TECHNICAL REPORT

ISO/IEC TR 24748-2

First edition
2011-09-01

Systems and software engineering — Life cycle management —

Part 2:
Guide to the application of ISO/IEC 15288 (System life cycle processes)

Ingénierie des systèmes et du logiciel — Gestion du cycle de vie —

Partie 2: Guide pour l'application de l'ISO/CEI 15288 (Processus du cycle de vie du système)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

In exceptional circumstances, 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), it may decide to publish a Technical Report. A Technical Report is entirely informative in nature and shall be subject to review every five years in the same manner as an International Standard.

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

ISO/IEC TR 24748-2 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering*.

This first edition of ISO/IEC TR 24748-2 cancels and replaces ISO/IEC TR 19760:2003, which has been technically revised.

ISO/IEC TR 24748 consists of the following parts, under the general title *Systems and software engineering — Life cycle management*:

— *Part 1: Guide for life cycle management*

— *Part 2: Guide to the application of ISO/IEC 15288 (System life cycle processes)*

— *Part 3: Guide to the application of ISO/IEC 12207 (Software life cycle processes)*

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Introduction

ISO/IEC 12207:1995 (*Information technology — Software life cycle processes*) and ISO/IEC 15288:2002 (*Systems engineering — System life cycle processes*) have application guides (ISO/IEC TR 15271:1998 and ISO/IEC 19760:2003, respectively) for the use of each International Standard individually. However, both International Standards were re-published in 2008 after significant revisions to align their terminology and structure. As a consequence, the two published application guides no longer relate to their respective standards and can not provide the guidance intended.

ISO/IEC TR 24748-1 (*Systems and software engineering — Life cycle management — Part 1: Guide for life cycle management*) was published in 2010 to facilitate the joint usage of the process content of ISO/IEC 15288:2008 and ISO/IEC 12207:2008 by providing unified and consolidated guidance on life cycle management of systems and software. This helps ensure consistency in system concepts and life cycle concepts, models, stages, processes, process application, key points of view, adaptation and use in various domains as the two standards are used in combination. That in turn helps a project design a life cycle model for managing the progress of its project. ISO/IEC TR 24748-1 also aids in identifying and planning use of life cycle processes described in ISO/IEC 15288 and ISO/IEC 12207 that enable the product or service project to be completed successfully, meeting its objectives/requirements for each stage and for the overall project.

This part of ISO/IEC TR 24748 supports use of ISO/IEC 15288:2008 and replaces ISO/IEC TR 19760. This part of ISO/IEC TR 24748 and its companion, ISO/IEC TR 24748-3 (*Guide to the application of ISO/IEC 12207*) — which replaces ISO/IEC TR 15271 — continue and make use of the alignment effort evident in the two revised International Standards. Both terminology and structure in the guides are identical wherever possible and content is aligned consistent with that in the two International Standards. Consequently, the users of ISO/IEC 12207:2008 and ISO/IEC 15288:2008 will benefit from having documents complementarily addressing all aspects of products or services over their life cycle.

Besides the above, 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 any process documents subsequently created that focus on areas besides systems and software. This could include hardware, humans, 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 TR 24748 series of Technical Reports is intended to allow its extension to such additional domains where that will provide value to users.

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Systems and software engineering — Life cycle management —

Part 2:
Guide to the application of ISO/IEC 15288 (System life cycle processes)

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1 Scope

This part of ISO/IEC TR 24748 is a guide for the application of ISO/IEC 15288:2008. It addresses system, life cycle, process, organizational, project, and adaptation concepts, principally through reference to ISO/IEC TR 24748-1 and ISO/IEC 15288:2008. It then gives guidance on applying ISO/IEC 15288:2008 from the aspects of strategy, planning, application in organizations, and application on projects.

This part of ISO/IEC TR 24748 is intentionally aligned with both ISO/IEC TR 24748-1 and ISO/IEC TR 24748-3 (*Guide to the application of ISO/IEC 12207*) in its terminology, structure and content.

2 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 12207:2008, ISO/IEC 15288:2008 and ISO/IEC TR 24748-1:2010, apply.

3 Overview of ISO/IEC 15288:2008

3.1 General

ISO/IEC 15288:2008, Systems and software engineering – System life cycle processes, establishes a common framework for system life cycle processes, with well-defined terminology, that can be referenced by the systems engineering industry. 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.

ISO/IEC 15288:2008 may be used stand alone or jointly with other International Standards, such as ISO/IEC 12207, and supplies a process reference model that supports process capability assessment in accordance with ISO/IEC 15504-2 (Process assessment).

The purpose of ISO/IEC 15288:2008 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 15288:2008 is written for acquirers of systems and for suppliers, developers, operators, maintainers, managers, quality assurance managers, and users of systems.

3.2 Structure of ISO/IEC 15288:2008

ISO/IEC 15288:2008 contains requirements in two Clauses:

— Clause 6, which defines the requirements for the system life cycle processes,

— Annex A that provides requirements for tailoring of ISO/IEC 15288:2008.

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Five informative annexes support the use of ISO/IEC 15288:2008 or its harmonization with ISO/IEC 12207:2008:

— Annex B provides information about use of the system life cycle processes as a process reference model to support process assessment.

— Annex C provides a description of the process constructs used in ISO/IEC 15288:2008.

— Annex D provides an example of a process view for Specialty Engineering, intended to illustrate how a project might assemble processes, activities and tasks of ISO/IEC 15288 to provide focused attention to the achievement of product characteristics that have been selected as being of special interest.

— Annex E describes the alignment of the processes of ISO/IEC 15288 and ISO/IEC 12207.

— Annex F provides support for IEEE users and describes relationships of ISO/IEC 15288:2008 to IEEE standards.

Readers of ISO/IEC 15288:2008 are advised to consult clause 5 of that International Standard to gain understanding of the key concepts used.

3.3 Context of ISO/IEC 15288:2008

ISO/IEC 15288:2008 has a focus 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. A project is assigned responsibility that encompasses one or more life cycle stages of the system-of-interest. ISO/IEC 15288:2008 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 context of ISO/IEC 15288:2008 is illustrated in Figure 1.

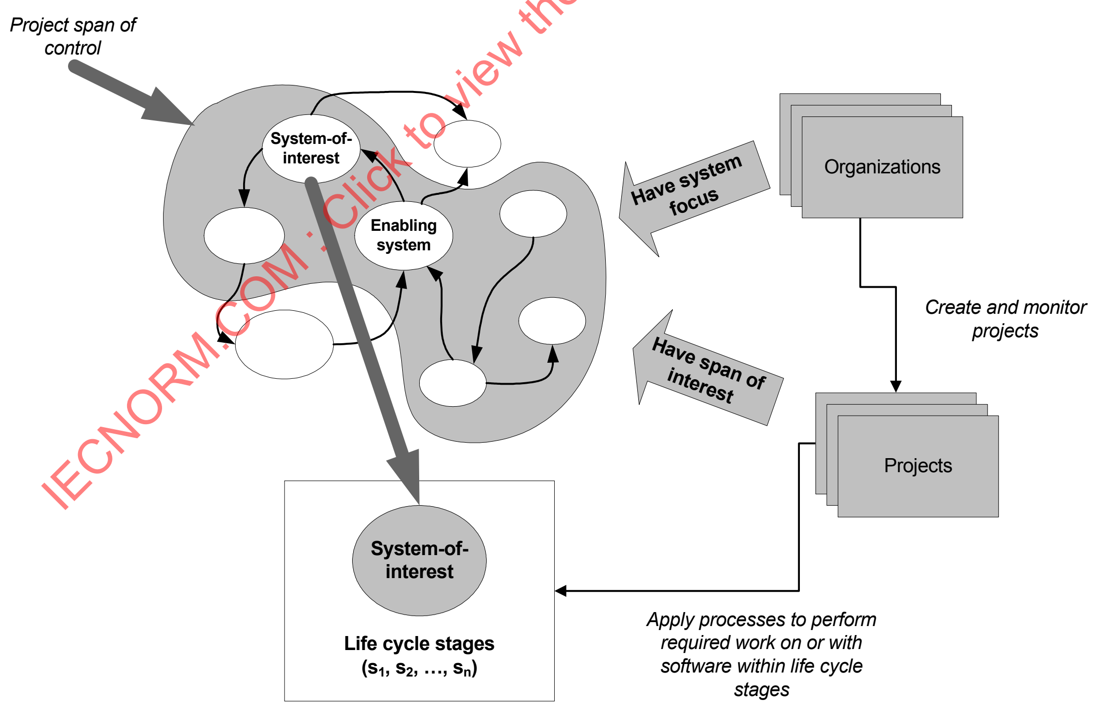

Figure 1 — Context of ISO/IEC 15288:2008

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A single project may involve multiple organizations working together as partners. Such a project should use ISO/IEC 15288:2008 to establish common terminology, as well as information flows and interfaces among the several organizations to enhance communications.

When an organization applies ISO/IEC 15288:2008 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. An example of typical stages is:

— s_1: concept,

— s_2: development,

— s_3: production,

— s_4: utilization,

— s_5: support,

— s_6 retirement.

NOTE 1 Stages are described in clause 5.2.2 of ISO/IEC 15288:2008 and in clauses 3.2 and 4 of ISO/IEC TR 24748-1.

NOTE 2 The management of the progression from one stage to another and the engineering activities associated with providing appropriate work products and decision-making information are described in clause 5 of ISO/IEC TR 24748-1.

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 can require one or more enabling systems. 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 ISO/IEC 15288:2008 is applied to it, it then becomes a system-of-interest.

NOTE 3 The role and use of enabling systems are described in clauses 4.6.3 and 5.4.3.5 of this Technical Report.

NOTE 4 For related material on enabling systems, see also clause 5.1.4 of ISO/IEC 15288 and clause 3.1.5 of ISO/IEC TR 24748-1.

ISO/IEC 15288:2008 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 ISO/IEC 15288:2008 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.

NOTE 5 For related material on system structure, see clause 5.1.3 of ISO/IEC 15288 and clause 3.1.4 of ISO/IEC TR 24748-1.

NOTE 6 A view from a project hierarchy perspective is given in Clause 4.6.4 of this Technical Report.

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.

NOTE 7 Related project concepts are described in Clause 4.6 of this Technical Report.

NOTE 8 System life cycle concepts are described in clause 3.2 of ISO/IEC TR 24748-1.

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

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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.

NOTE 9 The span of interest is described in Clause 4.6.3 of this Technical Report.

The work performed by projects is on or with the system-of-interest within one or more life cycle stages. The scope of ISO/IEC 15288:2008 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.

ISO/IEC 15288:2008 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 15288:2008 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 10 This may be performed by adapting the life cycle as described in clauses 6 and 7 of ISO/IEC TR 24748-1 and tailoring described in Annex A of ISO/IEC 15288:2008.

3.4 Comparison to prior version of ISO/IEC 15288:2008

Clause 9.1 of Technical Report ISO/IEC TR 24748-1 gives extensive detailed comparison between the 2002 and 2008 versions of International Standard ISO/IEC 15288, as well as comparisons between the old and new versions of International Standard ISO/IEC 12207 and between International Standards ISO/IEC 15288 and ISO/IEC 12207. Basically:

- The structure of the processes in ISO/IEC 15288:2008 has been changed to align with the structure in ISO/IEC 12207:2008 by decomposing process activities into more detailed tasks.
- Individual processes have been adjusted in both International Standards. This mostly consists of process renaming in ISO/IEC 15288:2008, with a few processes added or combined with others, as shown in Figure 2.

ISO/IEC 15288:2002		ISO/IEC 15288:2008		
Clause	**Process**	**Clause**	**Process**	**Changes**
5	**System life cycle processes**	**6**	**System life cycle processes**	
5.1	Introduction			Deleted
5.2	Agreement processes	6.1	Agreement processes	Numbering
5.2.1	Introduction	6.1	Agreement processes	Combined into 6.1; deleted separate clause
5.2.2	Acquisition process	6.1.1	Acquisition process	Numbering
5.2.3	Supply process	6.1.2	Supply process	Numbering
5.3	Enterprise processes	6.2	Organizational project-enabling processes	Topic and title revised; numbering
5.3.1	Introduction	6.2	Organizational project-enabling processes	Combined into 6.2; deleted separate clause
5.3.2	Enterprise environment management process	6.2.2	Infrastructure management process	Topic and title revised; numbering
5.3.3	Investment management process	6.2.3	Project portfolio management process	Topic and title revised; numbering

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ISO/IEC 15288:2002		ISO/IEC 15288:2008		
5.3.4	System life cycle processes management process	6.2.1	Life cycle model management process	Title revised; numbering
5.3.5	Resource management process	6.2.2	Infrastructure management process	Separated human resources from other resources; numbering
		6.2.4	Human resource management process	
5.3.6	Quality management process	6.2.5	Quality management process	Numbering
5.4	Project processes	6.3	Project processes	Numbering
5.4.1	Introduction	6.3	Project processes	Combined into 6.3; deleted separate clause
5.4.2	Project planning process	6.3.1	Project planning process	Numbering
5.4.3	Project assessment process	6.3.2	Project assessment and control process	Processes merged; numbering
5.4.4	Project control process			
5.4.5	Decision-making process	6.3.3	Decision management process	Title revised; numbering
5.4.6	Risk management process	6.3.4	Risk management process	Numbering
5.4.7	Configuration management process	6.3.5	Configuration management process	Numbering
5.4.8	Information management process	6.3.6	Information management process	Numbering
		6.3.7	Measurement process	Added
5.5	Technical processes	6.4	Technical processes	Numbering
5.5.1	Introduction	6.4	Technical processes	Combined into 6.4; deleted separate clause
5.5.2	Stakeholder requirements definition process	6.4.1	Stakeholder requirements definition process	Numbering
5.5.3	Requirements analysis process	6.4.2	Requirements analysis process	Numbering
5.5.4	Architectural design process	6.4.3	Architectural design process	Numbering
5.5.5	Implementation process	6.4.4	Implementation process	Numbering
5.5.6	Integration process	6.4.5	Integration process	Numbering
5.5.7	Verification process	6.4.6	Verification process	Numbering
5.5.8	Transition process	6.4.7	Transition process	Numbering
5.5.9	Validation process	6.4.8	Validation process	Numbering
5.5.10	Operation process	6.4.9	Operation process	Numbering
5.5.11	Maintenance process	6.4.10	Maintenance process	Numbering
5.5.12	Disposal process	6.4.11	Disposal process	Numbering
Annex A	Tailoring process	Annex A	Tailoring	Title revised

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Figure 2 — Mapping of process clause sets between ISO/IEC 15288:2002 and ISO/IEC 15288:2008

4 Application concepts

4.1 Overview

This Technical Report provides guidelines for life cycle management in the field of systems. This clause highlights and explains essential concepts on which this Technical Report is based, and introduces key concepts useful in reading and applying ISO/IEC 15288:2008.

NOTE ISO/IEC TR 24748-1 provides more information on concepts related to life cycle management in general.

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4.2 System concepts

Application of ISO/IEC 15288 presupposes an understanding of system concepts. System concepts for systems that are any mix of products and services are introduced in ISO/IEC 15288, clause 5.1. Additional discussion is in ISO/IEC TR 24748-1, clause 3.1.

4.3 Life cycle concepts

Application of ISO/IEC 15288 presupposes an understanding of life cycle concepts.

NOTE Life cycle concepts are introduced in ISO/IEC 15288, clause 5.2. Additional discussion is in ISO/IEC TR 24748-1 clause 3.2.

4.4 Process concepts

4.4.1 General

4.4.1.1 Introduction

Application of ISO/IEC 15288 presupposes an understanding of process concepts.

NOTE 1 Process concepts are introduced in ISO/IEC 15288, clause 5.3. Additional discussion is in ISO/IEC TR 24748-1 clause 3.3.

The focus of ISO/IEC 15288:2008 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, or service provider) or management to fulfil responsibilities pertaining to the system-of-interest. Additionally, the processes in ISO/IEC 15288:2008 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). An activity is a set of cohesive tasks. A task is a requirement, recommendation, or permissible action, intended to contribute to the achievement of one or more outcomes of a process.

A task is expressed in the form of a requirement, self-declaration, recommendation, or permissible action. For this purpose, Note 3 of Clause 2.3 in International Standard ISO/IEC 15288:2008 carefully employs certain auxiliary verbs to differentiate between the forms of tasks:

— “Shall” is used to express a requirement of ISO/IEC 15288:2008;

— “Should” to express a recommendation;

— “May” to indicate permission.

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 organizations using the processes selected for a life cycle stage.

NOTE 2 Process concepts are introduced in ISO/IEC 15288, clause 5.3, ISO/IEC 12207, clauses 5.1.9 and 5.1.10, and ISO/IEC TR 24748-1, clause 3.3.

NOTE 3 Criteria for processes are discussed in ISO/IEC 12207, clause 5.1.8, and the decomposition of processes are discussed in clause 5.1.11. ISO/IEC 15288 does not contain corresponding material.

Figure 3 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.

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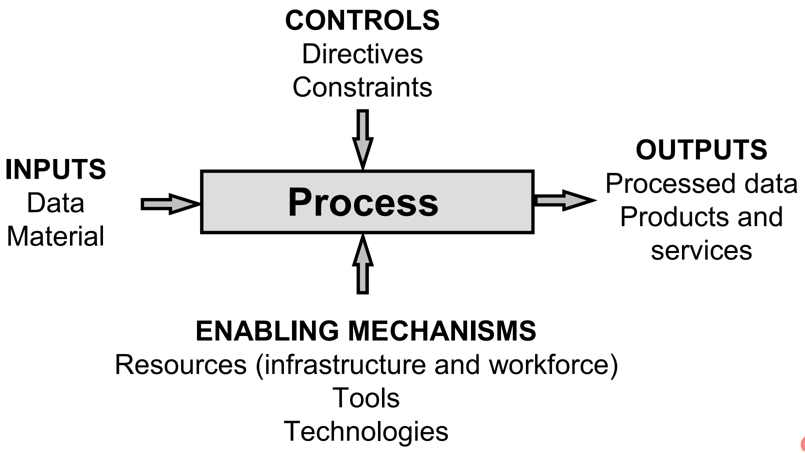

Figure 3 — Example process inputs and outputs

4.4.1.2 Inputs

Inputs can come from outside an organization or project, or from other processes that precede or accompany the process being examined. Examples of inputs to a process include:

a) Information, such as requirements, interface or architecture definitions.

b) Data, such as measurements and test reports.

c) Material that either ends up in the output or is consumed in producing the output.

d) Services that are part of a chain of services, such as setting up a computer prior to, or coincident with establishing an account.

4.4.1.3 Outputs

Outputs can go to other processes or back to the same process (recursive processing) inside the organization, project (or both), or they can go outside the project or organization, or both. Examples of outputs parallels the examples given for inputs in 4.4.1.1. However, the outputs are often (but not necessarily) transformed in some way by the process being examined.

4.4.1.4 Controls

Processes can be controlled by organizational or organization 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 processes used on other systems for which the project is responsible (see Clause 4.6.3 of this Technical Report).

c) The applicable system life cycle stage or stages.

d) Internal standard practices of the organization, or the part of the organization that has project responsibility.

