
Systems engineering — A guide for the application of ISO/IEC 15288 (System life cycle processes)

Ingénierie systèmes — Un guide pour l'application de l'ISO/CEI 15288 (processus de cycle de vie des systèmes)



Reference number
ISO/IEC TR 19760:2003(E)

AVA Documents
Document Sharing Hub
© ISO/IEC 2003

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

© ISO/IEC 2003

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword	v
1 Scope	1
1.1 Purpose	1
1.2 Audience	1
1.3 Prerequisites	1
2 Normative references	2
3 Context of this Technical Report	2
3.1 Overview	2
3.2 Context of the International Standard	2
3.3 Process categories of the International Standard	4
4 Use of the International Standard	5
4.1 Overview	5
4.2 Concept of use	5
4.2.1 General	5
4.2.2 Scope tailoring	5
4.2.3 Process tailoring	5
4.3 Planning for use	6
4.4 Tailoring	8
4.4.1 General	8
4.4.2 Tailoring considerations	8
4.4.3 Tailoring guidance	9
4.4.4 Tailoring documentation	10
5 Application concepts	10
5.1 Overview	10
5.2 System related concepts	10
5.2.1 System structure	10
5.2.2 Kinds of systems	11
5.2.3 System boundary	12
5.3 Project related concepts	12
5.3.1 Project focus	12
5.3.2 Hierarchy of projects	15
5.3.3 Project organizational structure	15
5.4 System life cycle concept	16
5.5 Process application concepts	17
5.5.1 Process use	17
5.5.2 Life cycle processes	18
5.5.3 Recursive/iterative application of processes	20
5.5.4 Methods and tools	21
6 Application of the International Standard life cycle processes	22
6.1 Overview	22
6.2 Application of the technical processes to engineer a system	22
6.2.1 General	22
6.2.2 Related technical processes for system definition	23
6.2.3 System structure definition	26
6.2.4 Related technical processes for system realization	27
6.2.5 Enabling system definition and realization	29
6.3 Application of life cycle processes to form an agreement	30
6.4 Application of life cycle processes to satisfy an agreement	32

7 Application of International Standard processes using the system life cycle 33

7.1 Overview..... 33

7.2 Enterprise view 34

7.2.1 Approaches 34

7.2.2 Sequential approach 36

7.2.3 Incremental approach 37

7.2.4 Evolutionary approach 38

7.3 Engineering view 39

7.3.1 General 39

7.3.2 Technical reviews..... 41

7.3.3 Configuration audits 42

8 Application by organizations 42

8.1 Overview..... 42

8.2 Uses of the International Standard within an organization 43

Annex A (informative) Relationship between ISO/IEC 15288 and other more detailed standards 45

Annex B (informative) References for design related special factors..... 47

Annex C (informative) Notes for application of ISO/IEC 15288 processes 51

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. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 19760, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and system engineering*.

Systems engineering — A guide for the application of ISO/IEC 15288 (System life cycle processes)

1 Scope

1.1 Purpose

This Technical Report provides guidance for the application of ISO/IEC 15288 *Systems engineering — System life cycle processes* (referred to as the International Standard) to systems and projects of various size and type. This Technical Report can be used as a companion document to the International Standard.

This Technical Report elaborates on factors that should be considered when applying the International Standard. It does this in the context of the various illustrative ways in which the International Standard may be applied. Also, lists within this Technical Report are not meant to be exhaustive but to provide the user with examples to consider.

The guidance contained in this Technical Report may be tailored as appropriate to the system and project using guidance in Annex A of the International Standard and 4.4 of this Technical Report.

This Technical Report is intended to provide appropriate links to other ISO documents for supporting application of the International Standard and to aid in assessing the effectiveness of the application of the International Standard.

Not all areas of the International Standard are meant to have equal treatment in this Technical Report. More specific information is provided where providing such information will help in the application of the International Standard. This Technical Report is not meant to provide how-to guidance for each area of the International Standard.

1.2 Audience

This Technical Report is applicable to audiences such as identified below:

- a) those who apply the International Standard;
- b) those who use the International Standard for a specific system;
- c) those who prepare organizational and specific domain standards based on the International Standard.

1.3 Prerequisites

The list below provides prerequisites for users of this Technical Report:

- a) availability of ISO/IEC 15288;
- b) familiarity with ISO/IEC 15288;
- c) familiarity with relevant organizational and project policies;
- d) general knowledge of project management, systems engineering and system life cycle models.

2 Normative references

The following referenced documents are indispensable for the application 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 15288, *Systems engineering — System life cycle processes*

ISO/IEC 12207, *Information technology — Software life cycle processes*

ISO/IEC TR 15271, *Information technology — Guide for ISO/IEC 12207 (Software life cycle processes)*

ISO/IEC 15504 (all parts), *Information technology — Software process assessment*

ISO 9001:2000, *Quality management systems — Requirements*

3 Context of this Technical Report

3.1 Overview

This clause has two objectives. The first objective is to provide an overview of the dynamic utilization of the International Standard with respect to key concepts and processes. Illustrated in this clause are the relationships between types of systems, system life cycles and the application of agreement, enterprise, project and technical processes. The second objective is to give pointers to the various clauses of this Technical Report that provide guidance to a user for applying the International Standard concepts and processes.

3.2 Context of the International Standard

Organizations need to be able to conduct commerce in systems (including their associated products and services). The International Standard facilitates commerce by providing the common framework for establishing and executing agreements between system acquirers and suppliers with respect to developing, using, and managing a system within the defined life cycle of that system. The International Standard is applicable to organizations, enterprises and projects whether they act as the acquirer or the supplier of a system.

The context of the International Standard is illustrated in Figure 1.

A single project may involve multiple organizations working together as partners. Such a project should use the International Standard to establish common terminology, information flows and interfaces among the several organizations to enhance communications.

When an organization applies the International Standard to a particular system, that system becomes the system-of-interest. The system-of-interest has a life cycle that consists of multiple stages through which the system passes during its lifetime, denoted s_1 , s_2 , ... s_n . Typical stages, as described in Annex B of the International Standard, are concept, development, production, utilization, support and retirement. The management of the progression from one stage to another and the engineering activities associated with providing appropriate work products and decision-making information is described in Clause 6 of this Technical Report.

A number of enabling systems are deployed throughout the system life cycle to provide the system-of-interest with support as needed. Each life cycle stage prior to system use (concept stage, development stage, and production stage) can require an enabling system. Enabling systems that cooperate with the system-of-interest during its utilization, support and retirement stages can be needed, as well. It is important to note that an enabling system has its own life cycle and that when the International Standard is applied to it, it then becomes a system-of-interest. The role and use of enabling systems are described in 5.2.3, 5.3.1.4, and 6.2.5 of this Technical Report.

The International Standard is applicable at any level of the structure associated with a system-of-interest. As a system is decomposed recursively into its system elements, the processes of the International Standard may be used for each system and system element in the system structure. Each system and system element has a life cycle of its own and its own set of enabling systems. This system structure is described in 5.2.1 of this Technical Report.

