these are physical interfaces between the SoI and the external system.

Enabling systems are systems that support the SoI at various points along its life cycle. Consequently, they apply to all parts of the life cycle and potentially support any process. Some enabling systems have a physical interface to the SoI (e.g. maintenance laptop) while some do not (e.g. training system). Also, enabling systems can be either inside or outside the boundary for which a project is responsible. Whether a particular enabling system is inside or outside the project boundary, the enabling system is within the span of interest of a project because of interface and scheduling constraints. Thus, enabling systems should be considered especially whenever there are changes to the design of the SoI. If the interface to one of the enabling systems can no longer be supported as a result of the change to the SoI, it can lead to cost-intensive changes to this enabling system. In such a case, it is advisable to perform a trade-off study to weigh the consequences of making the proposed change. If it is necessary to develop enabling systems to support the SoI, care should be taken to ensure that the schedules of these two development projects are closely aligned. Failure to provide a necessary enabling system in a timely manner can have a massive impact on the schedule of the SoI.

In case the enabling system is inside the project boundary, for each architecture or design solution in the SoI or system element, the enabling system requirements should be identified. The enabling system requirements should be satisfied either by engineering the enabling systems that need to be developed or by acquisition or scheduling the existing and available enabling systems. These actions should be carried out to help ensure that required enabling system services or products are available when needed to support the SoI or systems elements during the applicable life cycle stage.

The requirements for each enabling system should be provided to the concept definition and system definition processes of the applicable SoI and system elements. Requirements can include allowable tolerances and types of materials and material processing such as cutting, milling and stamping. Additionally, the concept of operations (or strategy) for implementation should be available as well as any implementation constraints to include special techniques to be used. An enabling system can be defined as an SoI and can also have its own set of enabling systems to provide appropriate life cycle support.

[Annex B](#) provides examples with explanations of interfacing, enabling and interoperating systems.

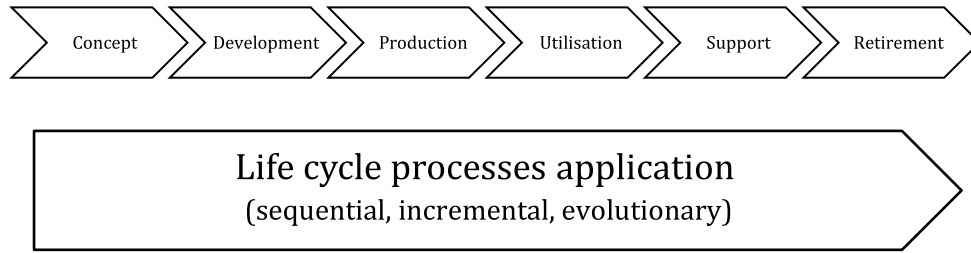
6.4 Application of life cycle concepts

6.4.1 Overview

ISO/IEC/IEEE 15288:2023, 6.2.1.3 a) requires the establishment of a life cycle model to provide a framework in which the processes of ISO/IEC/IEEE 15288 are performed. It also requires the definition of purpose and outcomes for each stage in the established life cycle model. ISO/IEC/IEEE 24748-1:2024, Clause 4 provides a description, including the purpose and outcomes, of a life cycle model with a set of six life cycle stages. This model is included in [Figure 2](#).

NOTE 1 For simplicity of exposition, the life cycle model in [Figure 2](#) is drawn as if the stages were sequential and equal in length. As described in ISO/IEC/IEEE 24748-1:2024, 4.3.1, stages can be interdependent and overlapping, can be of differing durations and can iterate or be applied recursively.

Generic system life cycle stages

**Figure 2 — Generic system life cycle model**

The system life cycle model illustrated in [Figure 2](#) does not imply any application precedence or sequence for the application of ISO/IEC/IEEE 15288 life cycle processes. The use of the life cycle processes is influenced by multiple factors such as social responsibilities, world trade laws, organizational cultures and technical considerations. Each of these factors can vary during the life of a system. A manager of a system life cycle stage typically selects the appropriate set of life cycle processes to meet entry or exit criteria and other stage objectives. For example, during any of the later life cycle stages a manager can use the operation process, maintenance process and disposal process to manage the system while it performs its required functions or is serviced to meet system requirements. During earlier life cycle stages the same processes can be used to help manage the development of the system as well as affect the disposal of waste products or work products that are no longer needed.