4.4.1.5 Enabling Mechanisms

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

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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

4.4.2 Process principles

4.4.2.1 Introduction

ISO/IEC 15288:2008 establishes a top-level architecture of the life cycle of systems from conception through retirement. The architecture is constructed with a set of processes and interrelationships among these processes. The processes are based on two primary principles: modularity and responsibility.

4.4.2.2 Modularity

The processes are modular, in that they are:

a) Strongly cohesive: All the parts of a process are strongly related. This reduces the dependency of one process on others, which in turn increases the efficiency with which the process can be executed;

b) Loosely coupled: The number of interfaces among the processes is kept to a minimum, which reduces the amount of communication required for each process to successfully complete.

In principle, each process is dedicated to a unique function at each usage in a given stage of the life cycle and may employ another process for a specialized function. The following presents the rules for identifying, scoping, and structuring processes:

a) A process must be modular i.e. one process should perform one and only one function within the life cycle and the interfaces between any two processes should be minimal;

b) Each process is invoked in the architecture;

c) If a process A is invoked by a process B and only process B, then A belongs to B;

d) If a function is invoked by more than one process, then the function becomes a process in itself;

e) It must be possible to verify any function within the life cycle model;

f) Each process should have an internal structure defined sufficiently to be executable.

4.4.2.3 Responsibility

The principle of responsibility is closely linked to the concept of an organization. Each process is considered the responsibility of an organization (or party). An organization may perform one or more processes. A process may be performed by one organization or more than one organization, with one of the organizations being identified as the responsible party. A party executing a process has the responsibility for that entire process even though the execution of individual tasks may be by different people.

The responsibility principle facilitates tailoring and application of ISO/IEC 15288:2008 on a project, in which many persons may be legitimately involved.

NOTE 1 ISO/IEC TR 24748-1, clause 3.3.2 provides more information on process responsibility.

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NOTE 2 Organizations and parties are discussed in clause 4.6 of this Technical Report.

4.4.3 Process categories of ISO/IEC 15288:2008

The four process groups of ISO/IEC 15288 as well as the primary relationships between the groups are portrayed in Figure 4. The role of the Organizational Project-enabling and Project groups of processes is to achieve the project goals within applicable life cycle stages to satisfy an agreement. Organizational Project-Enabling 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.

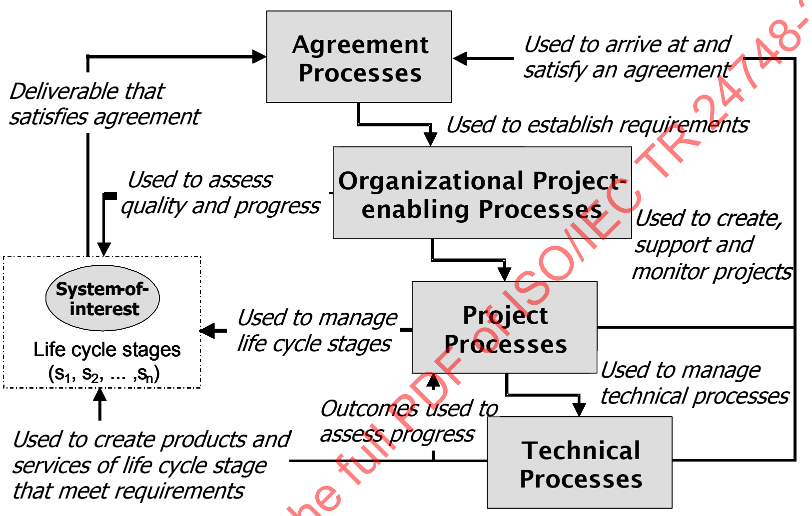

Figure 4 — Role of the ISO/IEC 15288:2008 processes

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 5. 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 Clause 5.4.2 of this Technical Report.

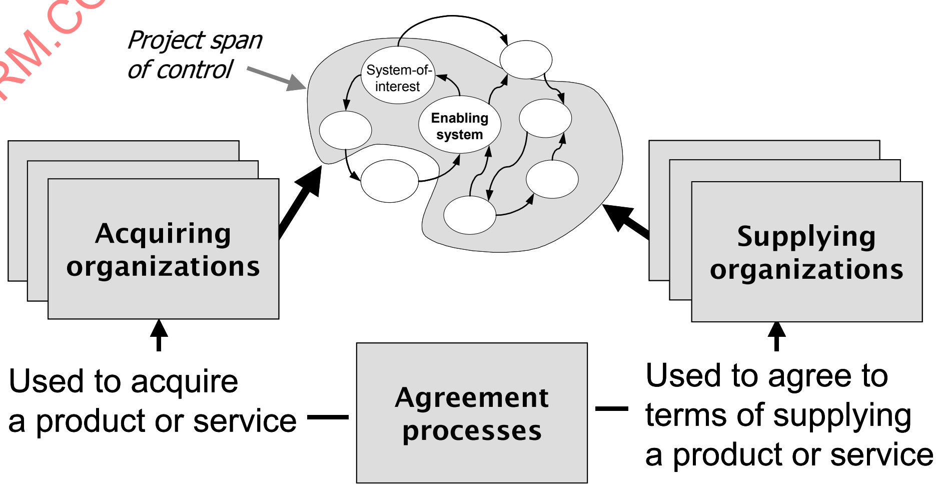

Figure 5 — Use of agreement processes

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4.4.4 Recursive/iterative application of processes

4.4.4.1 General

Two forms of process application – recursive and iterative – are essential and useful for executing the requirements of ISO/IEC 15288:2008.

4.4.4.2 Recursive application of processes

When the same set of processes or the same set of process activities are applied to successive levels of system elements within the system structure, the application form is referred to as recursive. The outcomes from one application are used as inputs to the next lower (or higher) system element in the system structure to arrive at a more detailed or mature set of outcomes. Such an approach adds value to successive parts of the system structure. Figure 6 illustrates the recursive application of processes to systems from the top down.

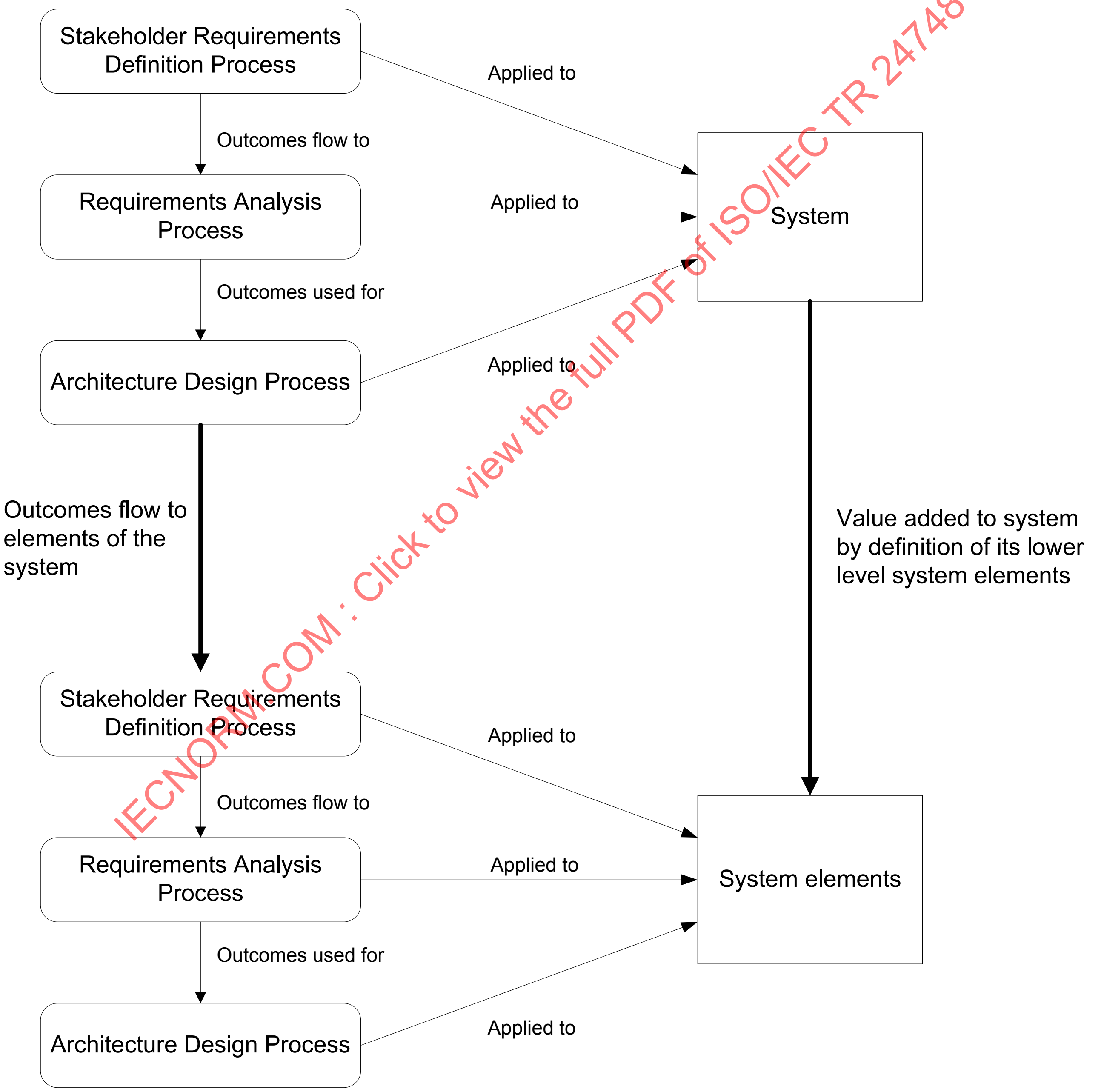

Figure 6 — Recursive application of processes

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4.4.4.3 Iterative application of processes

When the application of the same process or set of processes is repeated on the same system, the application is referred to as iterative. Iteration is not only appropriate but also expected. New information is created by the application of a process or set of processes. Typically this information takes the form of questions with respect to requirements, analyzed risks or opportunities. Such questions should be resolved before completing the activities of a process or set of processes. When re-application of activities or processes can resolve the questions, then it is useful to do so. Iteration can be required to ensure that information with admissible quality is used prior to applying the next process or set of activities to a system-of-interest. In this case iteration adds value to the system to which the processes are being used. The iterative application of processes is illustrated in Figure 7.

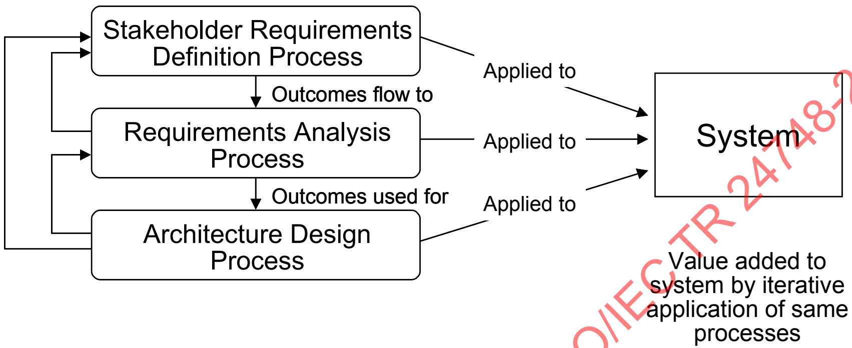

Figure 7 — Iterative application of processes

4.4.4.4 Methods and tools

In practice, there are many situations where system size and complexity, project duration and the number of contributing organizations require process execution to be supported by methods and tools.

The selection of methods and tools depend on many factors including stage in the life cycle, level in the system's hierarchy and application domain. As a result, neither ISO/IEC 15288:2008 nor this Technical Report includes discussions of specific methods and tools. Nevertheless, there are some issues that the user of ISO/IEC 15288:2008 should bear in mind when selecting and using methods and tools to accomplish life cycle process activities or related tasks. Four such issues are listed below.

a) A method or tool does not pre-empt the process to be followed but should support the set of activities of a selected process. Methods should be selected to fit the system life cycle stage.

b) Selection of tools should be based on connectivity to other tools that provide inputs or use outputs of the tool being considered for use. The engineering data produced should be in an appropriate form to enable the data to be captured, stored and available as long as it is needed. Those members of organizations, organizations, projects and other stakeholders who have the need should be given access authority to the data.

c) The training requirements for application of the method or tool should be considered. The initial, as well as subsequent training time after a user has not used the tool for a period of time, should be included in the consideration.

d) Enabling systems as well as tool administration should be considered.

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4.5 Organizational concepts

4.5.1 General

An organization is a person or a group or people and facilities with an arrangement of responsibilities, authorities and relationships. An identified part of an organization (even as small as a single individual) or an identified group of organizations can be regarded as an organization, if it has responsibilities, authorities and relationships. In ISO/IEC 15288:2008, the terms "organization" and "party" are closely related. When an organization, as a whole or a part, enters into a contract, it is a party. Organizations are separate bodies, but the parties may be from the same organization or from separate organizations.

NOTE Organizations and parties are introduced in ISO/IEC 12207, clause 5.1.3. Organizational-level and project-level adoption is discussed in clause 5.1.4.

4.5.2 Responsibility

Each process is considered the responsibility of a party. An organization may perform one or more processes. A process may be performed by one organization or more than one organization, with one of the organizations being identified as the responsible party. A party executing a process has the responsibility for that entire process even though the execution of individual tasks may be by different people.

The responsibility feature of the life cycle architecture facilitates tailoring and application of ISO/IEC 15288 on a project, in which many persons may be legitimately involved.

An organization (or a party) derives its name from the process it is currently performing, for example, it is called an acquirer when it performs the Acquisition process. In ISO/IEC 15288:2008, the agreeing parties are called the acquirer and the supplier.

When the following terms are used in ISO/IEC 15288:2008, they do not have their generic meaning, but instead, refer to the organization or party responsible for executing the process with a similar name: acquirer, supplier, implementer, maintainer, and operator. The processes and organizations (or parties) are only related functionally. ISO/IEC 15288:2008 does not dictate or imply a structure for an organization (or a party).

NOTE ISO/IEC TR 24748-1, clause 3.3.2 discusses process responsibilities in organizations.

4.5.3 Organizational relationships

A project has relationships with the organization, the business (or other entity) and other project-enabling structure in which the project resides. The project places certain demands on the organization and the organization places demands on the project. The project requires physical infrastructure, financial and human resource support to carry out project work. The organization both constrains and supports a project. Examples of such organizational constraints and supports are given below:

a) sets standards, policies, and procedures by which projects are carried out within the organization;

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 various organizational elements.

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4.5.4 Project organizational structure

The application of International Standard ISO/IEC 15288 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. The teams may include representatives from each stage of the life cycle.

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.

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4.6 Project concepts

4.6.1 General

A project is an endeavour with defined start and finish dates undertaken to create a product or service in accordance with specified resources and requirements. A project portfolio is a collection of projects that addresses the strategic objectives of the organization.

A project may be viewed as a unique process comprising coordinated and controlled activities and may be composed of activities from the Project Processes and Technical Processes defined in ISO/IEC 15288:2008.

NOTE 1 ISO/IEC 24748-1, clause 3.1.4, provides more detail on structure in systems and projects.

NOTE 2 ISO/IEC 24748-1, clause 3.1.5, provides more detail on enabling systems.

For the purpose of ISO/IEC 15288:2008, any project is assumed to be conducted within the context of an organization. This is important because a system project is dependent upon various outcomes produced by the business processes of the organization, e.g., employees to staff the project and facilities to house the project. For this purpose, ISO/IEC 15288:2008 provides a set of Organizational Project-Enabling processes. It is important to note that the Organizational Project-Enabling processes are not assumed to be adequate to operate a business, nor are the Project Processes assumed to be adequate to operate a project. Instead, the processes, considered as a collection, are intended to state the minimum set of dependencies that the project places upon the organization.

ISO/IEC 15288:2008 describes the set of processes that comprise the life cycle of any human-made system. Therefore, ISO/IEC 15288:2008 is designed so that it can be tailored for a project of any type, size and complexity, whether focused on tangible products, services, or a mix of both.

The processes, activities, and tasks in ISO/IEC 15288:2008 are arranged in their most general, natural positional sequence. This positional sequence does not dictate the life cycle model sequence. It is intended that the project select, order, tailor and iterate the processes, activities, and tasks as applicable or appropriate.

On the same project, ISO/IEC 15288:2008 may be separately applied more than once. For example, in a given system implementation project, an acquirer may request a supplier to perform system implementation, with the acquirer and the supplier executing one application of ISO/IEC 15288:2008. The supplier may then request its sub-contractor to perform all or part of the system development, e.g. develop the software. The

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supplier (now in an acquisition mode) and its sub-contractor (in supplier mode) execute a separate application of ISO/IEC 15288:2008. In both situations, it is necessary to tailor ISO/IEC 15288:2008 to reflect the arrangements.

NOTE 3 IEEE Std. 1490-2003, *Adoption of PMI Standard: A Guide to the Project Management Body of Knowledge*, provides more information on projects and project management.

4.6.2 Project relationships

A relationship can exist between a project and other projects, and subprojects. A subproject as used here and in Figure 8 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 8 illustrates typical roles of agreements that establish project relationships internal and external to the project.

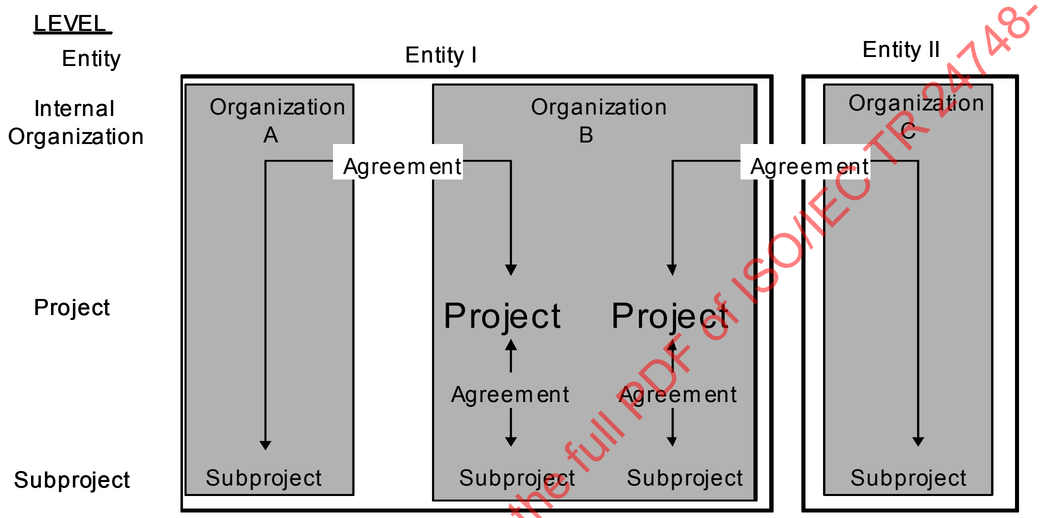

Figure 8 — Roles of agreements

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Project relationships are managed through formal or informal agreements in accordance with organizational policies and procedures, as appropriate. Depending on the type of project relationship involved, agreements may exist within a single organization, or may span organizational boundaries. Agreements may be between a project and a specific organizational element or elements, among multiple projects, or among 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 of agreement, not shown in Figure 8, 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.