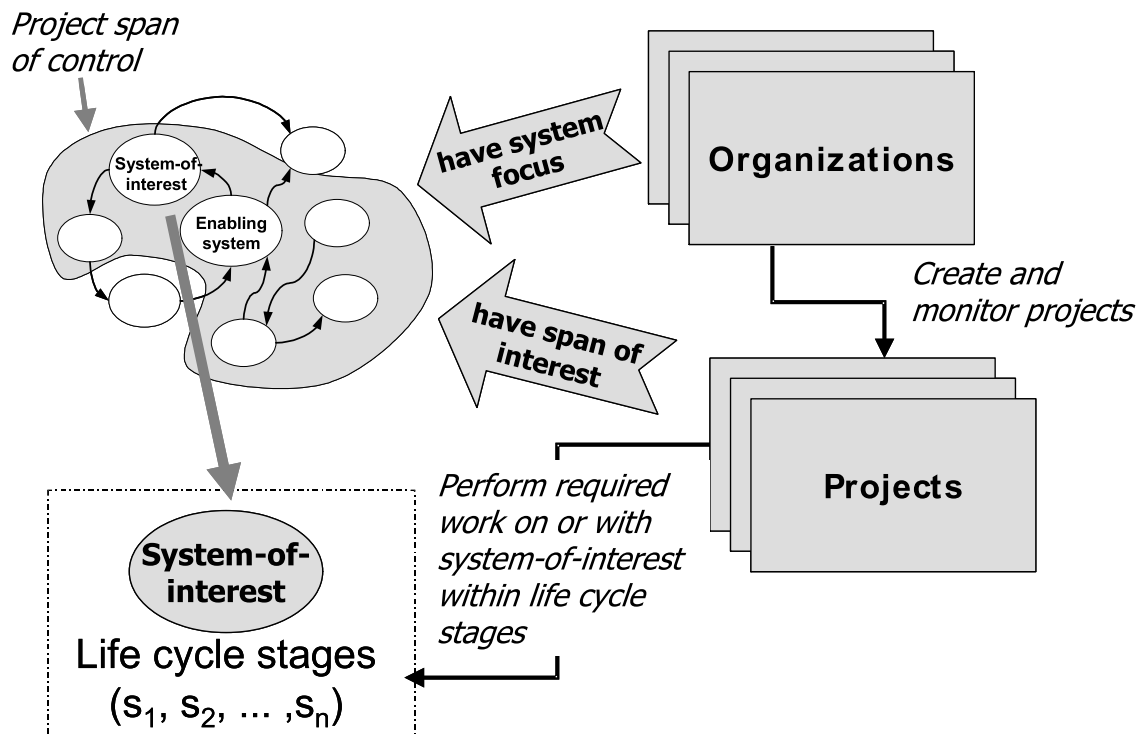


Figure 1 — Context of the International Standard

In order to perform needed operations and transformations upon systems during their life cycles, the organization creates and monitors projects. Projects have 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 one hour or tens of years. The focus of the project is related to the system-of-interest and its systems and system elements in some form of system structure or stage partitioning. Related project concepts are described in 5.3 of this Technical Report and system life cycle concepts are described in 5.4.

Organizations focus on systems that are created by projects within the organization or in conjunction with other organizations. Projects have a span of interest that includes the system-of-interest and its related enabling systems. Some enabling systems are under direct control of the project. The system-of-interest and those enabling systems make up the project span of control. The span of interest is described in 5.3.1.4.

The work performed by projects is on or with the system-of-interest within one or more system life cycle stages. The scope of the International Standard includes the definition of 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.

The International Standard can be applied to all types of 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 the International Standard for systems within this broad scope is one of its main advantages.

The use of the International Standard may be adapted to accommodate the varying project requirements in treating system life cycles. This may be performed by adjusting the scope as described in 4.2 and tailoring described in 4.4 of this Technical Report and Annex A of the International Standard.

3.3 Process categories of the International Standard

The four process groups of the International Standard as well as the primary relationships between the groups are portrayed in Figure 2. The role of the Enterprise and Project group processes is to achieve the project goals within applicable life cycle stages to satisfy an agreement. Enterprise processes provide enabling resources and infrastructure that are used to create, support, and monitor projects and to assess project effectiveness. The project processes ensure that adequate planning, assessment, and control activities are performed to manage processes and life cycle stages.

Appropriate processes are selected from the Technical Processes and used to populate projects in order for the project to perform life cycle related work.

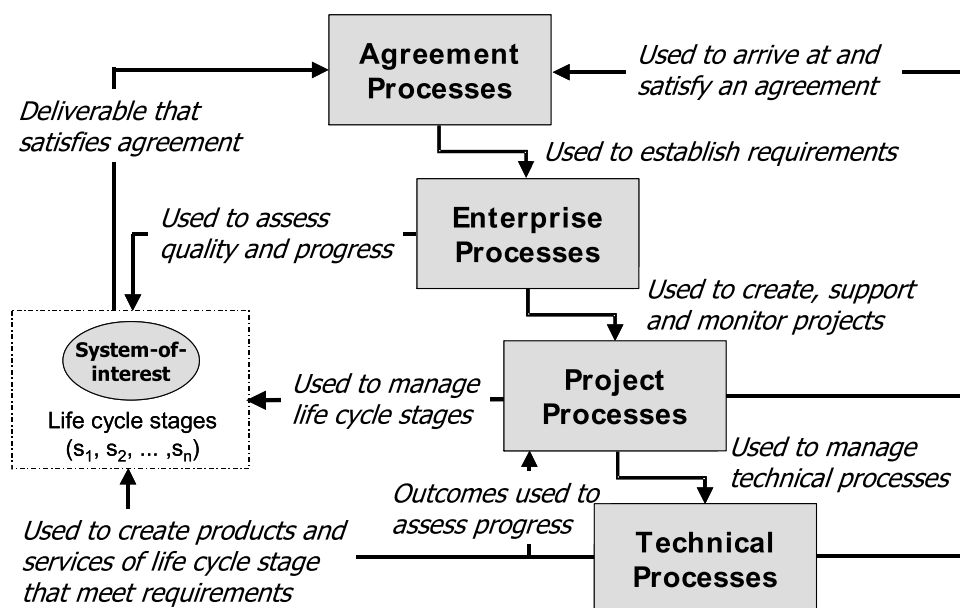


Figure 2 — Role of International Standard processes

Projects may need to establish relationships with other projects within the organization, as well as those in other organizations. Such relationships are established through the agreement processes of acquisition and supply as shown in Figure 3. The degree of formality of the agreement is adapted to the internal or external business relationships between projects. An example and discussion of the use of the agreement processes is provided in 5.3.1.3 of this Technical Report.