To determine which processes to select and apply during a system life cycle stage, a user of ISO/IEC/IEEE 15288 is guided by the purpose and outcomes for each of the stages (see ISO/IEC/IEEE 24748-1:2024, Clause 5). The selection of the appropriate processes enables the system's progression through its life cycle to be managed. The system life cycle model of [Figure 2](#) can be considered as an illustration of an orderly passage associated with a system going from one stage of life to another.

An organization (e.g. an automobile company or medical equipment supplier) or a domain group of an organization (e.g. a government defence agency or industry group) often has a unique view of the system life cycle to control the passage from one system life cycle stage to the next. From an organizational perspective, the focus is more on management-focused activities that are used to form both milestones and decision gates.

The organization uses these milestones and gates as decision points where investment decisions can be made as to whether a system should remain in the current stage, be continued to another system life cycle stage, have the plans for the other stages revised before approval, be cancelled or be retired. These milestones and decision gates can be used by organizations to contain the inherent uncertainties and risks associated with costs, schedule and functionality when a system is created or utilised.

There are different approaches that can be used to meet organization goals and objectives. In order to meet the exit criteria of a decision gate, the appropriate artefacts should be produced to provide decision-making information and required deliverables. Thus, planned engineering activities should take place during each system life cycle stage to obtain the outcomes and meet the purpose of the stage or a set of stages.

Some system life cycle models, particularly those related to incremental or evolutionary approaches, feature the iterative execution of several of the life cycle stages shown in [Figure 2](#). For example, a small improvement to an existing system can be conceived, developed and produced within a “timebox” of a few weeks. Subsequent improvements use the same approach in consecutive future “timeboxes”. In this environment, it may not be practical to align certain key concepts to the completion of a stage, such as decision gates ([6.4.2](#)) and technical reviews. Instead, an alternate alignment strategy, such as the completion of one or more iterations, can be necessary. However, the intent of these key concepts should be retained.

6.4.2 Decision gates

Although there are many different approaches to develop systems, there is an underlying notional set of characteristic milestones and decision gates that exists. Each milestone and decision gate has a distinct

purpose and contribution to the system life cycle. These milestones and decision gates should be considered when planning and executing the system life cycle. Cognizant governance should specify the mechanism to arriving at a decision.

NOTE 1 Examples of decision options and their purpose for each stage of a life cycle are shown in ISO/IEC/IEEE 24748-1:2024, Table 1.

Milestones provide an opportunity for management to review progress and decide to declare that milestone as satisfactorily completed and proceed to the next milestone. If the milestone marks the end of a stage, then a decision gate is reached. The decision gates provide a framework within which organization management has high-level visibility and control of the project.

NOTE 2 Some approaches, such as agile and DevOps, accomplish their reviews in a different cadence and tend to avoid the terms “milestones” and “decision gates.”

During each system life cycle stage, management can use established decision gates to determine whether the objectives (financial as well as technical) of that system life stage were satisfactorily completed and the way forward.

The specific rationale for the decision can vary for each stage. For example, during life cycle stages while the system is being used (utilization and support), the decision as to whether to continue in that stage or if the system should be appropriately retired (move to the retirement stage) can be based on:

- a) whether system technology should and can be refreshed (change to the baseline configuration without changing performance);
- b) whether new system technology should and can be inserted (change to system performance).

Decision gates to move to another stage can occur at more than one point in a given stage. Examples of when decision gates can be appropriate for the concept stage are:

- after a period of pre-study;
- after studying the feasibility of the alternative concepts.

The considerations given can be applied not only to the SoI but also to its system elements as well as enabling systems. If the SoI is an SoS, the considerations can be applied to the constituent systems. Different organizations can be responsible for different systems of the system structure. Also, individual systems or system elements can have a shorter life than the SoI in which they are embedded, so there can be a need to replace these individual systems or system elements with improved ones during the life of the SoI.

6.4.3 Application approaches

6.4.3.1 General

Organizations employ different approaches to satisfy contrasting business and risk resolution strategies. Sequential, incremental, evolutionary or agile approaches are frequently used. These approaches are discussed in [6.4.3.2](#) to [6.4.3.5](#). Alternatively, a suitable hybrid of these approaches can be developed.

The selection, development and use of one of these approaches by an organization depend on several factors such as the following:

- a) the acquisition policy of the organization;
- b) the nature and complexity of the system;
- c) the stability or feasibility of system requirements;
- d) technological opportunities;
- e) the need for different system capabilities at different times;
- f) the availability of resources.

A careful selection of an appropriate application approach should be made as it:

- affects the plans and controls for the project;
- forms the basis for project cost and schedule estimates;
- determines the work relationship between acquirer and supplier;
- defines how the team works together;
- shapes what types of informal and formal reviews are established.