Regardless of the kind of agreement, there is some basic information needed to do the work required in ISO/IEC 15288:2008. Each agreement, whether formal or informal, should include the following information to the appropriate level of detail:

a) responsibilities for the work expected to be done, for example in the form of work statements;

b) 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;

c) deliverables, for example products, services and data;

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d) 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).

NOTE A model is provided in Clause 5.4.2 of this Technical Report for the application of ISO/IEC 15288:2008 processes to reach an agreement.

4.6.3 Enabling system relationships

Another relationship among projects 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 organizations, as applicable, to ensure that specified enabling system services are provided when needed. A project span of interest is illustrated in Figure 9.

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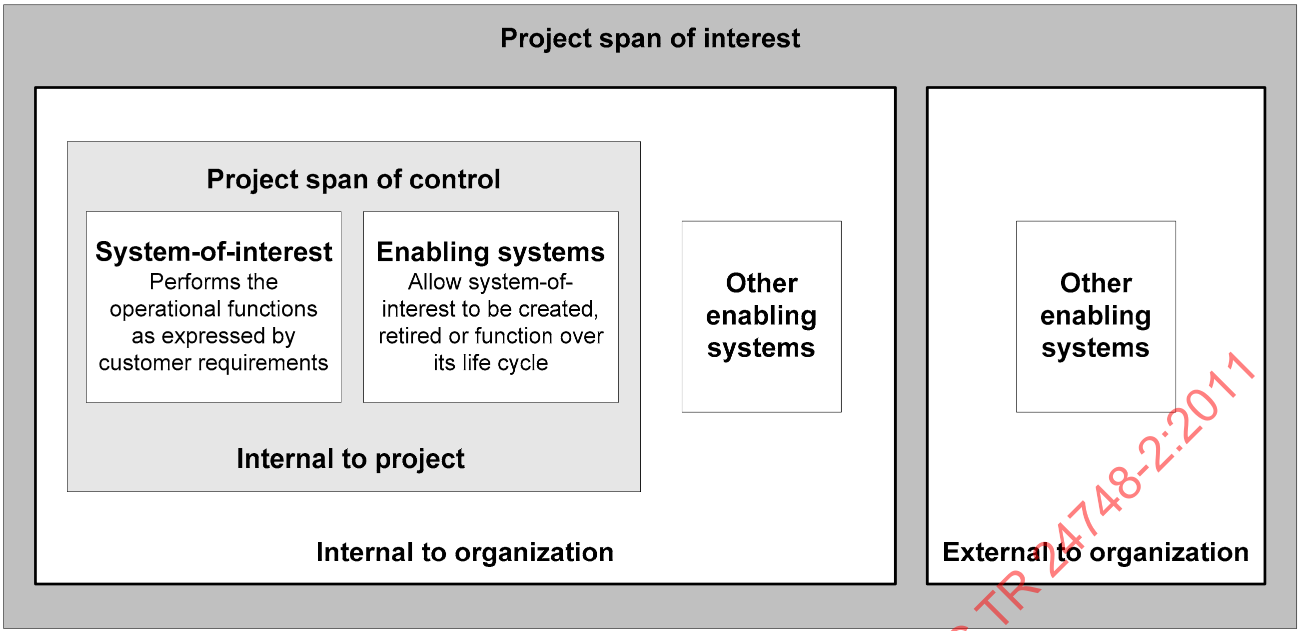

Figure 9 — Project span of interest

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4.6.4 Hierarchy of projects

The basic relationship of Figure 9, which illustrates the project span of interest, can be combined with the hierarchical view of a system structure illustrated in Figure 2 of ISO/IEC TR 24748-1 and the system-of-interest structure in Figure 3 of ISO/IEC TR 24748-1 to give a hierarchal 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 4 of ISO/IEC TR 24748-1 and is portrayed in more detail in Figure 10 of this Technical Report.

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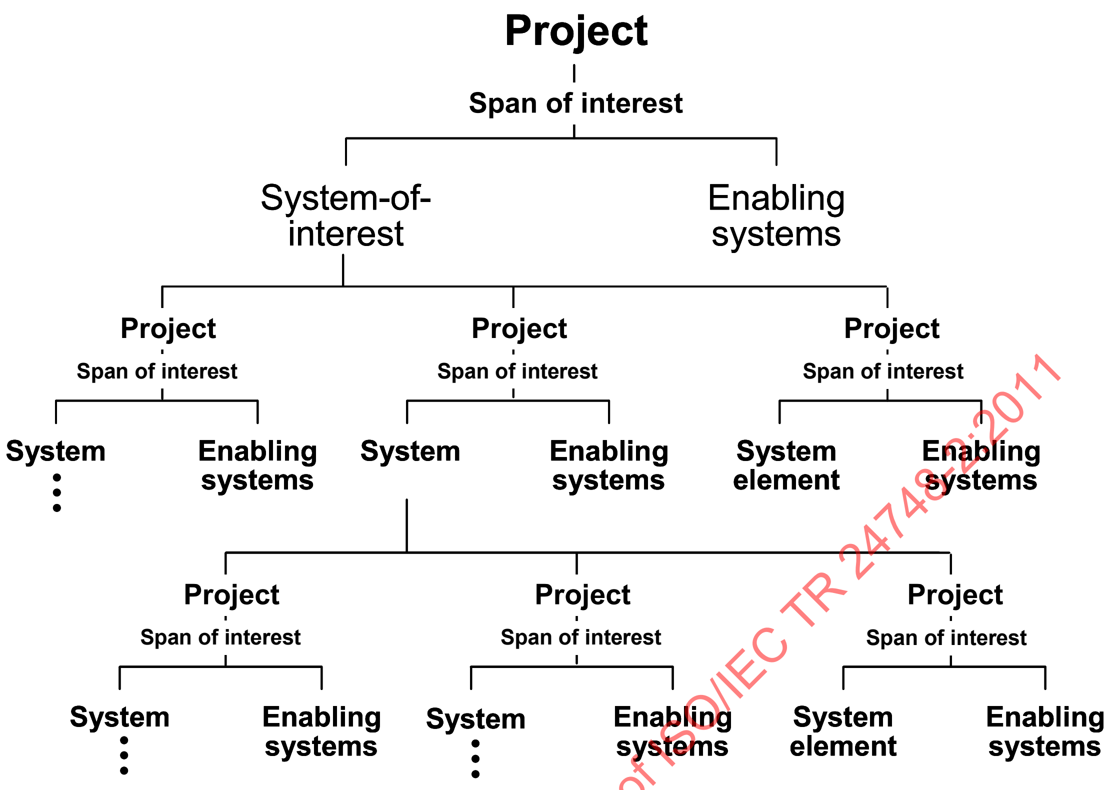

Figure 10 — Hierarchy of projects

Figure 10 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 10 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 9, the enabling systems of Figure 10 may be under project control or, if external to the project, under the control of other organizations. However, the project should work with these other organizations through agreements to ensure that the required enabling systems are available when needed to support the system-of-interest during its life cycle.

4.7 Adaptation concepts

4.7.1 General

To adapt means to make suitable, or to alter so as to make fit. Adaptation is the act or process of adapting by adding, revising, or removing material. Tailoring is adaptation that only removes compliance material.

NOTE 1 Process tailoring (removal of compliance material) concepts are introduced in ISO/IEC 15288, clause 5.3.4 with further discussion in Annex A.

NOTE 2 ISO/IEC TR 24748-1 adds material on adapting (tailoring or adding material) life cycle models in Clause 6 and on adapting processes in Clause 9.4.3.

ISO/IEC 15288:2008 provides requirements for a number of processes suitable for usage during the life cycle of a product- or service-based system. It is recognized that particular projects or organizations may not need to use all of the processes provided by ISO/IEC 15288:2008. Therefore, implementation of ISO/IEC 15288:2008 typically involves selecting a set of processes suitable to the organization or project.

NOTE 3 The requirements in ISO/IEC 15288:2008 are contained in ISO/IEC 15288, Clause 6 and Annex A.

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ISO/IEC 15288 may be conformed to in the following ways:

a) An organization declares publicly as a condition of trade, a set of processes, activities and tasks from ISO/IEC 15288 to which suppliers to the organization conform;

b) A project adapts appropriate processes, activities, and tasks, which are performed in accordance with contractually established criteria.

NOTE 4 Conformance to the International Standard is discussed in ISO/IEC 15288, Clause 2.

It is important to note that ISO/IEC 15288:2008 is not intended to be in conflict with any organization's policies, procedures, and standards, or with any national laws and regulations. Any such conflict should be resolved before using ISO/IEC 15288:2008.

4.7.2 Adaptation

The processes from ISO/IEC 15288:2008, as well as life cycle models, may be adapted for an individual project to reflect the variations appropriate to the organization, project and system. ISO/IEC 15288:2008 provides five primary mechanisms for adaptation:

a) Process selection: Claims of conformance to ISO/IEC 15288:2008 are made for a declared set of processes. Neither an organization nor a particular project is required to use every process. They may select the processes relevant to their needs and declare that subset as the basis of conformance.

b) Process substitution: Processes used in related standards, such as ISO/IEC 12207 are described as "specializations" of processes in ISO/IEC 15288. Explicit permission is granted to use the system-level process as a basis for conformance rather than the software-level process.

c) Use of Outcomes: According to the conformance clause of ISO/IEC 15288:2008, "conformance is achieved by demonstrating that all of the requirements of the declared set of processes have been satisfied using the outcomes as evidence." The fact that outcomes are used as evidence of conformance provides that alternative selections of activities and tasks may be performed if the outcomes of the declared set of processes are achieved.

d) Use of Notes: ISO/IEC 15288:2008 use non-normative notes or other forms of guidance for provisions that are not required for conformance. In specific situations, implementation of selected notes will be appropriate.

e) Process tailoring: Tailoring of processes is permitted. Tailoring is defined as the deletion of selected outcomes, activities, or tasks.

4.7.3 Life cycle adaptation

Life cycle adaptation is discussed in detail in Clause 6 of ISO/IEC TR 24748-1.

4.7.4 Adaptation for domains, disciplines and specialties

Adaptation for domains, disciplines and specialties in ISO/IEC 15288 is written at a general level and with sufficient scope that its normative provisions can be used on systems that are comprised of or include aspects of different domains (e.g. hardware, software, services, facilities, etc,). Standards used in conjunction with ISO/IEC 15288 may have specific instantiations of the general ISO/IEC processes to provide better linkage of the two standards for the practitioners in the domain and such linkages are advised wherever the domain practitioners deem them helpful. An example is ISO/IEC 12207, which has included software specific processes in Clause 7 to link to the system-related processes in Clause 6 of that standard.

Disciplines (such as mechanical engineering or facility engineering) and specialities (such as human factors, safety, or security) may find analogous adaptations of their standards to be helpful. One way of making these domain, discipline or specialty adaptations is by including them in agreements of the appropriate form, following the provisions of ISO/IEC 15288, Clause 6.1.

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NOTE Life cycle model use and adaptation for domains, disciplines and specialties is addressed in Clause 7 of ISO/IEC TR 24748-1.

4.7.5 Tailoring

Tailoring is not a requirement for conformance to ISO/IEC 15288:2008. Tailoring is not permitted if a claim of "full conformance" is to be made. If a claim of "tailored conformance" is made, then tailoring is to be performed as required by the tailoring process described in ISO/IEC 15288:2008.

NOTE 1 Tailoring is introduced in ISO/IEC 15288, Clause 2.3.

NOTE 2 ISO/IEC 15288, Annex A, describes the tailoring process and defines the basic activities needed to perform tailoring of ISO/IEC 15288:2008.

As stated in ISO/IEC 15288:2008, tailoring may diminish the perceived value of a claim of conformance to ISO/IEC 15288:2008. That is because it is difficult for other organizations to understand the extent to which tailoring may have deleted desirable provisions. An organization asserting a single-party claim of conformance to ISO/IEC 15288:2008 may find it advantageous to claim absolute conformance to a smaller list of processes rather than tailored conformance to a larger list of processes.

5 Applying ISO/IEC 15288:2008

5.1 Overview

Understanding concepts does not give the ability to immediately apply them without further thought and work. The following clauses give guidance on what must be done to bridge the gap between concept and practical use in different project, organizational and life cycle environments, starting with planning the application of International Standard ISO/IEC 15288.

Modern businesses strive to develop a robust set of life cycle processes that are applied repeatedly to the projects of the business. To accommodate that need, ISO/IEC 15288:2008 is intended to be useful for application at either the organization level, or at the project level. An organization would adopt the standard and supplement it with appropriate procedures, practices, tools and policies. A project of the organization would typically conform to the organization's processes rather than conform directly to this standard.

In some cases, projects may be executed by an organization that does not have an appropriate set of processes adopted at the organizational level. Such a project may apply the provisions of ISO/IEC 15288:2008 directly to the project.

5.2 Application strategy

5.2.1 Overview

ISO/IEC 15288:2008 may be applied for a variety of reasons, such as:

— To define the processes, activities and tasks required for use on a specific project;

— To improve processes used by an organization across multiple projects;

— To 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 15288, a suggested application strategy consists of the following:

a) Plan the application;

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b) Adapt ISO/IEC 15288:2008, if applicable;

c) Conduct pilot project(s);

d) Formalize the approach;

e) Institutionalize the approach.

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

Whether the existing basis for system life cycle processes is ISO/IEC 15288:2002 or some other reference point, the fundamental starting point is to identify all the changes to go from that basis to ISO/IEC 15288:2008. If the existing process basis is ISO/IEC 15288:2002, the amount of changes will be noticeably less than if a different process basis is in use.

Bringing all the stakeholders together 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 checklist of things that must be considered in applying ISO/IEC 15288. This may include, and possibly will not be limited to:

a) Documentation changes, including flow and nomenclature;

b) Staff training needs;

c) Responsibility changes, including need for new agreements;

d) Impacts on tools and databases;

e) Changes in the inputs required by and outputs from each process.

The initial checklist should be then be used by an immediately following, larger, group of all stakeholders to work through what other items need to be added and what the specific changes are for each item on the checklist. Repeated reviews of checklist drafts should be held to find the final few surprises.

Once there is a detailed listing of the changes derived in this, or equivalent, manner, the time and cost impacts of each need to be assessed. Then further analysis of the sequence of implementing the changes is necessary. The group should explore phasing in changes in a way that minimizes cost, project disruption and the potential for adverse human reactions. Readiness criteria should be developed for starting the each step of a phase-in, as well as checks for successful completion after each step of phasing in the changes. Quantitative metrics should be developed and used.

Throughout, a core group should be maintained to oversee the change from one basis to another, with periodic meetings of the entire group of stakeholders.

When a project or organization is already in a steady state, i.e. where the processes have been established and institutionalized, then the implementation strategy could be shortened and would probably include the following:

a) Plan the application;

b) Adapt ISO/IEC 15288:2008, if applicable (for the risk level of the work);

c) Conduct the project(s).

5.2.2 Planning the application

Applying ISO/IEC 15288:2008 should be considered as a specific project and planned as such.

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

a) Define the scope of the project. Possibilities include:

- A single project either internal to an organization or as part of a two party contract;
- Concentration on some key processes or even a single process where there is expected to be some gain for an organization. This approach could be used where a weakness has been detected previously and could lead to a full application of ISO/IEC 15288:2008 at some future point;
- Adoption of ISO/IEC 15288:2008 across a range of projects with probably a staged introduction. Here the organization would probably have no or few defined processes and would be standardizing on ISO/IEC 15288:2008;
- Adoption of ISO/IEC 15288:2008 across all projects and within all parts of the organization. It is unlikely that any organization except a very small one would take this approach. It would be relevant though for a new subsidiary of an existing organization that has adopted ISO/IEC 15288 into working practice previously.

b) Identify the project goals and determine how they fit into the organization-wide business goals. If no obvious link is established between this 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 project team/organization, assigning a single point of responsibility for each process. In many cases, one individual or organization may be responsible for more than one process, particularly in small projects or organizations;

d) Identify the resources available for the application of ISO/IEC 15288:2008, such as time, money, people and equipment;

e) Create and document the project management plan for applying ISO/IEC 15288:2008.

5.2.3 Conduct pilot project(s)

When introducing ISO/IEC 15288:2008 in an organization across many projects, some pilot use in key areas and for key processes will help to limit the exposure of the organization. A successful introduction would usually include such approaches as the following:

a) Identify pilot projects that can utilize the processes selected. 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, and that can be expected to provide quick, visible results;

b) Select a team of volunteers to conduct the pilot projects then publicize and reward their efforts;

c) Train all involved. Awareness can be aided by regular communication of progress in the implementation process, in addition to formal training classes;

d) Plan the pilot projects and identify critical success factors;

e) For each pilot project, incorporate the selected tailored process or processes into the project management plan. Reference or include as appropriate, the necessary documentation, e.g. the tailoring decisions and rationale;

f) Execute the pilot project(s), tracking and documenting the performance against the critical success factors. Document lessons learned throughout the pilot project(s). Incorporate the lessons learned into revised processes.

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5.2.4 Formalize the approach

Formalizing involves the introduction of a new process across several projects and/or across the organization. Issues such as training, documentation, provision of support tools for the process(es), and the tracking and oversight of the new process(es) use and acceptance. Planning for the transition to the new process(es) for any project that is already up and running should be addressed.

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

5.2.5 Institutionalize the approach

Institutionalization focuses on what is involved in ensuring that a process is used consistently and automatically throughout the project or organization. This also involves measuring performance of the process, and implementing process improvement again as necessary.

5.3 Application in organizations

5.3.1 Overview

Organizations are producers and consumers of systems; that is they trade products and services. The processes in ISO/IEC 15288:2008 are used by organizations that acquire and use or create and supply a system. Any of the processes apply at any level in a system structure during any applicable stage of the system life cycle and to any organization assigned responsibility for a system. How they are applied, possibly with adaptation, varies depending on such factors as the project, organization, and life cycle model. The outputs of one level, whether information, products or services, are an input to the level below (and may feed back to the level above) and result in a corresponding response including information, products or services. The use (recursively) of the same underlying set of processes to describe an organization's business, project and technical actions at each level of detail in a system structure is a key aspect of the application of ISO/IEC 15288:2008.

Additionally, a management group of a multi-organization project working on the same system can use ISO/IEC 15288:2008 to provide a common set of processes, an integrated system life cycle model, and a common basis for communication and for working together.

The processes in ISO/IEC 15288 form a comprehensive set to cater for a wide variety of organizations. An organization, small or large, depending on its business purpose, can select an appropriate subset of the processes (and associated activities and tasks) to fulfil that purpose. ISO/IEC 15288 is intended to be applied internally by an organization or contractually by two or more organizations. In order to facilitate application of ISO/IEC 15288:2008 either internally or contractually, the tasks are expressed in contractual language. When applied internally, the contractual language is interpreted as self-imposed tasks.

ISO/IEC 15288 is to be harmonized with an organization's policies and standards that are already in place. It is usually the case that an organization has been utilizing its own existing standards and specific techniques. When applying ISO/IEC 15288:2008 within an organization, it is therefore important to clarify the relationship between ISO/IEC 15288, the organization's own standards, and the various techniques that have been employed.