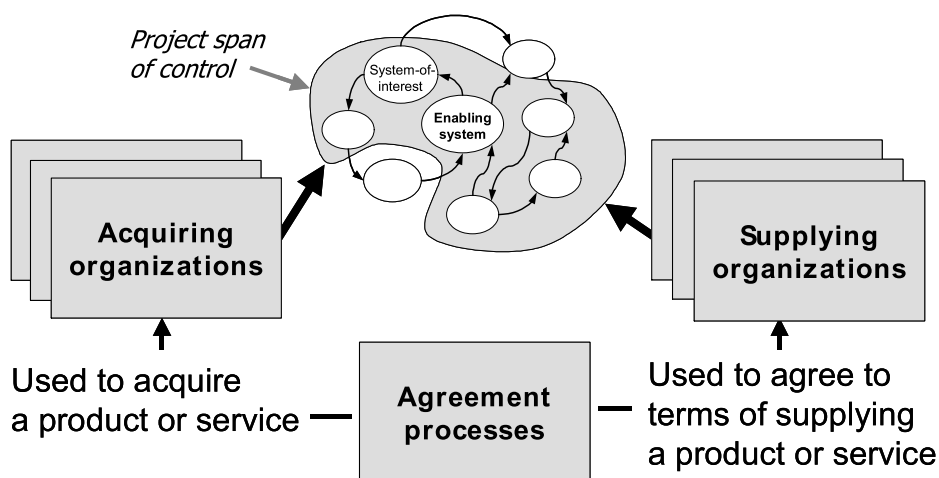


Figure 3 — Use of agreement processes

4 Use of the International Standard

4.1 Overview

The International Standard can be used for one or more of the following reasons.

- a) A specific project can use the International Standard for engineering, utilizing, supporting or retiring a system-of-interest.
- b) An organization can use the International Standard for supporting and controlling the operation of one or more of the system life cycle stages.
- c) A domain organization or other organization can use the International Standard for developing domain-specific or organization-specific standards. These can address the engineering of systems, the management of engineering activities or the operation of one of the system life cycle stages.
- d) Multiple organizations can use the International Standard as a basis for joint projects.

4.2 Concept of use

4.2.1 General

Each organization is driven by the nature of its business, its social responsibilities, and its business strategy. These provide constraints on available business opportunities that the organization and its enterprises can exploit. To help exploit opportunities the enterprise establishes policies and procedures to guide the performance of projects. To help establish these policies and procedures, and to determine the resources needed by the enterprise, the International Standard can be used to provide specific standardized processes for use within one or more life cycle models.

A suggested use concept is illustrated in Figure 4. This figure provided the basis for tailoring the scope of the International Standard for one of the specific uses of 4.1.

4.2.2 Scope tailoring

For example, if an enterprise that does development only and is not involved in the utilization, support, or retirement life cycle stages, that enterprise could tailor the scope of the International Standard accordingly. The policies and procedures called for in the non-applicable parts of the International Standard would not be included in the organization's policies and procedures. Additionally, inputs such as those listed below can help shape the policies and procedures of an enterprise:

- a) life cycle model and related entry or exit criteria used by the enterprise for decision making as well as for establishing milestone reviews of a project;
- b) resource availability and the resources the enterprise is willing to commit;
- c) expertise and skills available to the enterprise to provide enterprise products and services;
- d) technology available for enterprise products and services.

4.2.3 Process tailoring

When a project is established to satisfy a set of stakeholder requirements or acquirer specifications, processes included in the enterprise policies and procedures or in the International Standard itself can be tailored according to the scope, size and funding of the work to be done. Planning the work of the project can be dependent on factors such as the following:

- a) the team structure required by enterprise policy and procedures or by the acquirer and the enterprise culture in which teams exist and perform;
- b) requirements and schedules established in the agreement with the acquirer;
- c) the specific life cycle model to be used for performing the processes of the life cycle;
- d) the resources made available to the project by the enterprise.

Figure 4 illustrates application of tailored technical and management processes from the International Standard within a project context. The enterprise processes of the International Standard can also be selected for application at the enterprise level.

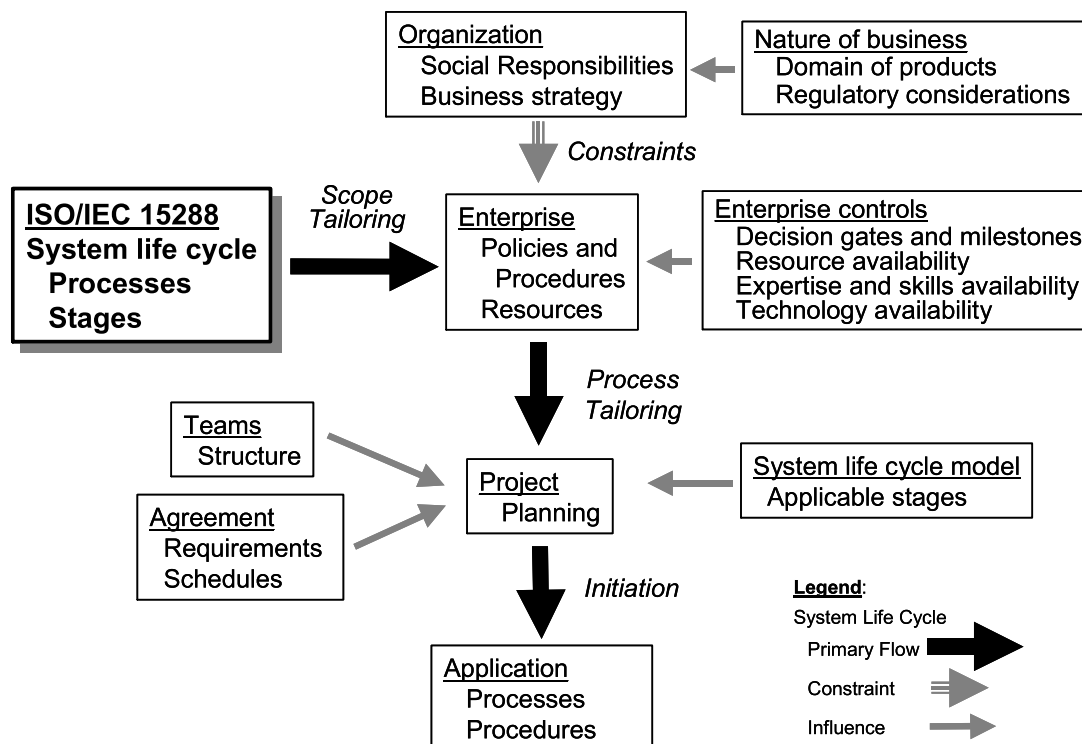


Figure 4 — Concept of use

4.3 Planning for use

The International Standard can be considered for a specific project with a set duration or for a continuous work effort conducted by an organization.

The following are examples of items to consider while planning use of the International Standard.

- a) The scope of the work effort such as:
 - 1) a single project either internal to the organization or an enterprise within the organization, or as part of a multi-party agreement;
 - 2) concentration on some key processes or a single process where there is expected to be some gain for the organization or enterprise;
 - 3) concentration on a single life cycle stage to carry out the operation of that stage.