6.4.3.2 Sequential approach

6.4.3.2.1 General

For systems that have long development cycles before delivery of the first system, a sequential approach can be appropriate. Many systems, such as produced by the automotive industry, use a similar approach with development taking up to three years before a new automobile model is introduced. Projects using this approach faces many challenges including cost control, funding changes, technology changes, workforce retention and final customer or acquirer requirements satisfaction. These challenges are created because of the long period from establishing the initial requirements for the system to the deploying of the system in the marketplace.

The sequential approach has defined decision gates so that an organization can manage an orderly progression of the system from concept through retirement. For systems that rely heavily on off-the-shelf system elements, development is often started without doing concept studies. In this case, the project needs to be aware of the risks of starting development without doing the risk reduction engineering of earlier studies. Use of off-the shelf system elements does not replace system feasibility analyses or the risk reduction analyses and effectiveness assessments needed to confirm that interfaces are compatible. This off-the-shelf approach can reduce the need to go through earlier decision gates, but it does not eliminate the analysis necessary to reduce risks.

The sequential approach can be very effective and efficient for engineering systems where the requirements are well known and stable, or for updates to existing systems.

6.4.3.2.2 Applicable systems

This approach can be applied to systems that are one or a few of a kind or those that have large quantities produced. Examples of systems for which this approach can apply are infrastructure information technology systems, a manufacturing system modification, automobiles, control systems and consumer products. During the production stage either one or a few systems can be produced and delivered, or a large quantity production can be initiated that can continue into the utilization and support stages. The utilization and support stages are typically the longest period of this life cycle and can last for many years. Major systems realised using this approach often have an operation life of tens of years with modifications using technology refreshments and technology insertions made to sustain the system and lengthen its useful life.

This sequential approach can be applied to modernization of legacy systems. The engineering, however, is done on the system being enhanced and its related lower-level systems and system elements of the system structure. The impact on the SoI should be analysed and where conflicts are revealed, the changes to higher-level systems and the SoI should be made or the requirements for the applicable system should be revised.

6.4.3.2.3 Risks

Because of the long duration of development using the sequential approach, several risks such as the following should be considered and resolved before adoption:

- a) expectations and requirements related to the system can change over the years of development;
- b) knowledgeable workers on teams can turn over;

- c) decision-making personnel in the organization can change;
- d) customer personnel in the acquirer's organization can change;
- e) suppliers of system elements and related services can go out of business or change technologies;
- f) obsolescence can arise during a long development;
- g) disruptive changes of events or the environment can impact the project.

6.4.3.2.4 Opportunities

The opportunities such as the following can be associated with the sequential approach.

- a) The deliberate, stepwise refinement approach, whereby the progress of system development is carefully evaluated at each milestone allows system quality and risks to be evaluated and investment decisions confirmed before progressing to the next stage of development, production lot or delivery to market.
- b) All system capabilities can be delivered at the same time.
- c) In-service modification decisions allow determination of whether to do maintenance, a major modification or to retire the system from service.
- d) Old systems can be simultaneously retired from service or withdrawn from the market.

6.4.3.3 Incremental approach

6.4.3.3.1 General

The incremental approach can be applied to organizations that market new versions of a product. Milestones are established at planned intervals to introduce a planned version of the system that can be released to the market. The system realised as a result of the concept stage can be a first version.

The overall capabilities of the last version to be marketed can be known at the start of system development. However, a limited set of capabilities is allocated to the first version. With each successive version, more capabilities are added until the last release fully incorporates the overall capabilities.

The application of ISO/IEC/IEEE 15288 life cycle processes, further described in [6.7](#), is performed to realise each version. The operation and support of each version is done in parallel with the development, utilization and support of successive versions. Early versions of the system and support for those versions can be phased out as newer versions are bought and used by the customer base or a block modification to earlier versions can be made to incorporate the new capabilities of a later version.

6.4.3.3.2 Applicable systems

This approach can be applied to systems that rely on new, enhanced capability versions of the system to be introduced in short intervals so as to remain competitive in the marketplace. Examples include information technology systems such as business systems, medical systems and routing and firewall systems.

6.4.3.3.3 Risks

The incremental approach has associated risks such as the following that should be considered and resolved before adopting this approach.

- a) Initial versions of the system can have such a limited set of capabilities that customers can be dissatisfied and not be interested in buying the next version.
- b) Versions marketed with too short an interval can cause customer dissatisfaction with the cost to upgrade or the retraining costs.
- c) Costs for training (time and money) to move from one version to the next can be unacceptable.