Figure 11 shows one possible example of such relationships that may be useful when applying ISO/IEC 15288:2008 within an organization. ISO/IEC 15288 is located at the first level, standards in the organization are located at the second level and the third level is for detailed activities, techniques, and tools that are specific to a project. The terms defined and used in the second and the third levels are required to conform to ISO/IEC 15288:2008.

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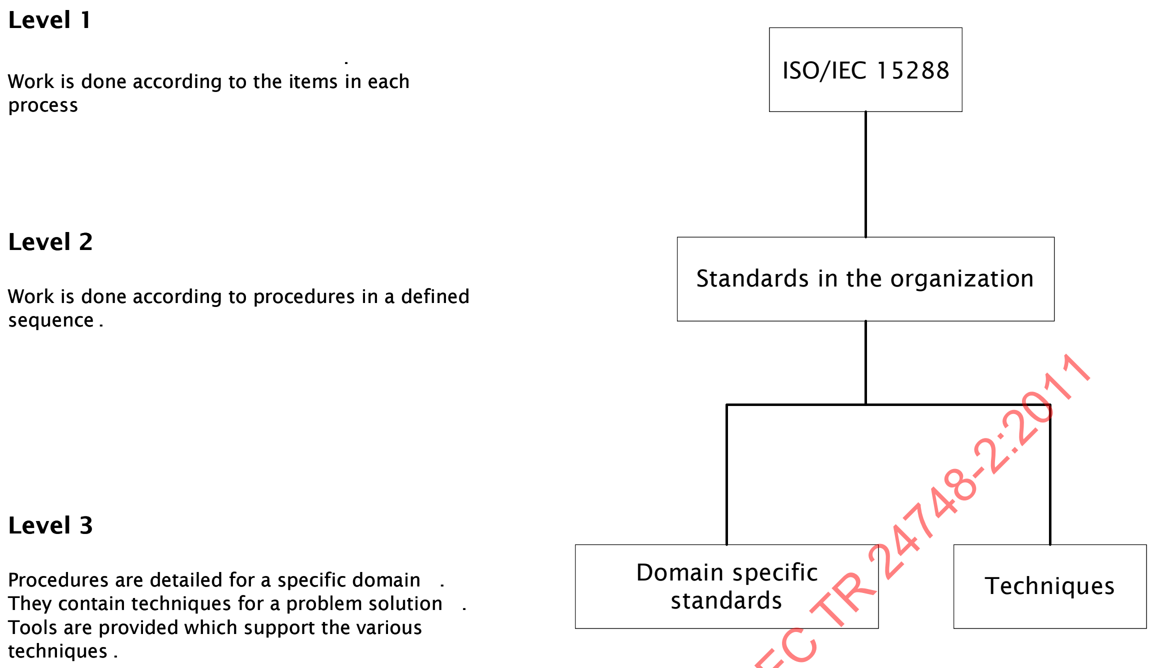

Figure 11 — Relationship with existing documents

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Resolution of any conflicts is left to the organization applying ISO/IEC 15288 and may involve developing a mapping and if necessary, filling any gaps.

5.3.2 Considerations and techniques

Organizations would generally use ISO/IEC 15288 as part of an effort to improve system-related processes. This may be through standalone use or in conjunction with available process assessment and capability determination methods.

NOTE The application of ISO/IEC 15288:2008 within an organization is based upon the same approaches as are used on projects. Consideration is given to the issues raised and the strategies described in clause 5.2 of this Technical Report are followed by organizations when using ISO/IEC 15288:2008.

5.3.3 Application opportunities

The reasons for applying ISO/IEC 15288 internally within an organization may include such situations as:

— Verifying the thoroughness of an existing method. This would usually be more relevant where the method was developed in-house or adopted and extensively modified;

— Adapting an existing method to cater for the risks associated with moves into new market sectors where more rigor is required because of perceived risks;

— Developing a new method e.g. to meet the needs of a new organization. This includes organizations created through mergers or business alliances. It may be necessary to maintain several process models to suit particular activities;

— Managing the introduction of new technology. Examples include the automation of existing manual processes, or a change in the techniques used to implement a product or service. ISO/IEC 15288 defines criteria which can be used to benchmark the completeness of the method before and after the technology is changed;

— Evaluating an internal capability of a party to meet agreed criteria e.g. as part of a tender review process;

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— Establishing a benchmark upon which improvement programs can be developed e.g. audit against ISO/IEC 15288.

5.3.4 Management commitment

As with any program which results in changes to work practices, it is essential that the management within the affected organization is visibly committed to implementing and supporting the changes. In a two-party situation this would be initiated by a contract and then, as for general organizational use, it would be normal practice to establish policies covering the relevant parties.

5.3.5 Uses of ISO/IEC 15288:2008 within an organization

There are three key uses of ISO/IEC 15288:2008 within an organization. These uses are illustrated in Figure 12 and described below.

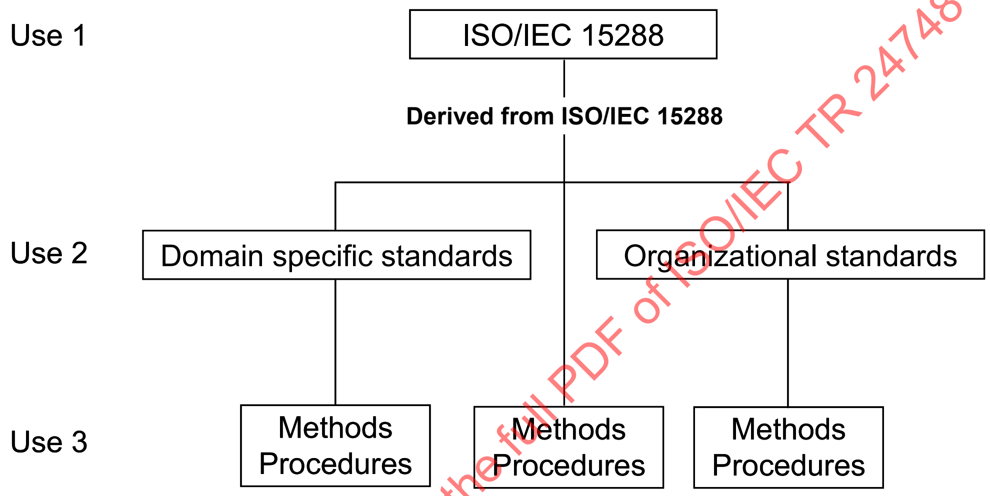

Figure 12 — Three uses of ISO/IEC 15288:2008

Use 1 is a direct application of ISO/IEC 15288:2008 to organizational work. ISO/IEC 15288:2008 describes the life cycle processes in terms of process name, purpose, outcomes and activities. Thus, direct application is the application of a set of selected life cycle processes to the appropriate system-of-interest during a life cycle stage to achieve the process outcomes and satisfy stage objectives and exit criteria. To successfully apply the selected processes each activity is further defined by the organization. This further definition includes identifying the tasks by which an activity will be accomplished. From these tasks and the nature of the activity, methods and tools are determined for completing the tasks efficiently and effectively.

The outcomes from performing tasks should include appropriate documentation. The extent of documentation should be based on project size, life cycle stage exit criteria, agreement deliverables, resources available and any other influencing factors identified.

For successful application of ISO/IEC 15288:2008 within an organization the methods and tools for completion of activities and tasks should be selected and made available to projects. The team members involved with applying the processes should be trained on the concepts and requirements of ISO/IEC 15288:2008 as well as the selected methods and tools.

Use 2 is for the purpose of creating appropriate organizational standards and organizational domain standards. These standards can be derived from the applicable concepts and requirements of ISO/IEC 15288:2008 in order to standardize the primary work of the organization and domains such as aerospace, automotive, medical equipment and so forth. In this use it would be an adaptation of the scope of ISO/IEC 15288:2008 to the organization, to the applicable domain, or both. Use 2 type standards should be more focused to the business of the various organizational units and domains. As in Use 1, the activities should be defined in more detail by identifying necessary tasks, selecting and providing the appropriate

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methods and tools and performing work according to procedures and sequencing defined in these standards. Organizational and domain team members should be trained in the appropriate standard and the applicable methods and tools prior to applying on a project.

Use 3 is for the purpose of preparing appropriate documents describing organizational and domain-wide methods, procedures and guidance for implementation of organizational and domain standards as well as for direct application of ISO/IEC 15288:2008. Appropriate training on the applicable document is necessary prior to application on a project.

5.4 Application on projects

5.4.1 Overview

ISO/IEC 15288:2008 life cycle processes can be used by a project for at least four purposes.

a) To establish agreements with organizational entities external and internal to the project to acquire or supply a product or service (Agreement processes).

b) To ensure the organization's capability to acquire and supply products or services through the initiation, support and control of projects (Organizational project-enabling processes).

c) To establish and evolve project plans, to execute the project plans, to assess actual achievement and progress against the plans and to control execution of the project through to fulfilment (Project processes).

d) To contribute to the satisfaction of Technical objectives for one or more life cycle stages (Technical processes).

The requirement to perform ISO/IEC 15288:2008 life cycle processes is independent of system size or complexity. Instead, factors such as the system requirements and the concept of operation affect the system size and complexity. Thus, the outcomes and activities from the ISO/IEC 15288 life cycle processes are meant to be generic and applicable to the engineering of any system within the scope of ISO/IEC 15288:2008. The size and complexity of a system can affect the work of a project, for example the tasks performed to accomplish an activity of a system life cycle process or the type and form of work products from application of the processes can be affected.

5.4.2 Application of agreement processes on a project

5.4.2.1 Application of acquisition process

The processes of ISO/IEC 15288:2008 can be used to attain an agreement. Figure 13 illustrates the use of the agreement processes in conjunction with the other life cycle processes of ISO/IEC 15288:2008 to attain an agreement. Agreements can be between organizations, between projects, and for work efforts within a project. Such cases are illustrated in Figure 8.

The Figure 13 model is not meant to reflect all possible process flows to attain an agreement but to show that all processes of ISO/IEC 15288:2008 can have a role in forming an agreement, especially formal agreements that can be legally binding. When an agreement involves a relationship between individuals of sub-projects within the same project much less formality can be expected than suggested by the Figure 13 model. The following paragraphs describe the process flow of the Figure 13 model and exceptions as appropriate.

The processes of ISO/IEC 15288:2008 can be initiated with the receipt of an acquisition request such as a formal request for proposal or an informal internal directive for certain work to be done. This could be before a project is formed for a new engineering effort or within a project if it is for project-related work.

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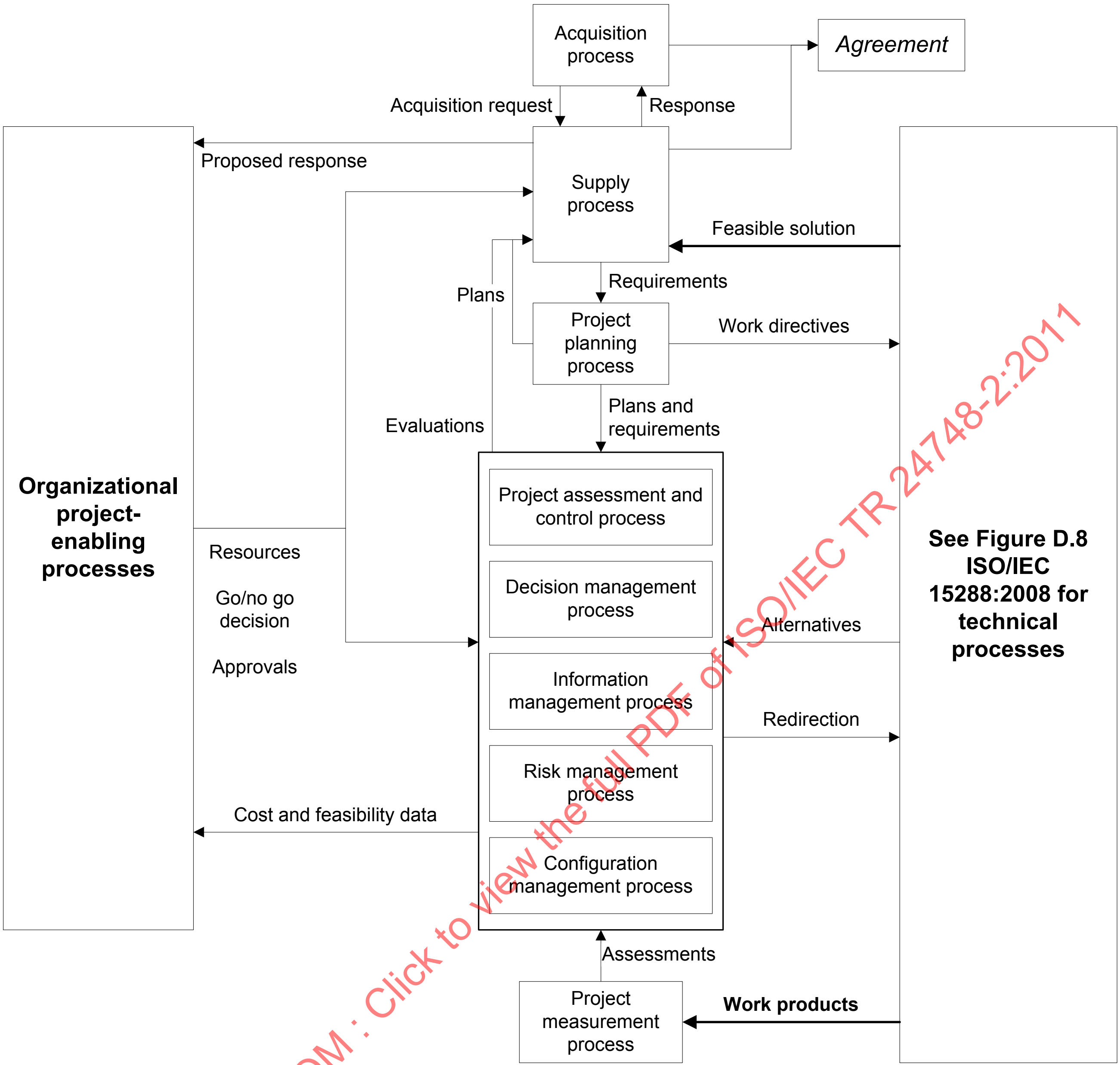

Figure 13 — Application of processes to form a formal agreement

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An appropriate team or individual, depending on the project size and complexity, would be assigned to consider and prepare a response to the acquisition request. For smaller projects a single individual could be assigned the responsibility to prepare the response, to do the work and to create the required work products to be delivered.

The assigned team or individual should perform the activities of the supply process appropriate to establishing an agreement. First the team or individual should do the necessary planning to scope a strategy for the response preparation effort and to understand the capabilities required to do the requested work. The plan should include a schedule of milestones and decision criteria for submitting a response and consider the goals of the organization or project as well as applicable investment decision criteria.

To determine whether to respond to the request for proposal or to determine the specifics of the response, the technical processes can be planned and performed to the level of the system structure appropriate to the nature and size of the system and the system life cycle stage. In addition, the scope of work, cost of the system and the feasibility of meeting requirements within given constraints should be determined. The

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application of the technical processes should be in accordance with the plan and should be assessed and controlled using the appropriate project processes. The organizational project-enabling processes are implemented to the extent necessary to support the technical processes and monitor the outcomes and approve the response, as appropriate.

Appropriate to the level of formality, the following list of expectations should be used to establish a common basis for the acquirer and supplier to understand the project requirements.

a) System and service requirements.

b) Expected deliverables.

c) Development and delivery schedule milestones.

d) Acceptance conditions, exception handling procedures, conditions requiring re-negotiation of the agreement, conditions required to lawfully terminate the agreement, conditions required to impose penalties or invoke bonuses and payment schedules.

e) Rights and restrictions associated with technical data, intellectual property, copyrights and patents.

The negotiation can be considered complete when the terms of agreement are acceptable to both the acquirer and supplier.

5.4.2.2 Application of supply process

After an agreement is established a project is formed, if not already in place, and the appropriate agreement, project and organizational project-enabling processes of ISO/IEC 15288:2008 are used in conjunction with the Technical processes of the International standard to do the work to meet agreement requirements. The model illustrated in Figure 14 provides an example of the relationship of processes used within a project for satisfying an agreement. This example is not meant to represent all possible process flows by all possible projects. It does, however, provide an approach one can consider in establishing a process flow appropriate to a particular project. Smaller projects would still do the same processes but the formalization, documentation and level of activity could be reduced in scale as appropriate to the economics of the project.

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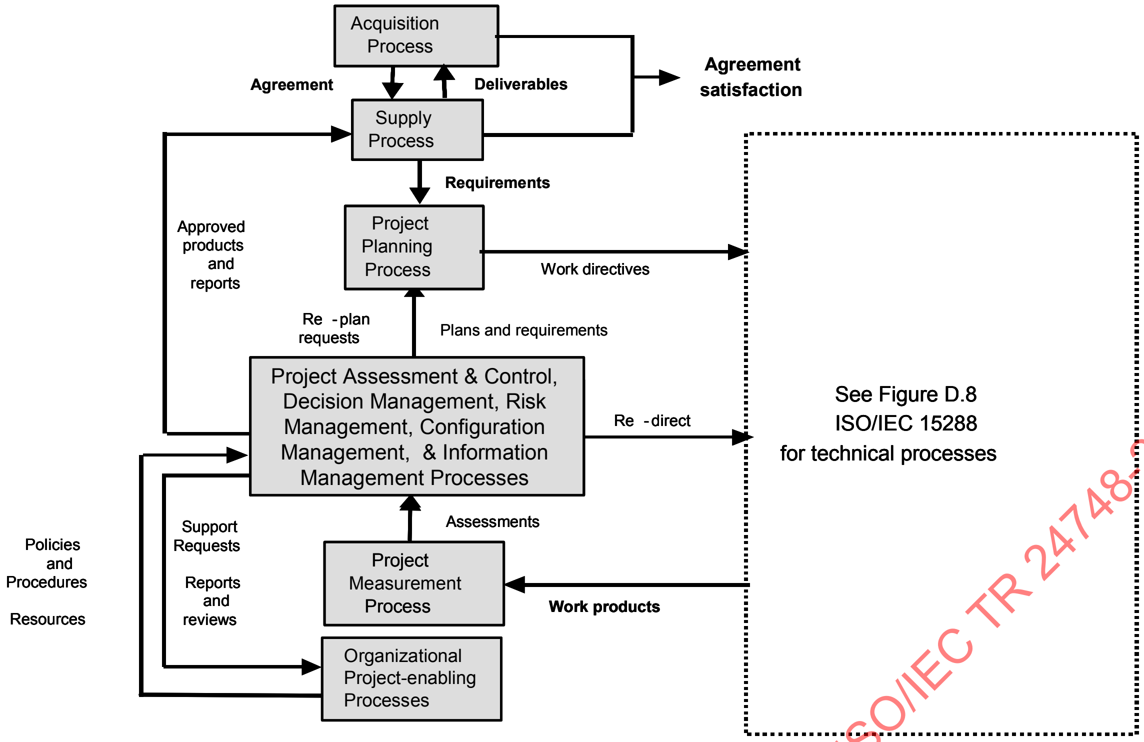

Figure 14 — Application of processes to satisfy an agreement

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The project work should not be undertaken until the resources such as funds, team members, equipment and facilities needed to meet the project agreement and plans are attained.