- b) Identification and listing of stakeholders such as:
 - 1) intended users or customers of the work products, applicable systems or services;
 - 2) providers of enabling systems;
 - 3) other interested parties who have an interest or stake in the products or services;
 - 4) sources of requirements (including constraints).
- c) Desired outcomes such as:
 - 1) work products (for example system-of-interest, paper report, digital data, hardware or software configuration item, waste material or procedure document);
 - 2) services or capabilities to be delivered or demonstrated at the end of the project and at specific milestones.
- d) Special considerations such as:
 - 1) systems technologies that focus on software, hardware, humans, processes or procedures;
 - 2) system utilization including single use, repeated use and continuous use;
 - 3) system fabrication, for example one-of-a-kind, replicated or mass-produced;
 - 4) system topologies such as networks (for example a corporate global network), system of systems (for example a command and control or telecommunication system) and long-lived systems (for example those that never reach an end of use life such as electric power service);
 - 5) methods and tools that enable implementation of the processes throughout the life cycle.
- e) Goals and objectives of the project such as:
 - 1) specific objectives identified by milestones;
 - 2) long-term utilization goals related to the work and work products, especially with respect to the use of a system.
- f) Project strategy such as:
 - 1) how the project will be carried out, including any agreement considerations;
 - 2) how work packages will be planned, assessed and controlled;
 - 3) how work products will be planned, evaluated and controlled;
 - 4) how work and changes will be authorized;
 - 5) major milestone decision or event points (for example management reviews, meetings, pilot tests, deployments and deliveries) with milestone entry or exit criteria.
- g) Requirements and constraints such as:
 - 1) specific functional and performance requirements for capabilities of or data from a system, including special attributes and usability expectations or concerns;
 - 2) policies, priorities and constraints that will affect meeting the cost, schedule and quality requirements and objectives of the project;

- 3) core organizational technologies that will affect system requirements or other work product requirements and constraints; applicable organizational processes, standards and specifications (including source and availability); product implementation risks; and how information of required quality (including different product versions) will be captured, stored and controlled;
- 4) applicable system life cycle stage activities (for example development, pilot testing, full production, retirement) and expected outputs (for example. deliverables, work products and management reviews);
- 5) relevant stage entry or exit criteria, including expected level of system maturity, level of acceptable risks and management review concerns;
- 6) project start-up and end dates, including milestone dates associated with approval and progress reviews and pilot tests, as applicable;
- 7) management structure, including participants and their roles;
- 8) exclusions of organizations or persons (if applicable), including when the exclusion is or is not valid;
- 9) level of security classification and other security considerations, if applicable;
- 10) expected deliverables at milestones, at end of project and during project performance;
- 11) environment, recycling and reuse issues.

The information from a) through g) above should be appropriately documented. Based on the above documented information, appropriate detailed action planning should be performed to generate appropriate plans that can guide application of the International Standard.

4.4 Tailoring

4.4.1 General

When the International Standard is used by an enterprise to form a set of policies and procedures governing project work, then tailoring may be used to appropriately reduce or extend the scope of the International Standard as necessary for the business strategy and kind of business for which the policies and procedures are framed.

When the International Standard is used by a project, then tailoring may be used to appropriately consider the peculiar characteristics of the project, life cycle stage or agreement. Since each project has to consider and demonstrate the benefits of what it does to satisfy stakeholder requirements, there is a need to concentrate on the relevant processes and activities and the expected outcomes, including specific output documentation.

Tailoring takes the form of deletion, alteration or addition. Careful consideration should be given to dropping factors of the International Standard that do not add value to the process, system-of-interest or system element.

When tailoring is done, it may be important to ensure that applicable conformance requirements of the International Standard are met (see Clause 2 of the International Standard).

4.4.2 Tailoring considerations

The objectives and requirements of an agreement should define the context of application of the International Standard. To assist in defining the level of detail and effort required for execution of some processes, the following should be considered in tailoring:

- a) the life cycle stage and the applicable exit criteria;

- b) the mission profiles, operational scenarios and operational concepts for each major functional requirement of the system-of-interest;
- c) the set of measures of effectiveness, with relative importance, by which the acquirer typically determines satisfaction of the requirements;
- d) empirical data that describes the constraints and risks that could affect the project and enterprise, including budget, resources, competition and schedule;
- e) the technology base and any limitations on the use of technologies.

Additional tailoring considerations can be found in the conformance requirements of Clause 2 and Annex A of the International Standard.

4.4.3 Tailoring guidance

Either the organizational unit responsible for forming policies and procedures, or the project team or individual assigned to plan the project can be responsible for completing appropriate tailoring. To aid tailoring the following factors affecting the project effort should be helpful.

- a) Project requirements such as the required work, schedule, funding and technical requirements (for example functional requirements, performance requirements and interface requirements) can drive stage timing and the definition of the system under consideration. These can also drive the criticality of the system and its enabling systems.
- b) The applicable processes of the International Standard that apply to the domain, business of the organization and type of enterprise (for example supplier, user, acquirer, or other stakeholder) should be included in project plans. Other processes that are not in the International Standard can be required by an agreement, or they can be required by the nature of the project, the applicable system or the type of organization. These processes may be added, complete with their purpose, outcomes and activities.
- c) Activities for each applicable process and the expected outcomes of each activity should be selected. Depending on the size and scope of the project, the type of enterprise and whether an unprecedented system is the object of the project, one or more of the International Standard activities for a process could possibly not apply. Likewise, outcomes and activities may be added to a process when needed to meet agreement requirements or to meet unique requirements for a system. See Annex A of this Technical Report for sources of such additional activity detail.
- d) Tasks, methods and tools required for activity completion should be determined. The applicable tasks, methods and available tools are not included in the International Standard. These may be added by the project or organization during planning for an adopted process. See Annex A of this Technical Report for sources of additional task detail.
- e) Reporting and technical review requirements applicable to the life cycle stage or stipulated in the governing agreement or in organizational policies and procedures should be considered.
- f) Project measurement requirement provisions should be included for the collection and reporting of key measures by which project progress will be evaluated.
- g) Requirements related to activities and tasks involving specialty engineering and functional disciplines may be integrated in appropriate processes. These processes include requirements (special requirements or critical project and system requirements) and life cycle stage entry or exit criteria (for example safety, security, human factor engineering, design, software development, production, test and logistics). Specialty and functional plans that are needed to ensure completion of project work may be included in work definition.
- h) Applicable standards, policies and procedures, regulations and laws can be the source of additional process and activity requirements to add to the work definition, even though not included in the

International Standard process requirements. Some reference standards for special factors that should be designed into architectural solutions are provided in Annex B of this Technical Report.

4.4.4 Tailoring documentation

According to the International Standard tailoring is required to be documented for the benefit of all who execute or assess the resulting set of processes. Tailoring records should be established and maintained. Some suggestions to follow in documenting tailoring are given below.

- a) Explicit process, activity and task descriptions and output document descriptions should be documented in the project management plan, engineering plan, operation plan or similar high-level plan.
- b) Where tailoring does not need to be formally documented, an annotated copy of the standard showing additions and deletions can be used.
- c) Templates or worksheets for each International Standard process and life cycle stage can be developed to prescribe the depth of detail required for particular project documentation.
- d) A matrix can be developed to show the level of conformance (full, tailored, none or not applicable), a description of tailoring and the rationale for deletions and traceability of the organization, enterprise or project documentation to the requirements of the International Standard.

5 Application concepts

5.1 Overview

This clause extends Annex D of the International Standard to provide the basis for application of the system life-cycle processes to a system within the constraints of system boundaries and applicable life cycle models.

5.2 System related concepts

5.2.1 System structure

Figure D.4 of the International Standard identifies three views of a system structure. The view on the left provides a hierarchical view of a system structure with a system composed of multiple systems. In this view, at some lower level of the hierarchy a system can be realized by being built, bought or reused. All systems in the hierarchy above this level are integrated composites of lower level systems.

The view in the middle of Figure D.4 is where the top system in the system structure is called a system-of-interest and consists of lower level systems. At the lowest level of the system structure are system elements.

Identification and understanding of the system structure is important in that in order to engineer a system-of-interest, each subordinate system and system element has to be engineered. The unique difference between the two system structures is that each system element has to be implemented whereas all other systems and the system-of-interest are integrated composites of lower level system elements and systems. The appropriate processes of the International Standard are applied individually to the system-of-interest, each system, and each system element in the system structure to define its requirements, develop its architectural design solution and realize its physical products and services.

A third view in Figure D.4 (the view on the right) provides a project hierarchy and assigns the responsibility for the system-of-interest to a project. Thus a project has the responsibility for the application of the International Standard life cycle processes to a system-of-interest.

5.2.2 Kinds of systems

The International Standard considers two specific kinds of systems – systems-of-interest and enabling systems. There is a relationship between these two kinds of systems. Each system-of-interest has its associated set of enabling systems needed for the system-of-interest to be created, utilized and retired from use during its life cycle.

A system-of-interest provides operational capabilities as well as operational functions required or expected by a stakeholder such as a customer or user. Examples of a system-of-interest are an aircraft, automobile, payroll processing system, satellite, ship, telecommunications network or x-ray machine. Subordinate systems of these example systems-of-interest are also considered as a system-of-interest when engineered by a project using the International Standard life cycle processes.

One or more enabling systems are associated with each system-of-interest. Essential services are required from other systems throughout the life of a system-of-interest. Such systems may be needed to perform the responsibilities associated with a life cycle stage, for example a concept system, development system, production system, utilization system, support system or retirement system. In addition there may be infrastructure systems such as water and electricity supply systems and systems for test, delivery, maintenance and training. Enabling systems related to a system-of-interest could exist already or need to be developed specifically to support the system-of-interest.

Figure D.1 in the International Standard provides an example of an aircraft system with several of its related systems (airframe, propulsion, aircrew, flight control and life support and navigation – with several of its related systems such as the display system and global positioning receiver system). Figure 5 of this Technical Report shows five example enabling systems for the aircraft system-of-interest. These include development, production, utilization, support, and retirement systems that enable an aircraft to be realized and perform its functions over its life cycle. Each enabling system has a set of products and services to enable performance of its functions. For example in Figure 5 aircraft enabling systems include training simulators for utilization, facilities for production and refuelling equipment for support. Figure D.5 in the International Standard indicates this interacting relationship between a system-of-interest and its enabling systems.

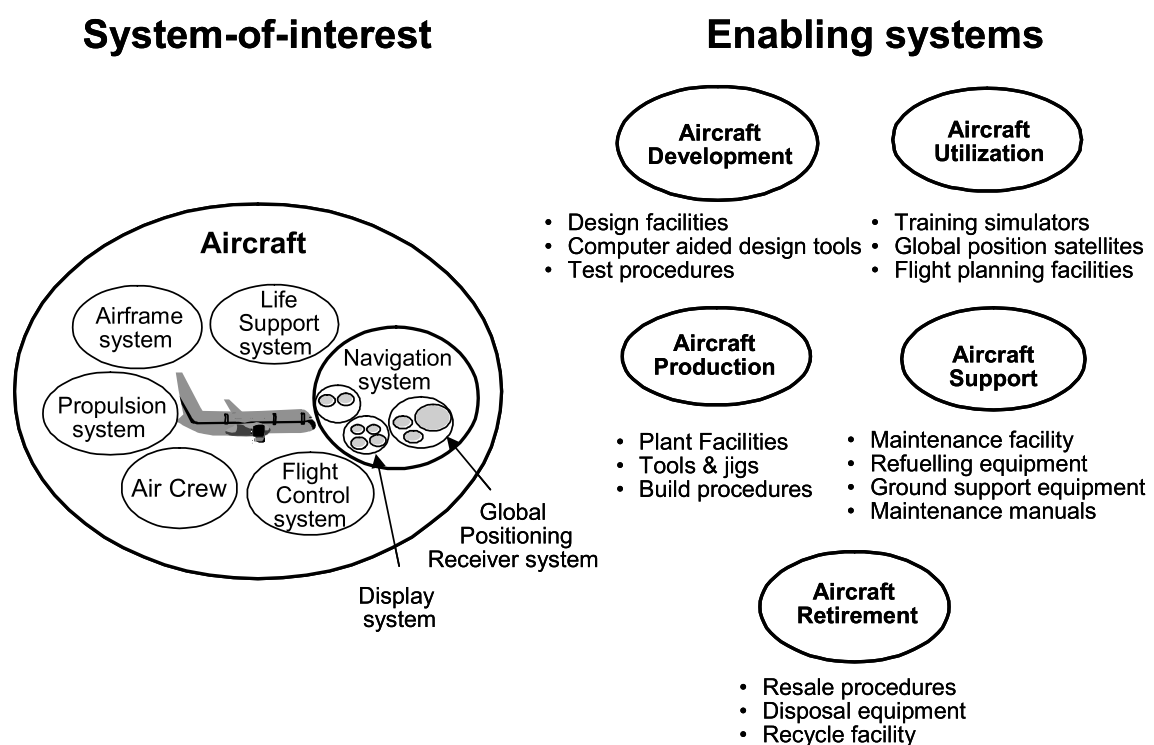


Figure 5 — Example aircraft system-of-interest and its enabling systems

Figure 5 together with Figure D.5 in the International Standard illustrate several important relations with respect to a system-of-interest and its enabling systems. These are provided below:

- a) enumeration of required enabling systems to provide life cycle support to a system-of-interest;
- b) interacting relationships between a system-of-interest and its enabling systems that give rise to functional and physical interface requirements;
- c) definition of system boundaries that establish interfaces requiring management;
- d) a system-of-interest can impact or be impacted by its enabling systems.

5.2.3 System boundary

The relationships among a system-of-interest and its enabling systems are defined by boundaries. Such a system boundary establishes which systems are or are not under direct control of a project. Systems inside a boundary are under direct project control. While the project cannot control those systems external to the boundary it could need to influence those systems in order to reduce the impact on the system-of-interest or to make them fit system-of-interest requirements. When systems external to the boundary cannot be influenced, they become design or other life cycle process constraints with respect to the systems inside the boundary.

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 boundary, the enabling system is within the span of interest of a project because of interface and scheduling constraints. Figure 1 in Clause 3 illustrates a boundary for a system-of-interest with some enabling systems inside and others outside the span of control of the project but all within the span of interest.

System boundaries also establish interfaces where requirements have to be defined for environmental, physical, functional or data connectivity between those systems inside the boundary and those systems external to the boundary.

5.3 Project related concepts

5.3.1 Project focus

5.3.1.1 General

The International Standard has a project focus that defines relationships with the enterprise, other projects and enabling systems. A project is assigned responsibility for one or more life cycle stages of the system-of-interest or system element.