The project exists to satisfy an agreement by providing the desired deliverables to the quality expected. The project performs the Planning Process that could consist of updating the plans used to form the response to the acquisition request or the applicable plans from the previous life cycle stage. Appropriate teams are assigned the work required to meet planned requirements. These teams do the work associated with application of the technical processes to obtain the work products required. The Assessment Process, Control Process, Decision Making Process, Risk Management Process, Configuration Management Process and Information Management Process should be used to monitor, control, and assess the technical process outcomes to be able to keep work within acceptable cost, schedule and risk in order to meet performance requirements for the system. The Organizational Project-enabling Processes and Project Processes are implemented to provide support to the project, and to review the project, as appropriate.

The activities of the processes shown in Figure 14 can be considered as complete when the agreement is fully satisfied with the delivery of required products and services.

The actual realized form of the system-of-interest, system or system element can vary from a conceptual model to a production representative product. The realized form of the deliverable is typically a function of the exit criteria of the applicable system life cycle stage and agreement requirements.

5.4.3 Application of technical processes to a project

5.4.3.1 General

Figure 15 provides a model for the application of the technical processes of ISO/IEC 15288:2008. This model includes only the technical processes that are primarily used for engineering a system-of-interest. Three of the technical processes are not shown in Figure 15: the Operation Process, Maintenance Process and Disposal Process. These three processes should be used as appropriate to provide inputs to the Stakeholder Requirements Definition Process. The requirements could be in the form of acquirer requirements such as

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operability, supportability and disposability or in the form of other interested party requirements such as for enabling systems to provide related services.

In the discussions below on the technical process model for engineering a system, process application will be to a system whether it is the top-level system-of-interest or one of the systems or system elements in the system structure. When a process application is relevant to just the system-of-interest or a system element in the system structure, then specific terminology will be used.

Although any system must be addressed over its full life cycle, it is common for projects to span only portions of that life cycle. For example, one project may define the system, while a second project turns the design into a realized system. With that in mind, application of technical processes to a project is covered in two clauses in this Technical Report. Clause 5.5.5.2 discusses system definition, whilst Clause 5.5.5.3 addresses system realization.

The Stakeholder Requirements Definition Process, Requirements Analysis Process and Architectural Design Process are used to design the solution for each system in the system structure. Application of these processes can be highly iterative (see Clause 4.4.3.3 of this Technical Report) in order to arrive at the desired design solution.

The Implementation Process, Integration Process, Transition Process, Validation Process and Verification Process are used to realize the architectural design solution for each system in the system structure. Likewise, application of these processes can be highly iterative.

The Stakeholder Requirements Definition Process, Requirements Analysis Process, and Architectural Design Process are applied recursively to the system-of-interest and then its systems from the top down until a system element can be implemented (for example built, bought, reused) using the Implementation Process. This occurs when no further systems need to be developed. After all system elements of the system structure are implemented, then the Integration Process, Verification Process, Transition Process and Validation Process are performed recursively on each system from the bottom up to include the top level system-of-interest.

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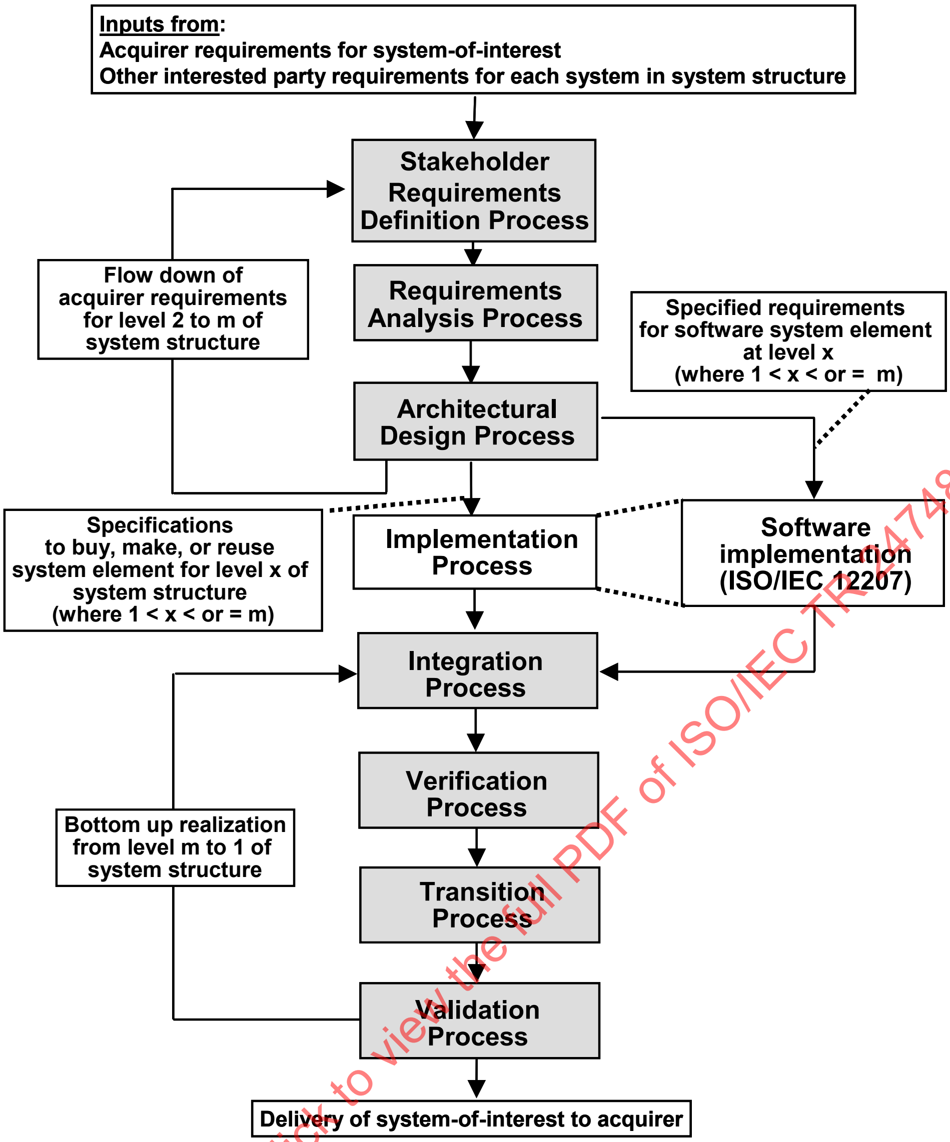

Figure 15 — Application of technical processes to engineer a system-of-interest

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Each process of this model is described below. Additional notes intended to help use these processes are found in Annex A of this Technical Report.

5.4.3.2 Related technical processes for system definition

5.4.3.2.1 General

The Stakeholder Requirements Definition Process, Requirements Analysis Process and Architectural Design Process should be used to create design solutions for a system from the top-level system-of-interest down through the lowest system element level of the system structure. Processes for system realization are covered in Clause 5.5.5.3.

5.4.3.2.2 Stakeholder Requirements Definition Process

The Stakeholder Requirements Definition Process can be used to identify, collect and appropriately define stakeholder requirements. The acquirer and other interested parties together form the stakeholders related to the system being engineered. The acquirer provides the initial set of requirements for each system in the

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system structure. Other interested parties typically provide additional requirements that can influence the design solution. Examples are given in the list below.

a) Interfaces with associated enabling systems or interfaces with other systems in the intended operational environment.

b) Critical factor needs such as safety, security, producibility, reliability, availability, usability and maintainability.

c) Operator and user need, skills, competencies and working environments.

The resulting set of stakeholder requirements represents a collection of requirements placed on the engineering of a system. These stakeholder requirements include the functions that are required to be performed, how well they should be performed, the environment in which they are to be performed, any required characteristics of the system and any service related to enabling systems. To ensure that all possible sources of stakeholder requirements have been considered, all the processes in ISO/IEC 15288 should be examined. So, as specific examples, the appropriate activities of the Implementation Process, Integration Process, Verification Process, Transition Process, Validation Process, Operation Process, Maintenance Process and Disposal Process could each generate requirements, otherwise overlooked that will influence the system being engineered. Likewise, the activities of non-Technical processes should also be examined to see if they generate stakeholder requirements,

After the set of stakeholder requirements is defined, upward and downward traceability (or completeness and consistency checks) should be performed to ensure that no requirements have been omitted or added without accountability.

The set of stakeholder requirements should be used when performing the Validation Process after the system has been implemented or integrated and verified. It is important to take into account the requirements for the operation of the system and the business when addressing the Stakeholder Requirements Definition Process.

5.4.3.2.3 Requirements Analysis Process

Stakeholder requirements are not always stated in technical terms and may not be readily usable for architectural design. The Requirements Analysis Process can be used to perform an analysis of the stakeholder requirements and transform the stakeholder requirements into a set of usable technical requirements. This includes the identification and analysis of external interface requirements, functional requirements, performance requirements, and constraints as well as the quantitative and qualitative measures related to these requirements.

The resulting set of technical requirements should be checked for upward and downward traceability to ensure that no stakeholder requirement has been omitted, all stakeholder requirements have child technical requirements, and all technical requirements have a parent stakeholder requirement. The resulting set of technical requirements should be checked for compound requirements containing multiple parts, which should then be decomposed into individual requirements.

5.4.3.2.4 Architectural Design Process

5.4.3.2.4.1 General

The Architectural Design Process can be used to transform the defined set of technical requirements into an acceptable architectural design solution that fulfils the technical requirements for the system being engineered. The architectural design solution should be documented in a technical data package or database that includes a set of architectural design solution specifications and other configuration descriptions.

5.4.3.2.4.2 Logical architecture definition

The first step should be to transform the set of technical requirements to a more detailed set of derived technical requirements that have been derived from a set of logical architectural design models [see Clause

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6.4.3.3 a) of ISO/IEC 15288:2008]. This can be accomplished by performing the logical architecture design task of the Architectural Design Process, then partitioning and capturing interfaces. Logical architectural design models can take one or more forms such as described below.

a) A functional flow block diagram reflecting the decomposition of major functions into their sub-functions.

b) A data flow diagram that decomposes functions while explicitly showing the data needed for each function.

c) A data structure with corresponding functions and processing flows related to the data and associated with assigned technical requirements.

d) Interface definition documents with logical, physical and functional attributes of system element and system to external system boundaries delineated.

e) A behavioural diagram that describes input stimuli and outputs by function and includes operating order, as appropriate to input or output criteria.

f) A control diagram that indicates the controlling factors of a function and the resulting behaviour.

g) The states and modes of the system.

h) A timeline that allocates a time requirement to a set of functions.

i) A functional failure modes and effects table that indicate the possible effects of a function failure mode, such as not doing what it is designed to do or doing a function for which it not expected to perform. Possible resolutions for each failure mode should be generated.

j) Objects that encapsulate a partition and mapping of technical requirements and that are characterized by services (behaviours, functions and operations) provided by encapsulated attributes (values, characteristics and data).

k) A set of algorithms derived from contextual diagrams.

l) An IDEF0 diagram. (IDEF0 (Integration Definition 0) function modelling is designed to represent the decisions, actions, and activities of an existing or prospective organization or system. See IEEE Std. 1320.1, *IEEE Standard for functional modelling language – Syntax and semantics for IDEF0* for more information.)

Each logical architectural design model should be evaluated to determine the impact of the model on system quality.

The set of technical requirements can be allocated to logical architectural design models to form a set of derived technical requirements taking into consideration the operational environment. These derived technical requirements can be used as the basis for physical architectural design.

Existing system elements, or the introduction of new technology, should be considered in establishing the logical architectural design models. The use of existing systems helps reduce developmental time and cost but may increase complexity. Use of new technologies can provide a competitive edge but can also increase risk. In such considerations, new interfaces may be introduced and should be included in the set of technical requirements through iteration of the Requirements Analysis Process.

The set of decomposed and derived technical requirements should be checked for upward and downward traceability with respect to the set of technical requirements generated by the System Requirements Analysis Process.

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5.4.3.2.4.3 Physical architectural design

5.4.3.2.4.3.1 General

Physical architecture design draws on the outputs of logical architecture definition and the two processes interact, iteratively. In performing physical architecture design, the logical architectural design models, the derived technical requirements and those technical requirements not allocated to logical architectural design models can be used to form alternative physical design solutions [see Clause 6.4.3.3 b) and c) of ISO/IEC 15288:2008]. After each alternative physical design is evaluated, the preferred architectural design solution should be selected using an appropriate analysis of cost effectiveness, operational effectiveness and risk.

5.4.3.2.4.3.2 Physical architectural design outputs

The architectural design solution selected should then be fully defined to provide the outputs listed below.

a) A configuration description including the system specifications of the system that was defined by the Stakeholder Requirements Definition Process, Requirements Analysis Process and Architectural Design Process. This configuration description should be used when the Verification Process is performed after the system has been implemented or integrated.

b) The requirements that will be flowed down to the next lower level systems or system elements. These requirements should be used as the acquirer initial specifications (or requirements) for the development of lower-level systems or system elements, unless the architectural design solution is for a system element that will have no lower-level systems to develop.

c) The requirements for enabling systems needed to provide life cycle support to the designed system. These requirements should be used to acquirer required enabling systems.

Configuration descriptions can be in the form of specifications, baselines, sketches, drawings, parts lists and other appropriate design descriptions. The specific configuration descriptions will depend on the life cycle stage in which the Architectural Design Process is being used and the information needed to satisfy the exit criteria of the life cycle stage and the entry criteria for the next stage.

5.4.3.2.4.3.3 Traceability of physical architectural design outputs

The requirements expressed in the configuration description outputs above should be checked by an appropriate means to ensure that they are upward and downward traceable. Traceability should be checked against three sources of requirements:

a) The derived technical requirements from logical architectural design.

b) The derived technical requirements that resulted from analyses of the alternative physical design solutions.

c) The output requirements from the Requirements Analysis Process that were not allocated to a logical architectural design model. This could happen when a technical requirement from requirements analysis cannot be allocated to a logical architectural design model.

The Stakeholder Requirements Definition Process, Requirements Analysis Process and Architectural Design Process can be performed again, as necessary, to refine the requirements for the physical architectural design solution and the related output configuration descriptions (see the discussion on the iteration concept, Clause 4.4.4.3 of this Technical Report). Factors that can cause this iteration include identification of a need for new stakeholder requirements during architectural design or the failure to satisfy the upward and downward traceability check.

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5.4.3.2.4.4 System structure definition

One of the possible outcomes from physical architecture design includes the requirements for the next lower level systems or system elements. These output requirements are the acquirer requirements for the recursive application of the Stakeholder Requirements Definition Process, Requirements Analysis Process and Architectural Design Process to a lower-level system or system element in the system structure. The systems or system elements at the next lower level of the system structure will later be integrated into the system from which the requirements were assigned.

The recursive application of the Stakeholder Requirements Definition Process, Requirements Analysis Process and Architectural Design Process is shown in Figure 15 as the loop identified as the flow down of acquirer requirements for each level of the system structure. For each system or system element of the system structure that has to be developed the Stakeholder Requirements Definition Process, Requirements Analysis Process and Architecture Design Process should be applied. Other interested party requirements should also be determined in order to form the input set of stakeholder requirements for each system or system element at the next level of the system structure. (See the discussion on the recursion concept, Clause 4.4.3.2 of this Technical Report).

The recursive loop of Figure 15 is continued until all system elements of the system structure have been defined and no additional systems or system elements need to be developed. System elements can occur at any level x of the system structure. At each level x, when no further development is needed for a system in the system structure, the next set of processes for system realization should be performed. This is an example of the recursive application of technical processes to enhance the top-level system-of-interest definition by defining its lower level systems and system elements. The top level for one organization can be the system that will be purchased by a consumer in a commercial market, such as an automobile. The top level for another organization can be a system within the system structure such as a motor that will be assembled into the automobile by another organization.

Also, at any level, a system element can be identified as having a unique standard that may be used for implementation of that system. This is illustrated in Figure 15 for software using ISO/IEC 12207.

The recursive application of the first three processes of Figure 15 is repeated within the system structure until the implementation process is applicable for a system element and until all system elements have been implemented. At this point the system structure is fully defined.

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5.4.3.3 Related technical processes for system realization

5.4.3.3.1 General

Technical processes for system definition are covered in Clause 5.4.3.2. The Implementation Process, Integration Process, Verification Process, Transition Process and Validation Process should be used to realize the architectural design solution for each system in the system structure from the bottom system element to the top-level system-of-interest of the system structure.

Each implemented system element should be verified using the Verification Process and validated using the Validation Process before integration is performed at the next higher level of the system structure.

After all system elements of the system structure are appropriately implemented, the definition of the system structure is complete. Then the bottom up, recursive application of the Integration Process, Verification Process, Transition Process and Validation Process should be performed from level m to 1 of the system structure for each system and for the system-of-interest.

5.4.3.3.2 Implementation Process

The Implementation Process can be used when further development of a system element is not needed. At this point the system element defined as part of an architectural design solution can be implemented. The Implementation Process should be used to transform such system element definitions into products or services appropriate to the applicable life cycle stage. The implemented system element can be either a single

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product or a composite product depending on its position in the system structure and its ability to be appropriately modelled, built, bought or reused.

5.4.3.3.3 Integration Process

The Integration Process can be used after the lower level system elements have been implemented and delivered to the integrator responsible for integration into a system at the next level above. Integration of the system elements may be performed by the same party that performed the implementation or by the acquirer. The implemented system elements are assembled and integrated into a higher-level system in accordance with the configuration descriptions developed during the top down definition and design of that system. This newly integrated system is verified using the Verification Process, transitioned to the acquirer at the next level above using the Transition Process and validated using the Validation Process. This bottom-up integration of systems is continued until the top-level system-of-interest is realized using these same processes.

5.4.3.3.4 Verification Process

The Verification Process can be used to establish correspondence between the performance and characteristics of the system with respect to technical requirements and other agreement requirements. This process ensures that each system element, system and the system-of-interest of the system structure has been implemented or integrated correctly from the perspective of fulfilling its technical requirements.

This verification should be performed in accordance with a verification plan. Verification can be dependent on the form of the system, on the decisions made regarding life cycle stage entry and exit criteria, as well as the specific life cycle stage. Example methods of verification are listed below.

a) Inspection (for example inspection of drawings).

b) Analysis (for example using mathematical modelling, simulation, a virtual reality prototype or similarity. An example of similarity is using already performed verifications of similar systems with similar configuration descriptions or systems that have already been certified to a standard).

c) Demonstration (for example using mock-ups, physical models or operation. An example of operation is the verification of configuration descriptions that apply to life cycle costs or system attributes such as MTBF).

d) Test (for example using physical products, prototypes, breadboards or brassboards).

The system implemented or integrated should be used for performing verification. During early stages of a system life cycle, inspection, analysis, demonstration or similarity could be used for verification. For later stages, operation or testing could be used. For non-critical requirements, however, use of inspection, analysis (including simulations), and demonstration during any life cycle stage for verification can be useful to save cost.

Generally, verifications are conducted under controlled conditions to ensure that each configuration description requirement is satisfied by the system. As such, actual operational environments and use of operators is not a factor. If the operational environment is a factor for a specific performance requirement then it should be included in any modelling, simulation or other form of verification.

Verification failure can result from poor conduct of the verification or improper implementation or integration of the system. Anomalies that are discovered during verification of the system (or system element or system-of-interest) need to be appropriately resolved prior to the transition of the system to the acquirer and before performing validation.

5.4.3.3.5 Transition Process

The Transition Process can be used to deliver to the acquirer a fully integrated and verified system. The delivered system can also be validated if the agreement requires validation to be accomplished by the supplier before transition. Appropriate transition should be performed for each system element, system and the system-of-interest from the bottom of the system structure to the top.

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Considerations for transition should include, as appropriate, packaging and handling, storage, transportation, installation and ensuring that each site is properly prepared for the installation or receipt of the system. Transition activities will be dependent on the life cycle stage and the position of the system within the system structure.

5.4.3.3.6 Validation Process

The Validation Process can be used to establish correspondence between the performance and characteristics of the system with respect to stakeholder requirements and other agreement requirements. Validation should ensure that the 'right' system has been implemented or integrated to fulfil stakeholder requirements or expectations. The set of stakeholder requirements used for validation are output from the Stakeholder Requirements Definition Process. The system implemented, integrated and verified should be used for performing validation in either its actual operational environment (considering other interfacing system elements or systems-of-interest) or its simulated operational environment. The environment of validation is dependent on the position of the system in the system structure. The form of the system will be dependent on the life cycle stage in which validation is performed.

Validation should be conducted to demonstrate that the 'right' system has been implemented or integrated after the same system has been verified using the Verification Process. The system should be verified that it was implemented or integrated correctly before showing that it is the 'right' system.

Validation can be done with simulation or mathematical modelling, with a technology prototype, with a pre-production prototype or with a delivered or installed system, as appropriate to satisfy the entry or exit criteria of the applicable system life cycle stage and the agreement. The validation should be performed using anticipated operators or users when possible and appropriate.

Validation can be completed either prior to transition to the acquirer or after transition as specified in the agreement. If validation of the system (“as modelled,” “as-built” or “as-integrated” and “as-verified”) is performed before transition, then the supplier normally does this. Otherwise, the acquirer validates the “as-delivered” system prior to the integration with other acquired lower level systems and system elements applicable to the system being integrated. The Validation Process can be performed using a mathematical or simulation model when cost of validation is a factor or where operational environments are not readily accessible.

There are several approaches such as listed below for performing the Validation Process.

a) Validation against acquirer and applicable interested party requirements using the same methods as used for verification, i.e. analysis (including simulation or mathematical modelling), inspection, demonstration, and/or test.

b) Certification tests against established requirements.

c) Acceptance tests using operational processes and personnel in an operational environment.

d) As specified in the agreement.

The approach used is dependent on the system life cycle stage in which validation is conducted as well as cost, schedule, level of the system within the system structure and available resources.

Validation failure can result from poor conduct of the validation or improperly transforming the stakeholder requirements into the preferred architectural design solution. Anomalies discovered during validation should be appropriately resolved prior to transition of the system (or system element or system-of-interest) to the acquirer (if validation is done by the supplier) or prior to integration with other systems or system elements into a higher-level system (if validation is done by the acquirer after receiving it from the supplier).

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5.4.3.4 Related technical processes for system utilization

5.4.3.4.1 General

The Operation Process, Maintenance Process and Disposal Process should be applied to utilize the system throughout and to the end of the remainder of its life cycle and are not considered to be part of system definition (clause 5.4.3.2) or system realization (clause 5.4.3.3). The Operation Process and Maintenance Process should be used to allow the stakeholders to achieve the service and/or product benefits sought from the system, at the level desired and over the extent of time intended, when they initially defined their stakeholder requirements. The Disposal Process should be used to ensure that the system is removed from service and, if appropriate, physically disposed of in a manner that ensures that no safety, environmental, operational or other hazards are created.

5.4.3.4.2 Operation Process

The Operation Process can be used whenever the system realization is sufficiently advanced for the system to provide outputs desired by the stakeholders, even if this is at a level significantly below full intended capability. It is increasingly common for systems to mature and evolve in some modular or stepwise fashion starting from a more modest core capability. Starting at a less mature point can allow the stakeholder to realize a beneficial return on their investment earlier than would otherwise occur. At the same time, early use of the Operation Process allows learning on the part of the operators, those who receive the functional benefits of the system (which may be different than the operators of the system), and those who support the system under the Maintenance Process. This opportunity for learning and refinement of the requirements for the final system can be formalized under an incremental build concept.

The Operation Process can be applied for much longer spans of time, and in different environments, than any of the product definition or realization processes were. Failure of the Operation Process, hence failure to obtain the intended benefits of the system over its lifetime, can occur if all parts of the Operations Process are not reviewed and addressed throughout the operating life of the system and similarly when changes occur to the system, whether large or small, rapidly or slowly.

5.4.3.4.3 Maintenance Process

The Maintenance Process can be used even before a system is formally considered operational. There can be overlap between the system realization processes and the Maintenance Process that can benefit both the developers and the maintainers. The quality of the documentation and training, as well as the adequacy of logistics arrangements, can be tested in this manner.

Like the Operation Process, the Maintenance Process can be applied for much longer spans of time, and in different environments, than any of the product definition or realization processes were. Corresponding failure of the Maintenance Process, hence failure to obtain the intended benefits of the system over its lifetime, can occur if all parts of the Maintenance Process are not reviewed and addressed throughout the operating life of the system and similarly when changes occur to the system, whether large or small, rapidly or slowly. Further, the long term success of the Maintenance Process also depends on ensuring that it stays aligned with changes in the operation of the system, with corresponding need to understand the changes occurring in the Operation Process.

5.4.3.4.4 Disposal Process

The disposal process can be used while a system is still operational and can be applied to part of a system as well as to the entire system. In the case of incremental development of capability, it is not uncommon to need part of a system to be disposed of. The disposal strategy can become complex in such cases and the strategy aspect should be considered carefully.

On the other hand, it is also not uncommon for only part of the disposal process to be applied. For example, an obsolete part of a system may be removed from operational use, but still be left intact and able to perform if need be, such as in an emergency or as a platform to test capabilities for yet further evolution of a system.

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While the Disposal Process always needs to be developed and executed in synchronization with operation and maintenance of the system, it is particularly important in these complex cases.

The Disposal Process should pay close attention to archiving information related to disposal, and ensuring that all required certifications are obtained and held available. This may be necessary over an indefinitely extended span of time.

EXAMPLE 1 A part of the system infrastructure can require a special disposal method to protect the ecology.

EXAMPLE 2 A storage device can require a special disposal method to protect the data in it.

5.4.3.5 Enabling system definition and realization

Enabling systems apply to all parts of the life cycle and potentially support any process. For each architectural design solution in the system structure the enabling system requirements related to the system 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 assure that required enabling system services are available when needed to support the system-of-interest in the system structure during the applicable life cycle stage.

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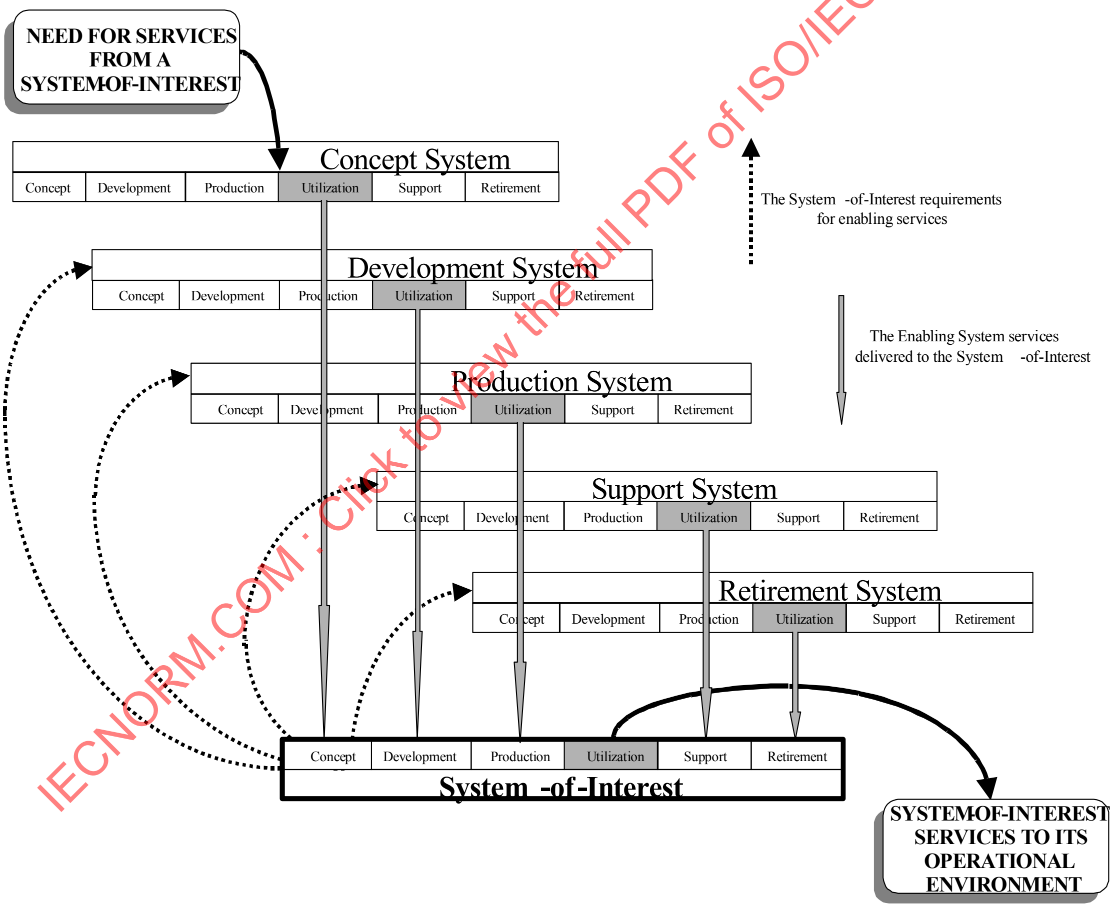

Figure 16 — Enabling systems realization

The following discusses an example of the application of Figure 16 to the availability of equipment and tools needed for implementation of a system element or for integration of lower-level system elements or systems. If such equipment and tools already exists, the processes of Figure 15 do not need to be used. Instead the existing enabling systems should be acquired or scheduled as appropriate. If, however, the equipment or tools need to be developed, then the processes of Figure 15 should be used in the way described in Clauses

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5.5.5.2 and 5.5.5.3. The acquirer requirements for each enabling system come from the requirements identified during the application of the Stakeholder Requirements Definition Process, Requirements Analysis Process and Architecture Design Process to the system that is to be implemented. Such requirements would include allowable tolerances, 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. Figure 16 suggests that an enabling system defined as a system-of-interest and realized using the processes of Figure 15 should also have its own set of enabling systems to provide appropriate life cycle support.

5.4.4 Application of processes in a life cycle model

5.4.4.1 Overview

ISO/IEC 15288:2008 requires the establishment of a life cycle model to provide a framework in which the processes of the International Standard are performed [See Clause 6.2.1.2 c)]. It also requires the definition of purpose and outcomes for each stage in the established life cycle model. ISO/IEC TR 24748-1 provides in Clause 4 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 17 as a reference for two related views of the system life cycle – the organization view and the engineering view.

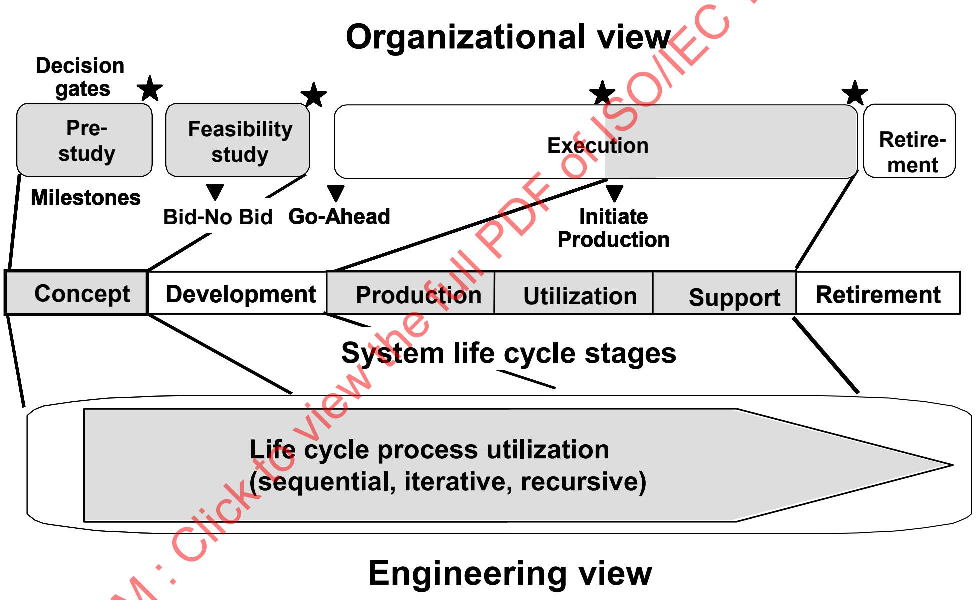

Figure 17 — Organization and engineering views related to representative system life cycle model

The system life cycle model illustrated in Figure 17 does not imply any application precedence or sequence for the application of ISO/IEC 15288:2008 life cycle processes. The order of 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 the 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 manager is guided by the purpose and outcomes for each of the stages (see Clause 4 of ISO/IEC TR 24748-1). 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 17 can be considered as an illustration of an orderly passage associated with a system

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going from one stage of life to another. Both the organization and engineering views of Figure 17 can be helpful in enabling this passage.

An organization (for example an automobile company or medical equipment supplier) or a domain group of an organization (for example 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. The organization view illustrated includes 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 be continued to the next system life cycle stage or be modified, be cancelled or retired or have the plans for the next stage revised before approval. 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 utilized.

The organization view of Figure 17 provides an example framework in which different approaches can be used to meet organization goals and objectives. The framework and example approaches for the organization view are described in Clause 5.5.6.2 below.

In order to meet the exit criteria of a decision gate, a system has to be appropriately engineered and the appropriate work products need to be produced to provide decision-making information and required deliverables. Thus planned engineering activities need to take place during each system life cycle stage to obtain the outcomes and meet the purpose of the stage or a set of stages. The engineering view of Figure 17 provides an example framework of engineering activities required to meet the criteria of management decision gates and related system life cycle model milestones. This engineering view is described in Clause 5.5.6.3 of this Technical Report.

5.4.4.2 Organizational view

5.4.4.2.1 Approaches

The organizational view of Figure 17 can vary according to the nature, purpose, use and prevailing circumstance of the system-of-interest or the business of the organization. Nevertheless, despite a necessary and apparently limitless variety in such views, there is an underlying notional set of characteristic milestone 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. Milestones provide an interim opportunity for management to review progress between or before decision gates. Examples of milestones are provided in the paragraphs below. The decision gates provide a framework within which organization management has high-level visibility and control of the project.

During early system life cycle stages, management can use established decision gates to determine whether the objectives (financial as well as technical) of the system life stages were satisfactorily completed and whether the system is ready to progress to the next stage. During later life cycle stages while the system is being used (utilization and support), the decision gate is typically used to make three kinds of decision as listed below:

a) whether system technology should be refreshed (change to the baseline configuration without changing performance);

b) whether new system technology should be inserted (change to system performance);

c) whether the system should be appropriately retired.

The concept stage of a system life cycle model has two major decision gates. The first decision gate is after a period of pre-study. Prior to this decision gate appropriate research and development is carried out, technology challenges and opportunities are explored and potential system concepts are analysed. Those concepts that have promise for future business opportunities are presented to management for approval to continue the development of the more promising concepts. The concepts can be needed to develop a new market, to respond to a specific threat or to respond to a request for proposal.

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After studying the feasibility of the alternative concepts a second decision gate is used. Determinations such as listed below should be made before a decision is made to initiate the execute stage of the organization view:

a) whether a concept is feasible and is considered able to counter an identified threat or exploit an opportunity;

b) whether a concept is sufficiently mature to warrant continued development of a new product or line of products;

c) whether to approve a proposal generated to respond to a request for proposal.

For organizations that are responding to a request for proposal, there is an important feasibility stage milestone. This milestone is used to determine whether or not to make a bid based on the initial results of a feasibility study.

The organization view illustrated in Figure 17 includes activities related to four stages of the system life cycle – development, production, utilization and support. Typically there are two decision gates and two milestones associated with execution activities of the management view. The first milestone provides the opportunity for management to review the plans for execution before giving approval to proceed. The second milestone provides the opportunity to review progress before the decision is made to initiate production. The decision gates during execution can be used to determine whether to produce the developed system-of-interest and whether to improve it or retire it.

This organization view applies not only to the system-of-interest but also to its systems and system elements that make up the system structure. 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 system-of-interest in which they are embedded, so these individual systems or system elements could need to be replaced with improved ones during the life of the system-of-interest.

Organizations employ the execution activities of the organization view of Figure 17 differently to satisfy contrasting business and risk resolution strategies. Sequential, incremental or evolutionary approaches are frequently used. These approaches are discussed in the clauses below. 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 those listed below:

a) the acquisition policy of the organization;

b) the nature and complexity of the system;

c) the stability of system requirements;

d) technological opportunities;

e) the need for different system capabilities at different times;

f) the availability of resources.

5.4.4.2.2 Sequential approach

5.4.4.2.2.1 General

For systems that have development cycles of five or more years 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 face many challenges including cost control, funding changes, technology changes, workforce retention, and final customer or acquirer requirements satisfaction. These challenges are

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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 is illustrated by the organization view of Figure 17 and has defined decision gates so that an organization can manage an orderly progression of the system from conception through retirement. For systems that rely heavily on off-the-shelf system elements, development is often directed to start in the execution phase of Figure 17 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 alleviate doing the engineering required to ensure system feasibility or doing the risk reduction analyses and effectiveness assessments needed to ensure that interfaces are compatible and that the system elements are expected to be compatible and interoperable so as to meet functional requirements. What this off-the-shelf approach does is to reduce the need to go through earlier decision gates, not eliminate the analysis necessary to reduce risks of this approach.

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

5.4.4.2.2.2 Applicable systems

This approach is valid for 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 could continue into the utilization and support stages. The utilization and support stages are typically the longest period of this life cycle and could last for many years. Major systems realized 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 is also applicable 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 system-of-interest does need to be analysed and where conflicts are revealed, the changes to higher-level systems and the system-of-interest need to be made or the requirements for the applicable system need to be revised.

5.4.4.2.2.3 Risks

Because of the long duration of development using the sequential approach, several risks such as those listed below should be considered and resolved before adoption.

a) Expectations and requirements related to the system could change over the years of development.

b) Knowledgeable workers on teams could turn over.

c) Decision making personnel in the organization could change.

d) Customer personnel in the acquirer's organization could change.

e) Suppliers of system elements and related services could go out of business or change technologies.

f) Technical risks could be present.

g) Technical obsolescence could arise during a long development.

5.4.4.2.2.4 Opportunities

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

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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 are 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.