5.3.1.2 Enterprise relationships

The first relationship is the one that a project has with the enterprise, the business structure in which the project resides. The project places certain demands on the enterprise and the enterprise places demands on the project. The project requires physical infrastructure, financial and human resource support to carry out project work. The enterprise both constrains and supports a project. Examples of such enterprise constraints and supports are given below:

- a) sets standards, policies, and procedures by which projects are carried out within the enterprise;
- b) initiates, redirects or terminates projects according to business opportunities and strategies;
- c) provides requested resources including physical and human within availability and financial constraints;
- d) provides infrastructure support;
- e) manages the overall quality of systems produced by a project for external customers.

A project plan is often used as a basis of an agreement between projects and the enterprise.

5.3.1.3 Project relationships

The second relationship is one that can exist between a project and organizations, enterprises, other projects, and subprojects. A subproject as used here and in Figure 6 is a set of resources and tasks organized to undertake a portion of a project. A subproject may be considered a project by those assigned the work. Figure 6 illustrates typical roles of agreements that establish project relationships internal and external to the project.

Project relationships are managed through formal or informal agreements in accordance with organizational or enterprise policies and procedures, as appropriate. Depending on the type of project relationship involved, agreements may exist within a single enterprise, or may span enterprise or organizational boundaries. Within the enterprise the agreements may be between a project and the enterprise, between multiple projects or between a project and its subprojects. Agreements provide a mutual understanding of the problem to be solved, work to be done, established constraints, deliverables and clearly defined responsibilities and accountability.

A fifth kind, not shown in Figure 6, would be applicable when two or more organizations cooperate on a single project. In this case, it is important to define each organization's authorities, responsibilities and rights, including the sharing of proprietary information applicable to the project in an agreement.

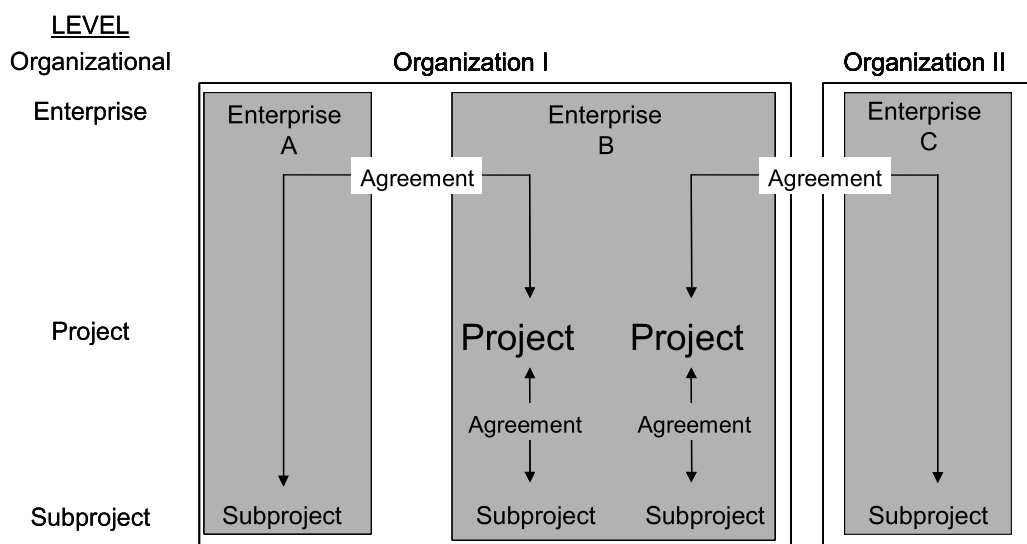


Figure 6 — Roles of agreements

Regardless of the kind of agreement, there is some basic information needed to do the work required in the International Standard. Each agreement, whether formal or informal, should include the following information to the appropriate level of detail:

- responsibilities for the work expected to be done, for example in the form of work statements;
- known functional and performance requirements, attributes and characteristics that clearly assign what the system and its related services are expected to do, be like or contain, including interfaces with other systems, humans and environments. These can be in the form of a set of formal requirement statements or a specification;
- deliverables, for example products, services and data;
- the stage or stages of the applicable life cycle model, including the related stage entry or exit decision criteria. Criteria provide the basis for determining whether the project is ready to progress to the next applicable life cycle stage;

- e) required technical reviews to track the fulfilment of the agreement and assess the maturity of the system;
- f) other appropriate information such as:
 - 1) cost and schedule constraints,
 - 2) development delivery milestones,
 - 3) payment schedules,
 - 4) planning documents including applicable work breakdown or system structure, related configuration documents and acquirer supplied engineering plans,
 - 5) verification and validation responsibilities,
 - 6) acceptance conditions and transition instructions (for example for packaging, handling, delivery and installation),
 - 7) rights and restrictions associated with technical data (for example for copyright, intellectual property and patents).

A model is provided in Clause 3 of this Technical Report for the application of the International Standard processes to reach an agreement.

5.3.1.4 Enabling system relationships

The third relationship is one that involves enabling systems. The project is responsible for ensuring that required enabling systems are available when needed to fulfil the functions of the system-of-interest or enable the system-of-interest to be realized. Some or possibly all enabling systems could be outside the direct responsibility (boundary) of the project. Some or all of the enabling systems could already exist within the project's organization. Other enabling systems could be easily made available, for example by rental or purchase. However, one or several enabling systems may not exist and have to be created and be made available in time to provide required services.

It is within the project's span of interest that not only the system-of-interest should appropriately be made available but also all enabling systems that are needed throughout the system life cycle. Thus the project should determine needed enabling systems and take appropriate actions to ensure their availability for use. Agreements should be established between the project and the internal or external organization or enterprise, as applicable, to ensure that specified enabling system services are provided when needed. A project span of interest is illustrated in Figure 7.

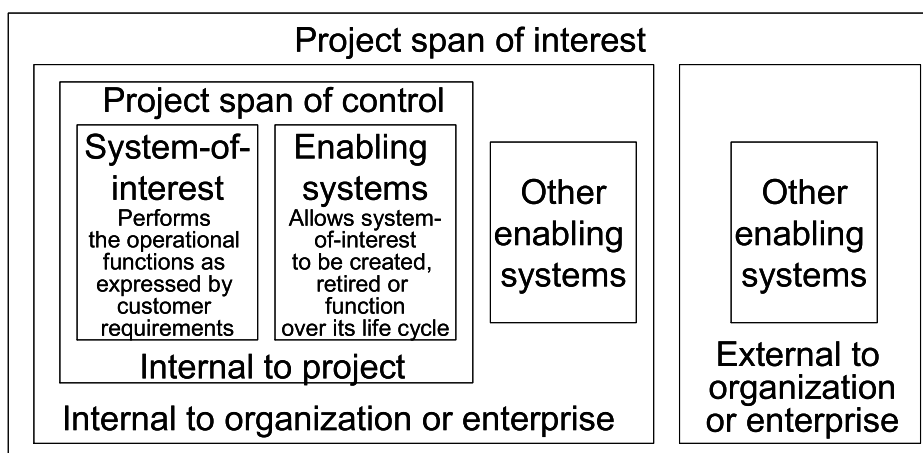


Figure 7 — Project span of interest

5.3.2 Hierarchy of projects

The basic relationship of Figure 7, which illustrates the project span of interest, can be combined with the hierarchical view of a system structure illustrated in Figures D.4 and the system-of-interest structure in Figure D.3 of the International Standard to give a hierarchical view of a project. The system that the project is responsible for is considered a system-of-interest. Each subordinate or sub-project is considered as a project itself. A resultant hierarchy of projects can then be formed. This hierarchy is illustrated in Figure 8.