5.4.4.2.3 Incremental approach

5.4.4.2.3.1 General

The incremental approach applies to organizations that market new versions of a product at regular or preplanned intervals. An organization view not unlike the view of Figure 17 is used. However, milestones are established at planned intervals to introduce a planned version of the system that can be released to the market. The system realized as a result of the concept stage can be a first version.

Typically 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 15288:2008 life cycle processes as illustrated in Figure 13, Figure 15 and Figure 16 is performed to realize 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 could be made to incorporate the new capabilities of a later version.

5.4.4.2.3.2 Applicable systems

This approach applies mainly 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.

5.4.4.2.3.3 Risks

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

a) Initial versions of the system could have such a limited set of capabilities that customers could be dissatisfied and not be interested in buying the next version.

b) Versions marketed with too short an interval could 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 could be unacceptable.

d) Expectations may not be met if customers desire the full capabilities in the first version.

e) Poor results may be realized if requirements are not as well understood as originally thought.

f) Unplanned technology changes or competitor system capabilities could require re-direction of the development and have a significant impact upon costs and schedule for subsequent versions.

g) The customer may change the requirements as the development progresses.

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5.4.4.2.3.4 Opportunities

The opportunities such as listed below can be associated with the incremental approach.

a) Acquirer requirements for early capabilities could be satisfied.

b) The prototypes developed for each early milestone could have a place in the market.

c) Early introduction of the system, even with limited capabilities, could enable exploitation of the marketplace by beating the competition to market.

5.4.4.2.4 Evolutionary approach

5.4.4.2.4.1 General

The evolutionary approach also applies to organizations that market new versions of a product at regular or preplanned intervals. The major difference of this approach with the incremental approach is that the full capabilities of the last version of the system are not known when an evolutionary development is undertaken.

Initially the requirements for the system are partially defined and then refined with each successive version of the system as lessons learned from the use of an early version are translated into new desired capabilities.

ISO/IEC 15288:2008 life cycle processes as illustrated in Figure 13, Figure 15 and Figure 17 are applied to realize each version. In this case, development of new versions could be done serially or in parallel with partial overlapping. As with versions developed using the incremental approach, different versions can be operated and supported in parallel. Particular care should be taken, however, to maintain configuration control of each version so that operation, training and support procedures are appropriate to the version being used.

Often, a new version with enhanced capabilities could replace an earlier version, or a block modification can be made to the earlier version to incorporate the new capabilities of a later version.

5.4.4.2.4.2 Applicable systems

This approach applies mainly to complex systems for which requirements are not well understood even though the need for the system is understood and approved. These are typically one of a kind or low quantity production systems. Example systems can include custom information technology systems, military information technology systems and specific information technology security systems. This approach is also useful for systems that have to achieve quality in use.

5.4.4.2.4.3 Risks

The evolutionary approach has associated risks such as listed below that should be considered and resolved before adopting this approach.

a) Full capabilities could be preferred at the same time.

b) Training costs could be unacceptable for moving to the next version.

c) There could be uncertainties related to determining future requirements.

d) There could be uncertainties with respect to planning the schedule release of the next version.

e) Configuration control could be a problem.

f) Inappropriate early use of a product prototype in production.

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5.4.4.2.4.4 Opportunities

The opportunities such as listed below can be associated with the evolutionary approach.

a) Acquirer requirements for an early capability can be satisfied.

b) Customer feedback could be used to enhance the capabilities of a future version of the system.

c) The prototypes developed to satisfy an early milestone could have a use in the market.

d) Early introduction of a limited capability system could enable countering a competitor threat.

e) Take advantage of emerging technologies.

5.4.4.3 Engineering view

5.4.4.3.1 General

Engineering is involved with a system in the early life cycle stages (concept and development) when it is being studied, defined and created. Additional engineering is involved in later stages (production, utilization, support, retirement) when unwanted and unexpected variations come about due to design errors or failures or new requirements are provided because of technology, competition, or threat changes.

To engineer a feasible system solution during the concept stage, a system structure needs to be sufficiently defined and evaluated. This should be done to assure that system requirements are met and that the costs and risks are understood for the feasible system concept selected. When a parts list is an exit criterion (for example required as part of a proposal or in order to prepare a creditable cost proposal), sufficiently detailed engineering should be done to ensure that the parts list is complete and that the costs and risks are understood.

To engineer a system solution during the development stage a system needs to be designed with appropriate detail from the system-of-interest level down through successive system levels until a system element can be made, bought, reused or implemented. Each system should be verified that it meets its specification requirements included in configuration descriptions from architectural design, and validated that it meets the acquirer and other interested party requirements. Each system element needs to be transitioned to the acquirer where it can be assembled and integrated into a higher-level system that is verified, transitioned and validated. This action continues through successive levels upward to realize the desired system-of-interest.

This approach whether applied to the concept stage or the development stage is typically called top down and bottom up engineering and describes one block of the engineering activities illustrated in the engineering view of Figure 18. The top down, bottom up approach is illustrated in Figure 18 and is identified in technical literature as the "Vee" diagram or model. This figure reflects the work products and actions expected from the recursive application of the processes in Figure 15 to define and realize the system structure.

Although the engineering "Vee" model of Figure 18 only shows four levels, the Stakeholder Requirements Definition Process, Requirements Analysis Process and Architecture Design Process should be applied to the system-of-interest, systems and system elements of a system structure, and the example work products (specifications and verification and validation plans) should be developed for each level of the system structure as illustrated in Figure 15.

The box at the bottom of the "Vee" in Figure 18 represents application of the Implementation Process at any level of the system structure. The result is an implemented system element that can be a mathematical model or physical prototype or the physical product to be transitioned to the acquirer. The actual product is dependent on the system life cycle stage and organization view exit criteria for a decision gate or milestone.

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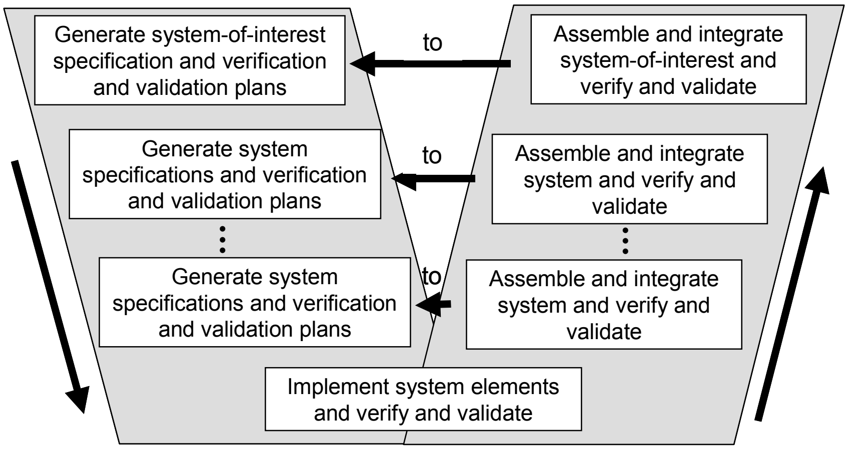

Figure 18 — The engineering “Vee” model

The right side of the “Vee” in Figure 18 illustrates the application of the Integration Process, Verification Process, Transition Process and Validation Process to form higher-level systems. These processes are applied recursively at each level to each system element, each system and finally the system-of-interest. This illustrates that each system, including the system-of-interest, in the system structure should be integrated and verified and validated against the configuration descriptions and other descriptive documents of the corresponding system on the left.

Engineering efforts to correct variations or failures and to meet changed requirements are typically initiated at a system level within the system structure and below the level of the system-of-interest. The same general engineering approach using the “Vee” model is appropriate. In this case, however, the system affected is the place in the system structure where the re-engineering effort begins. The requirements for the change are analyzed as to how they could affect interfacing and interacting systems and the performance of the system-of-interest. Then the Stakeholder Requirements Definition Process, Requirements Analysis Process and Architectural Design Process are used downward through successive levels of system structure to define architectural solutions. After the system elements are implemented using the Implementation Process, the Integration Process, Verification Process, Transition Process and Validation Process can be used upward through successive levels to the system-of-interest. This approach is often called middle-out engineering.

The engineering "Vee" model is used in each system life cycle stages as appropriate to meet stage entry or exit criteria or to meet the organization view milestone or decision gate requirements. Such use is illustrated in Figure 19 by replacing the "engineering activities" identified blocks shown in Figure 17 with the engineering "Vee" model of Figure 18. There are points along the system life cycle when all functions have been defined and can be captured in a configuration managed set of documents, which are often called a functional baseline. A similar point occurs when all functions have been allocated to hardware, software, processes, procedures, facilities, humans, or naturally occurring entities and an analogous allocated baseline can be created. While other such baselines can be established, commonly only a third one is formed when the first production instantiation of a system has been made. This is called a product baseline, where product can refer equally to a service, following the definition of a system in International Standard ISO/IEC 15288:2008.

Representative outputs are provided for each application of the “Vee.” These products are used to satisfy the requirements for the applicable milestone or decision gate of the organization view (see Figure 17).

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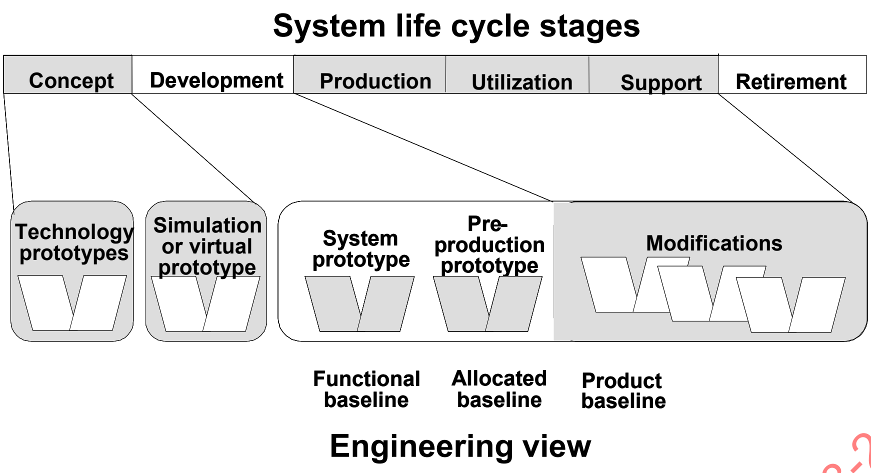

Figure 19 — Engineering view with engineering "Vee" models

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5.4.4.3.2 Technical reviews

Technical reviews such as listed below should be conducted for each project as appropriate to the engineering view used.

a) A review held prior to performing the Requirements Analysis Process to ensure that the stakeholder requirements are complete, consistent with the acquirer's intent, understood by the supplier and have been validated. This review can prevent proceeding with a less than acceptable set of requirements.

b) A review conducted to consider all concepts looked at and to determine whether the preferred concept has the potential of satisfying defined stakeholder requirements and is based on a set of viable, traceable technical requirements that are balanced with respect to cost, schedule and risk.

c) An evaluation of the established requirements baseline to ensure that the set of technical requirements are balanced with respect to cost, schedule and risk.

d) An evaluation of the established functional baseline to ensure that the system definition is based on achievement of technical requirements. It also could be used to ensure readiness to proceed with the preliminary design of each system of the system structure.

e) A review conducted for the preliminary design of each system of the system structure to confirm that:

   1) the specifications and other configuration descriptions are defined appropriately;

   2) the design solution is consistent with its acquirer's requirements;

   3) enabling system requirements are sufficiently defined to initiate enabling system developments, as required, or to acquire the applicable enabling systems;

   4) approaches planned for developing designs for pre-production prototypes are appropriately planned;

   5) risks are identified and resolution plans are feasible and judged to be effective.

f) A review conducted for the detailed design of each system of the system structure to demonstrate that:

   1) specifications and drawings are appropriately defined to realize the design solution through implementation or integration, as appropriate;

   2) the design solution is consistent with its acquirer requirements;

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3) enabling system requirements to provide life cycle support have been adequately defined to initiate enabling system development or acquisition, as appropriate.

g) Reviews conducted prior to each scheduled series of tests on an implemented or integrated test system to ensure test readiness by confirming that all test related enabling systems are in place and the test environment is prepared to accomplish test objectives.

h) Reviews conducted prior to releasing each design solution for first system or batch production to ensure production readiness by confirming that production enabling systems and materials are in place and the production environment is prepared to accomplish production objectives.

After completion of the detailed design of each system in the system structure that is based on the allocated baseline, and with proof that the production system is ready and other enabling systems are ready or are expected to be available when needed, the system can be released for production. The system produced can be a one of a kind, the first of a limited version or the first of many that will be produced.

5.4.4.3.3 Configuration audits

Two types of configuration audits can be performed – functional audit and physical audit. These two audits are described below.

a) A functional audit is used to demonstrate that system verification results compare favourably with the specifications against which verification was performed and that planned verification procedures were followed. This audit is also used to confirm that verification results compare favourably against configuration documentation such as drawings, authorized changes and “as-built” or “as-coded” records.

   A pre-production prototype or the first system produced is typically used for verification. This audit should be typically completed before release of the system for initial production.

b) A physical audit is performed to examine the “as-built” or “as-coded” system against its configuration documentation such as drawings, bill of materials, specifications, code lists, manuals, verification procedures and acceptance data. The “as-built” or “as-coded” system examined should be one or more of the first set of systems produced during the initial production. Selection of the systems to be used in the audit should be done at random by the auditors. The purposes of the physical audit are given below:

   1) to confirm that the system has been realized correctly in accordance with its drawings or specifications;

   2) to confirm that the information database represents the essential set of work products or artefacts from the engineering effort;

   3) to confirm that required changes to previously completed specifications have been included;

   4) to confirm that enabling systems for future system life cycle stages will be available, can be executed and meet stakeholder requirements;

   5) to provide the basis for approval of further production of the system, if applicable.

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Annex A
(informative)

Notes for application of ISO/IEC 15288:2008 processes

A.1 General

This annex provides users of ISO/IEC 15288:2008 with additional help for selection and use of selected International Standard processes. This help is based on notes that could affect process selection and application.

Two essential elements of each process in ISO/IEC 15288:2008 are the purpose and set of outcomes. The purpose statement provides the overall rationale for the use of the process. The outcomes are the expected observable results from carrying out the activities of a process. The outcomes provided for each process in ISO/IEC 15288:2008 provide a benefit that motivates selection and execution of that process. The notes below are intended to help in the application of process activities and tasks to realize the outcomes. Cross-reference with one or more clauses from ISO/IEC 15288:2008 are provided to aid use.

The NOTES embedded within the clauses of ISO/IEC 15288 are informative guidance material only and do not constitute requirements of ISO/IEC 15288:2008. The NOTES in ISO/IEC 15288 are intended to clarify the intent of the activity to which they are associated and have the same status as those included in this annex.

A.2 Agreement processes notes (Clause 6.1)

Table A.1 — Acquisition Process (Clause 6.1.1)

NOTES	ISO/IEC15288 CLAUSE
a) In order to properly accomplish the Acquisition Process activities and tasks, applicable Organizational Project-Enabling, Project and Technical processes should be implemented, as appropriate.	6.1.1.3 6.2, 6.3, 6.4
b) Typically in any acquisition situation there are several approaches or ways of doing something. An approach or way that best achieves the overall acquisition goals and constraints is desired. Considerations to include are: 1) After market opportunities. 2) Business unit policies. 3) Organization environment. 4) Financial resource availability. 5) Human factors. 6) Improvement strategy. 7) Integration and interoperability. 8) Logistics (supportability).	6.1.1.3 a) 1)

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NOTES	ISO/IEC15288 CLAUSE
9) Obsolescence. 10) Operational environment (pollution, disposal). 11) Producibility. 12) Safety. 13) Security. 14) Competition. 15) Stakeholder goals. 16) Survivability. 17) Time-to-market constraints. 18) Potential risks for acquisition and supply.	
c) An acquisition plan is prepared using the Project Planning Process.	6.1.1.3.a) 6.3.1
d) Typical solicitation documents include: acquisition request (for example request for proposal, request for bid, request for information, request for quote), memorandum of intent, offer or directive.	6.1.1.3.b)
e) Whenever possible for a formal contract situation involving outside suppliers the potential suppliers need to be involved in the definition of the acquisition request document to provide an optimum match of stakeholder needs with system requirements.	6.1.1.3 c)
f) The level of formality of the monitoring should be clearly established at a level appropriate to the scope and context of the agreement, including mutual responsibilities, frequency and mode of monitoring and ways of gauging acceptable execution of the agreement.	6.1.1.3 d)
g) Establish who is authorized to accept each distinguished product or service and on what basis, including applicable Verification and Validation processes	6.1.1.3 e) 6.4.6, 6.4.8

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Table A.2 — Supply Process (Clause 6.1.2)

NOTES	ISO/IEC15288 CLAUSE
a) In order to properly accomplish the Supply Process activities and tasks, applicable Organizational Project-Enabling, Project and Technical processes should be implemented, as appropriate.	6.1.2.3 6.2, 6.3, 6.4
b) A solicitation is typically from an internal or external business unit (it can be internal to the project). The solicitation does not need to be formal.	6.1.2.3 a)

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c)	Alternatively, business units conduct market research in order to establish the opportunities available within a particular business sector.	6.1.2.3 a)
d)	A supply plan is prepared using the Project Planning Process.	6.3.1
e)	Typically in any supply situation there are several approaches or ways of doing something. An approach or way that best achieves the overall organizational and supply goals and constraints is desired. Considerations to include are: 1) Applicable legislation and regulations that apply to the supplier. 2) Business unit goals. 3) Competition. 4) Organization environment and policies and procedures. 5) Resource availability. 6) Related management, technical and resource risks.	6.1.2.3 b)
f)	Whenever possible for a formal contract situation involving a primary and supporting suppliers the potential supporting suppliers need to be involved in the definition of the tender response and supply agreement negotiation, directly, indirectly, or both, to provide an optimum match of capabilities with system requirements.	6.1.2.3 b) and c)
g)	The level of formality of the monitoring should be clearly established at a level appropriate to the scope and context of the supply agreement, including mutual responsibilities, frequency and mode of monitoring and ways of gauging acceptable execution of the agreement.	6.1.2.3 d)
h)	Establish who is authorized to accept the supplied each distinguished product or service and on what basis, including applicable Verification and Validation processes	6.1.2.3 e)

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A.3 Organizational project-enabling processes notes (Clause 6.2)

Table A.3 — Life Cycle Model Management Process (Clause 6.2.1)

	NOTES	ISO/IEC15288 CLAUSE
a)	In selecting processes for application within a system life cycle stage some of the processes of ISO/IEC 15288:2008 may not be applicable for an organization. In this case, such processes are expected to be not included in organizational standards, policies and procedures or other directive media. In cases where the organization desires that certain activities of a process be part of directive materials, these selected activities can be included as part of the definition of other processes or an entire process could be subordinated to an activity level under another process.	6.2.1.3 a) 6.2.1.3 b)
b)	New project processes can be formed or an activity under one of the system life cycle processes can be elevated to the process level.	6.2.1.3 a) 6.2.1.3 b)