Figure 8 shows only the lower level of projects of one system. Each system, however, should be decomposed into lower level projects until each consists of only a system element and its enabling systems. Two such projects in Figure 8 end with a system element. Each project should be carried out using applicable system life cycle processes to the extent required by requirements and to satisfy applicable life cycle stage entry or exit criteria.

As explained in Figure 7, the enabling systems of Figure 8 may be under project control or, if external to the project, under the control of other organizations or enterprises. However, the project should work with these other organizations and enterprises through agreements to ensure that the required enabling systems are available when needed to support the system-of-interest during its life cycle.

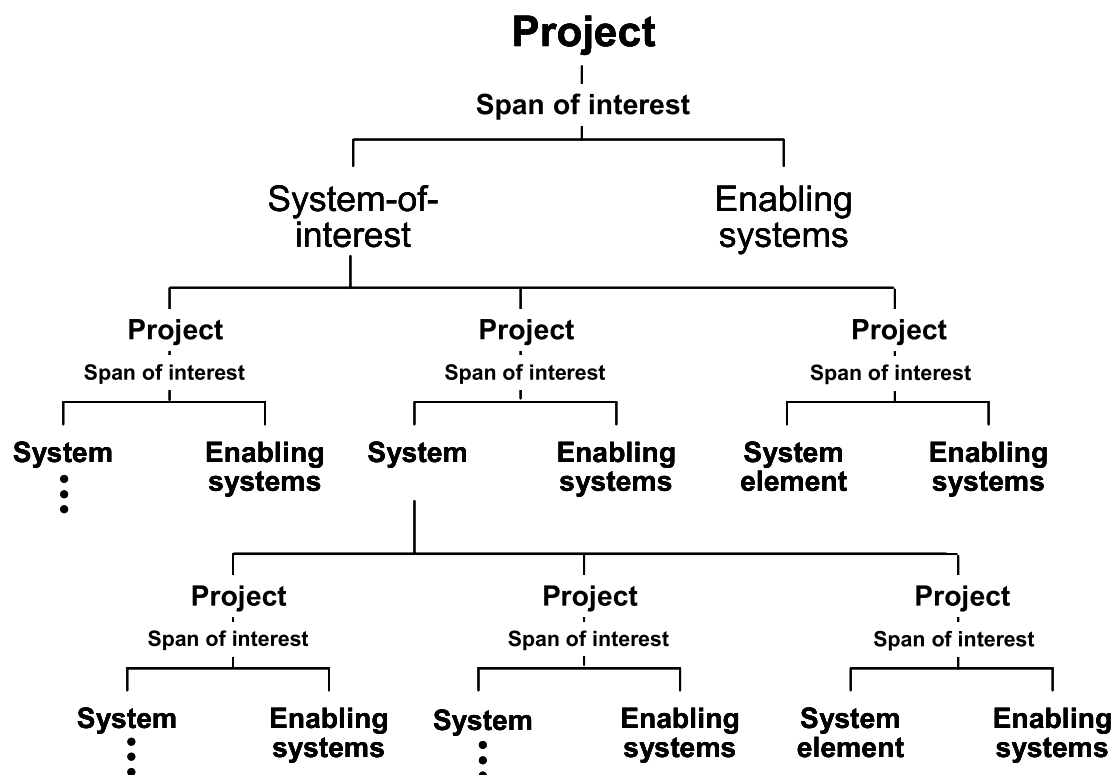


Figure 8 — Hierarchy of projects

5.3.3 Project organizational structure

The application of the International Standard does not require a specific organizational structure for projects. However, an appropriate organizational structure is essential. It is of particular importance that the appropriate teams or groups be assembled, structured and given the appropriate responsibility and authority for doing the work required to meet the project requirements, for example the activities and tasks of a process.

Team or group members assigned responsibility for a system-of-interest need to be available and competent. In the context of complex systems this could require that the structure of the teams or groups be multidisciplinary and include skills necessary to do required tasks.

As a rule of thumb, project teams consist of seven plus or minus two members to develop the teamwork necessary for maximizing efficiency and effectiveness. Typically the team needs to rely on the individual specialist or functional groups of the organization to do such tasks as assessments on security, safety, survivability, reliability and effectiveness as well as trade-off studies, risk analyses and design work. In this context the team then becomes the integrated decision-making structure for process activities performed in a system life cycle stage. It is, however, important that individual teams share knowledge and communicate with other teams working on enabling systems for the same system and other adjoining systems. Such communications should be established so that the resultant system-of-interest is properly integrated from the lowest level up. It is also important so that each system and system element in the system structure is appropriately supported over its life.

5.4 System life cycle concept

Every system-of-interest, whatever the kind or size, follows a life cycle from its initial conceptualization through its eventual retirement. A system life cycle is typically segmented by stages to facilitate planning, provisioning, operating and supporting the system-of-interest. These segments provide an orderly progression of a system through established decision-making gates to reduce risk and to ensure satisfactory progress.

Several factors make system life cycle planning, provisioning and operation difficult to manage. Economics and market forces, as well as novelty, complexity and operational stability affect the length of a system life cycle. Some systems have life cycles that are decades long (for example aircraft, satellites, ships) and some are very short (for example instruments and consumer electronics).

A typical system, however, progresses through a common series of stages where it is conceptualized, developed, produced, utilized, supported and retired. The representative system life cycle model shown in Figure 9 illustrates this passage. This model is based on the six stages described in Annex B of the International Standard and Clause 7 of this Technical Report.

Concept stage	Development stage	Production stage	Utilization stage	Support stage	Retirement stage
---------------	-------------------	------------------	-------------------	---------------	------------------

Figure 9 — Representative system life cycle model

This life cycle model is a framework that helps ensure that the system is able to meet its required functionality throughout its life. The stages in Figure 9, although drawn as discrete, are in practice interdependent and overlapping. Thus, while defining system requirements and developing system solutions during the concept and development stages, functional experts from stages later in the life cycle (for example production, utilization, support, retirement) are needed to perform trade-off analyses and to help make design decisions and arrive at a balanced solution. This helps ensure that a system has the necessary attributes designed in as early as possible. Also it is essential to have the necessary enabling systems available to perform required stage functions.

Three common principles associated with a life cycle model are listed below:

- a system progresses through specific stages during its life;
- enabling systems should be available for each stage in order to achieve the outcomes of the stage;
- specific life cycle stage attributes such as producibility, usability, supportability and disposability should be specified and designed into a system.

The system life cycle model that is presented in Figure 9 is discussed in Clause 7 from an enterprise view and an engineering view. The enterprise view illustrates sequential, incremental, and evolutionary approaches.

5.5 Process application concepts

5.5.1 Process use

5.5.1.1 General

The focus of the International Standard is on the processes that are applied within a life cycle. The processes can be used by organizations (for example functional organizations and projects) that play the role of acquirer, supplier (for example main contractor, subcontractor, service provider) or management to fulfil responsibilities pertaining to the system-of-interest. Additionally, the processes in the International Standard can be used as a reference model for assessments under ISO/IEC 15504.

A process is an integrated set of activities that transform inputs (for example a set of data such as requirements) into desired outputs (for example a set of data describing a desired solution).

Figure 10 illustrates example inputs and outputs of a process for engineering a system. The inputs can be either converted to desired outputs or can enable or control the conversion. Each set of these process inputs and outputs needs to be defined and managed.

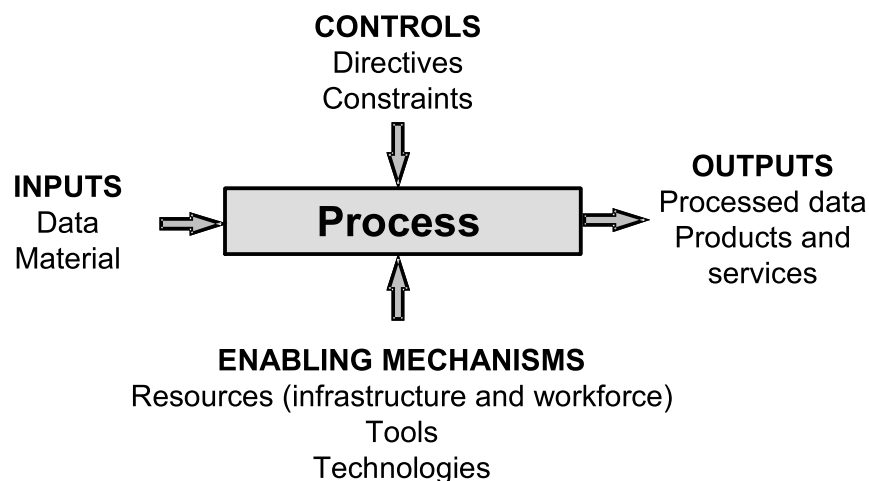


Figure 10 — Example process inputs and outputs

5.5.1.2 Controls

Processes can be controlled by organizational or enterprise management directives and constraints and by governmental regulations and laws. Examples of such controls on a process include:

- a) the project agreement;
- b) the interfaces with other systems for which the project is responsible (see Figure 8 of this Technical Report);
- c) the applicable system life cycle stage or stages;
- d) the organization or enterprise that has project responsibility.

5.5.1.3 Enabling mechanisms

Each process can have a set of process enabling mechanisms such as listed below:

- a) the workforce that performs the tasks related to the process;

- b) other resources required by the process such as facilities, equipment and funds;
- c) tools (for example software and hardware, automated, manual) required for performing the process activities;
- d) technologies required by persons performing the activities including methods, procedures and techniques.

5.5.2 Life cycle processes

5.5.2.1 General

Within a life cycle stage, processes are performed as required to achieve stated objectives. The progression of a system through its life is the result of actions managed and performed by people in one or more enterprises using the processes selected for a life cycle stage.

The International Standard describes four groups of system life cycle processes – agreement, enterprise, project and technical. Each process has a specific purpose, a set of expected outcomes and a set of activities. Each group of processes is described in Annex D of the International Standard and summarized in the following clauses of this Technical Report. Guidance for the application of the International Standard life cycle processes is provided in Clauses 6, 7 and 8 of this Technical Report.

Small organizations when considering a new project should select a life cycle model such as shown in Figure 9 and the necessary International Standard life cycle processes to satisfy applicable life cycle stage entry or exit criteria. Decisions as to which processes to select should be based on cost-benefit or risk reduction. The process groups are described below.

5.5.2.2 Agreement processes

The agreement processes are applicable for establishing the relationship and requirements between an acquirer and supplier. The agreement processes provide the basis for initiation of other project processes to enable arriving at an agreement to engineer, utilize, support or retire a system and to acquire or supply related services.

The agreement processes can be used for several purposes such as listed below:

- a) to form and ensure completion of an agreement between an acquirer and a supplier for work on a system at any level of the system structure;
- b) to establish and carry out agreements to acquire a system or related enabling system services;
- c) to obtain work efforts by consultants, subcontractors, functional organizations, projects or individuals or teams within a project. See Figure 6 of this Technical Report for examples;
- d) to provide the basis for closing an agreement after the system has been delivered or work has completed and payment made.

5.5.2.3 Enterprise processes

Enterprise processes are for that part of the general management that is responsible for establishing and implementing projects related to the products and services of an organization. Thus, the enterprise through these distinct processes provides the services that both constrain and enable the projects, directly or indirectly, to meet their requirements.

The enterprise processes included in the International Standard are not necessarily the only processes used by an enterprise for governance of its business. For example enterprises also have processes for managing accounts receivable, accounts payable, payroll processing and marketing. These processes are not directly within the scope of the International Standard and thus are not discussed further in this Technical Report.

For multiple projects involved in or interfacing with an enterprise, or for a teaming arrangement among external organizations, other enterprise processes can be appropriately established or the processes of the International Standard can be appropriately tailored.

To perform these processes, it is not intended that a new organizational unit or discipline within an enterprise be created. Identified and defined roles, responsibilities and authorities may be assigned to individuals or existing committees or to established organizational units. When necessary, however, a new enterprise unit can be formed.

The International Standard enterprise processes have specific objectives to fulfil such as listed below.

- a) Provide the proper environment so that projects within the organization can accomplish their purpose and objectives.
- b) Ensure that there is an orderly approach to starting, stopping and redirecting projects.
- c) Ensure that organizational policies and procedures are defined that set forth the processes of the International Standard and that are applicable to projects within the enterprise.
- d) Ensure that appropriate models, methods and tools are selected and provided to projects so that they can complete process activities efficiently and effectively.
- e) Ensure that projects have adequate resources for the project to meet budget, schedule and performance requirements within acceptable risks and that human resources are appropriately trained for completing their responsibilities.
- f) Ensure that project work products for delivery to customers are of a suitable quality.

5.5.2.4 Project processes

The project processes should be used to manage technical process activities and to assure satisfaction of an agreement. Project processes are performed to establish and update plans, to assess progress against plans and system requirements, to control work efforts, to make required decisions, to manage risks and configurations and to capture, store, and disseminate information. Outcomes from performing the project processes help in the accomplishment of the technical processes.

The project processes apply to engineering projects that are most often part of larger projects. When that is the case, the appropriate project processes are performed at each level of the system structure. These processes also apply when performing enterprise processes or carrying out the activities related to a life cycle stage, including utilization, support and retirement.

When several projects co-exist within one enterprise, project processes should be defined to allow for the management of the resources and performance of the multiple projects.

5.5.2.5 Technical processes

The technical processes are applicable across all life cycle stages. The following technical processes should be performed to engineer a system:

- a) Stakeholder Requirements Definition Process;
- b) Requirements Analysis Process;
- c) Architectural Design Process;
- d) Implementation Process;
- e) Integration Process;