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NOTES	ISO/IEC15288 CLAUSE
c) Standardization of life cycle processes within a business unit can vary. However, organizations typically encourage all projects and functional business units to use common practices and standards where it is advantageous to do so.	6.2.1.3 b)
d) Definition of standardized processes includes related methods and tools to be implemented in projects in accordance with organizational policies and procedures and investment decisions.	6.2.1.3 b) 6.2.1.3 c)
e) Appropriate disaster recovery procedures are typically established for all organizational project-enabling processes and databases.	6.2.1.3 b)

Table A.4 — Infrastructure Management Process (Clause 6.2.2)

NOTES	ISO/IEC15288 CLAUSE
a) Typically infrastructure is established based on: organizational strategic plan, capabilities, resources, risk levels, value to the customer, and technology policies. For a business, payoff goals, market segment, market position, investment and competitive advantage are also factors.	6.2.2.3 a)
b) It is critical to establish, use and continually refine metrics that show how well the infrastructure is supporting the needs of the organization in executing its mission, using resources that have demonstrated expertise in this area.	6.2.2.3 b)

Table A.5 — Project Portfolio Management Process (Clause 6.2.3)

NOTES	ISO/IEC15288 CLAUSE
a) The Project Portfolio Management Process sets the environments for organizations in which multiple ongoing projects are accomplished to include applicable strategic and tactical plans, system life cycle models, and policies, procedures and standards. In addition the process establishes constraints for technologies, product lines, and project management aids and provides communication paths with which projects interact with each other and the organization.	6.2.3 6.2.3 a)
b) Policies and procedures that support and direct projects that perform the services and produce the organizational products, services, or both, should be evaluated on a regular basis. Changes to policies and procedures are evaluated to ensure that continuous improvement of organizational maturity for satisfying its strategic and tactical objectives is realized.	6.2.3 b)
c) The integrity level for different systems produced by projects can require separate sets of policies and procedures.	6.2.3 b)
d) Appropriate management aids are typically established to enable availability of valid information for directing and enabling projects including project status, standardized automated tools, organizational products available for reuse, and the status of emerging technologies and related market opportunities and threats and the information databases in which captured data and documents are warehoused.	6.2.3 a) 6.2.3 b)

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NOTES	ISO/IEC15288 CLAUSE
e) It is critical to establish, use and continually refine metrics that show how well projects, individually and in the aggregate, are achieving their objectives and those of the organization, using resources that have demonstrated expertise in this area.	6.2.3 b) 6.2.3 c)

Table A.6 — Human Resource Management Process (Clause 6.2.4)

NOTES	ISO/IEC15288 CLAUSE
a) This organization process includes establishment of human resource services that enable organizations to achieve their goals and objectives within legal, financial and other constraints and agreement requirements.	6.2.4
b) Human resource services include, but should not be limited to: 1) Resource acquisition. 2) Skill assessment. 3) Skill development. 4) Skill measurement. 5) Effective skill deployment to organizational needs. 6) Direct and indirect compensation. 7) Knowledge capture, storage and re-deployment.	6.2.4 a) 6.2.4 b) 6.2.4 c) 6.2.4 d)
c) The infrastructure and skill mix of personnel in projects, individually and in the aggregate, ought to be reviewed for consistency with organizational strategic and tactical objectives.	6.2.4 a) 6.2.4 b) 6.2.4 c)

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Table A.7 — Quality Management Process (Clause 6.2.5)

NOTES	ISO/IEC15288 CLAUSE
a) This process is consistent with establishment of quality management approaches that lead to conformance with ISO 9001.	6.2.5
b) This process provides a sufficient level of confidence that system and service quality attributes for each project are adequately defined and activities are effectively and efficiently managed so that customer requirements are met and other parties interested in organizational success are satisfied.	6.2.5 a) 6.2.5 b)

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A.4 Project processes notes (Clause 6.3)

Table A.8 — Project Planning Process (Clause 6.3.1)

NOTES		ISO/IEC15288 CLAUSE
a)	The Project Planning Process defines the necessary plans to support other processes. For example, to 1) arrive at an investment decision, 2) prepare a responsive response to a solicitation, 3) determine whether to proceed or continue work to satisfy the requirements of a specific organizational model stage entry/exit criteria, 4) guide the work required to meet the requirements of an established agreement or 5) re-plan the work.	1) 6.2.3.3 a) 2) 6.1.2.3 b) 2) and 6.3.1.3 b) 6) 3) 6.2.3.3 c) 4) 6.3.1.3 b) and c) 5) 6.3.1.3 a) 1) and b) 2)
b)	Plans are constrained by organizational goals and objectives and stakeholder needs.	6.3.1.3 a)
c)	Plans include the scope, tasks, methods, tools, measures, risks and resources for applicable system or system element implementation, integration, verification, transition and validation processes, so that each contingency option can be efficiently and effectively used.	6.3.1.3
d)	Re-planning is typically initiated 1) when required by an agreement, 2) when significant variations or anomalies are identified from other process outcomes or 3) before implementation of the next engineering view or organization view stage related to the system life cycle model selected by the organization	6.3.1.3 a) 6.3.2
e)	Contingency options are used in a plan when there are known risks or opportunities (for example significant changes in budget, schedule, requirements or technology, or resource availability) that can cause the project or work effort to be redirected.	6.3.1.3 a) 1)
f)	Plans should be tailored as to the level and formality to suit project or work complexity, uncertainty and resources including funding.	6.3.1.3 a) and b)
g)	A work breakdown structure (WBS) of the system structure and applicable non-system-structure-specific related project process activities is typically established. Non-system-structure related project process activities include project planning, assessment and control, risk management, decision management, configuration management, information management and measurement.	6.3.1.3 a) 4) 6.3.2 6.3.3 6.3.4 6.3.5 6.3.6
h)	The initial WBS should be based on the system structure and the system life cycle processes. A WBS typically evolves to identify tasks and work packages associated with the specific system in parallel with the technical definition of the structure in which the system exists.	6.3.1.3 a) 4)
i)	The items 1) through 4) below should be helpful for determining project schedules, staffing requirements and resources requirements:	6.3.1.3 b)
	1) Key events required to meet technical requirements (for example technical review, production readiness review, verification, modification decision review).	6.3.1.3 b)

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NOTES	ISO/IEC15288 CLAUSE
2) Primary tasks related to accomplishing entry and exit criteria of each key event (for example define stakeholder requirements, prepare engineering drawings, complete technical or management review package, conduct test).	6.3.1.3 b)
3) Support tasks that enable the staff accomplishing primary tasks to meet their objectives [for example 1) acquire resources, equipment and facilities, 2) acquire appropriately skilled personnel for accomplishing the primary tasks, and 3) arrange travel].	6.3.1.3 b)
4) Management tasks required to direct, monitor, review and approve the primary and support tasks (for example serve as chair of a technical review, review and approve documents for transmittal to the customer, attend management review, and decide whether to do a technology refreshment, technology insertion or retire the system).	6.3.1.3 c)
j) After approval by the appropriate authority the project schedules are considered a baseline subject to change control in accordance with organizational policies and procedures.	6.3.1.3 b) 1) and 2)
k) After approval by the appropriate authority the planned budget is typically considered a baseline subject to change control in accordance with business unit policies and procedures.	6.3.1.3 b) 3)
l) Plans can be individual documents in a collective document or captured in an electronic media for access by appropriate participants. A plan is an initial output of a process that enables the process to be efficiently and effectively accomplished. A plan should be made using appropriate Project Planning Process activities.	6.3.1.3 b) 6)
m) The engineering plan provides an explanation of what needs to done, how it will be done, who will do it, when it will be done and where it will be done; as well as how much of a resource is necessary to do the work for each technical process. The engineering plan explains the above within established constraints of resources and staff and in order to meet cost, schedule and performance requirements within acceptable risks.	6.3.1.3 c) 1)
n) An engineering plan is appropriate for each applicable organization view stage and for each project (for the engineering or re-engineering of a system) using the engineering "Vee" model.	6.3.1.3 c) 1)
o) The engineering plan is also known as the Systems Engineering Management Plan (SEMP) or Integrated Management Plan (IMP).	6.3.1.3 c) 1)
p) The list below should be used as a checklist to ensure inclusion and completion of essential and applicable information in an engineering plan. 1) The general problem to be solved. 2) The benefit to the acquirer (organizational perspective). 3) The application context of the general problem to be solved. 4) The boundary of the general problem to be solved, denoting what can be controlled by the developer (inside) and what influences the development and is influenced by the development but not controlled by the developer (outside).	6.3.1.3 c) 1)

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5) The required inputs and outputs including dependencies on enabling systems. 6) The influencing factors and constraints. 7) The system concerns with respect to reliability, availability, maintainability, security, safety, information quality, health factors, survivability, electromagnetic compatibility, radio frequency management and human factors. 8) Project processes, activities, and tasks that will be accomplished. 9) How each applicable technical process will be accomplished and how each process connects (inputs and outputs data flows and sequencing) with other technical, project, organization and agreement processes. 10) Resources, methods and tools planned to accomplish the activities and tasks of each applicable process. 11) How required resources and tools will be acquired and used. 12) The organizing structure to be used to ensure efficient and effective teamwork. 13) How the project will be staffed and managed. 14) Key measures for product quality and how satisfaction will be determined. 15) Key intermediate events and how such event completion will be determined. 16) When, where and by whom activities and events will be completed. 17) The technical risks involved and how risks will be managed. 18) Potential opportunities and how the opportunities will be identified and tracked. 19) The completion criteria for the process activities. 20) The entry and exit criteria for re-performing each process. 21) How completion will be determined.	

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Table A.9 — Project Assessment and Control Process (Clause 6.3.2)

NOTES	ISO/IEC15288 CLAUSE
a) Formalized methods for cost and schedule management exist. Examples include: 1) Design-to-cost (used to establish a cost requirement equivalent to other system performance requirements). 2) Event-based scheduling [used to establish events (for example milestones), significant activities and tasks related to an event, and the criteria by which completion of activities or tasks are determined].	6.3.2.3.a)

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NOTES	ISO/IEC15288 CLAUSE
3) Earned value (used to define the budgeted cost of the work performed and make comparison to the budgeted cost of the work scheduled and the actual costs of work performed to determine estimates at completion and cost and schedule variances).	
b) Appropriate analyses and assessments are conducted to: 1) Determine the continuing consistency and relevance of project plans (management and technical). 2) Determine project technical progress using defined technical metrics based on estimated achievement and milestone completion. 3) Determine effectiveness of the project team technical roles and structure using where possible objective measures such as technical achievement and efficiency of resource use. 4) Determine the adequacy of team member technical competencies and skills to satisfy technical roles and accomplish technical tasks. 5) Determine the effectiveness and value of supporting training. 6) Determine the adequacy and availability of the technical infrastructure and services at defined intervals to confirm that intra-organizational commitments are satisfied. 7) Determine the quality and progress of the design of system, materials used, and enabling system services. 8) Determine technical variances with project estimates and identify variances to cost, availability and performance specifications. 9) Evaluate the effectiveness of technical data gathering, processing and dissemination. 10) Determine technical variations between expected results and assessment results to detect trends and identify root causes. 11) Determine the quality of technical data gathered, the value of the information derived, its timeliness, completeness, validity, confidentiality (if required) and its benefit to recipients.	6.3.2.3 a)
c) The Project Assessment Process should be used to select, assess and collect system and process measures to provide information for support of project management. Specifically it includes determining: 1) Progress of the project. 2) Information for risk resolution. 3) Meaningful financial and non-financial performance. 4) Effectiveness and risk information for doing trade-off analyses and providing recommendations on actions to take and resulting impacts.	6.3.2.3 a)

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NOTES	ISO/IEC15288 CLAUSE
d) Use of the Project Assessment Process aids management decision making by providing information that results from monitoring and analysing project work to determine: 1) Progress and achievement against plans (work productivity) and against technical requirements (product quality). 2) Adherence to practices and procedures. 3) Readiness to proceed to the next stage of the organization view (through decision gates or milestone reviews) or to the next level of the system structure. 4) Effectiveness, risks and opportunities associated with alternatives available to decision makers. 5) Trade-off analyses results to include recommended course of action and impacts of each on cost, schedule, performance and risk.	6.3.2.3 a)
e) Product measures assess progress and achievement against system and other work product technical requirements.	6.3.2.3 a) 1), 4) and 6)
f) System measures (also called product measures) are used to assess stakeholder satisfaction and to deliver an ever-improving value to the acquirers of project products and services. These measures also are indicative that the design process is continuing in the direction of an acceptable solution. An example of an input system measure is the quality of materials and skills of assigned project personnel. Examples of output measures include: customer complaints, in-service failure reports and technical performance measures (TPM). A TPM is a measure used to assess design progress, compliance to performance requirements, and technical risks for critical performance parameters. TPMs are derived from the MOPs (see Annex C.18 Note 4) focusing on the critical technical parameters of specific architectural elements of the system as it is designed and implemented. Selection of TPMs should be limited to critical technical thresholds or parameters that, if not met, put the project at cost, schedule, or performance risk. A TPM provides an early warning of the adequacy of a design in terms of satisfying selected critical technical parameter requirements. The TPM includes the projected performance, such as a growth curve with thresholds of acceptable variance. Performance of the system or system element is tracked through the life cycle and compared to the projected and required values. Early in the life cycle the performance values may be estimated, based on simulation and modelling. As the life cycle proceeds, actual data replaces estimates and adds to the fidelity of the information. This measurement of the design solution as it evolves allows action to be taken early in the process, rather than wait until system testing to address.	6.3.2.3 a) 5) and 6)
g) The planned times, and actual or estimated labour, material and service costs should be collected and evaluated and compared against baseline budgets and current forecasts.	6.3.2.3 a) 5) and 8)
h) The outcomes of a productivity assessment (progress satisfying plans) provide status information to enable efficient use of resources, evaluation of progress against plans, identification of variances of cost and schedule from planned project baselines and early identification and resolution of productivity problems.	6.3.2.3 a) 2) and 6)

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NOTES		ISO/IEC15288 CLAUSE
i)	When variations are significant or cannot be corrected by re-performing the process tasks that generated the outcome data, the project planning process is re-initiated in order to plan and implement appropriate corrective actions.	6.3.2.3 a) 4), 5) and 6)
j)	Measures are identified and used to assess the efficiency of the scheduled work. Example measures include earned value (cost/schedule measure), amount of waste, number of engineering changes, percentage of drawings completed, number of drawing errors, percentage of lines of code completed, rework percentage, idle time (for example work in progress), change rate and turnover in personnel. The criteria for process measure selection are based on how well enhancement in project performance correlates with improvement in potential customer satisfaction with respect to cost, schedule and risk.	6.3.2.3 a) 5)
k)	Measures are defined and used and the data is gathered to permit assessment of customer satisfaction.	6.3.2.3 a) 5)
l)	Technical reviews, audits and inspections are conducted against technical plans in accordance with defined schedules to demonstrate conformance of actions and outcomes to planned technical work.	6.3.2.3 a) 6)
m)	Typical review objectives include determination of: 1) System maturity and how well the solution satisfies requirements. 2) Traceability of requirements, the validity of assumptions and decision rationale. 3) Identification of un-resolved issues and those issues not determined during project work. 4) Related risks, needed resources and adequacy of preparation for conducting the next system life-cycle stage.	6.3.2.3 a) 6)
n)	System-of-interest level reviews can be done in conjunction with an organization view milestone, decision gate or quality review.	6.3.2.3 a) 6)
o)	Non-conformance of deliverable work products, services and processes ought to be recorded and appropriate actions recommended to correct the out-of-conformance condition.	6.3.2.3 a) 7) - 9)
p)	Use of the Project Control Process aids the capture and management of outcomes from project management and technical work including the redirection of that work to overcome obstacles, to respond to changing circumstances or to correct variances.	6.3.2.3 b)
q)	Requirements management is done in parallel with cost, schedule, quality, configuration, interface, risk and change management activities that track compliance of project agreement and technical requirements.	6.3.2.3 b)

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Table A.10 — Decision Management Process (Clause 6.3.3)

NOTES	ISO/IEC15288 CLAUSE
a) The types of trade-off analyses typically performed during performance of life cycle processes include: 1) Formal—formally conducted, with results reviewed at technical reviews. Specific formal trade-off analyses are normally identified in an agreement. 2) Informal—follows the same methodology of a formal trade-off analysis but requires less documentation and is of less importance to the acquirer. 3) Judgmental—selection of a recommended option, based on judgement of the analyst or designer after a less rigorous analysis than that required by a formal trade-off analysis and for which the consequences are not as important. Used when one option is clearly superior to others or time is not available for a more formal approach. Most trade-off analyses performed are of the judgmental type.	6.3.3.3 a) and b)
b) Trade-off analyses are conducted throughout implementation of project and technical processes to resolve conflicts (such as conflicting requirements) and select a recommended solution from a set of defined alternatives (such as optional actions to take for risk resolution, resolutions for requirement conflicts, alternative logical architectural design solutions and alternative physical architectural design solutions). Outcomes from a trade-off analysis include the recommended option, implementation considerations, impacts related to each option, basis of recommendation and assumptions made.	6.3.3.3 a) 2), b) 1) and c)

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Table A.11 — Risk Management Process (Clause 6.3.4)

NOTES	ISO/IEC15288 CLAUSE
a) Risk management should not be viewed as an extra activity, as an activity layered on assigned work or as an activity outside a project's responsibility.	6.3.4.1
b) Risk management is a general procedure for resolving risks. Risks are considered resolved when the possible consequences are acceptable. Acceptable means that the project can live with the worst-case outcome. Risk management includes: 1) Risk planning that includes preparing a risk management plan. 2) Risk assessment that is used to define the risk including identifying sources and evaluating potential effects. 3) Risk control that is used to resolve risks and includes developing risk resolution action plans, establishing triggers for implementation of risk resolution action plans, monitoring risk status, implementing risk resolution action plans when a trigger is tripped and correcting deviations from project plans.	6.3.4.3 a)
c) Risk management has two dimensions of awareness—past and future. The past dimension of risk is based upon past experience and includes benchmarking project measures and lessons learned, measuring actual results with expected results, mapping available resources to requirements with respect to defining and doing the work and implementation of the plan to produce the product. The future dimension is based on transformation of the project vision into goals and objectives used for	6.3.4.3 a)

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NOTES	ISO/IEC15288 CLAUSE
establishing plans and being aware of the future from which risks and opportunities are identified and the ambiguities of available information and resources as well as the uncertainties uncovered during work.	
d) Risk management includes: 1) Identification of risk to include sources and related issues, concerns, doubts, uncertainties and assumptions. 2) Analysis based on established criteria to include estimation of risk probability and consequences and the prioritization of risks. 3) Planning of alternative strategies for risk resolution, definition of a specific risk action plan for selected approach and establishment of triggers (or thresholds) for taking risk resolution action. 4) Tracking to include monitoring risk status and comparing thresholds to risk status, using triggers to provide early warning and reporting status based on risk measures. 5) Resolution of risks by appropriately identifying triggers, implementing an action plan, report results and continuing planned actions till risk is acceptable.	6.3.4.3 a)
e) Risk management tools include ones for: 1) Risk identification—risk taxonomy, research, interviews, lessons learned, control charts, affinity diagrams, interrelationship diagrams and system structure or WBS interfaces. 2) Risk analysis—impact models, probability models, Gantt chart, impact distribution, risk coupling, system structure or WBS interfaces, and iso-risk charts. 3) Risk alternative strategy planning—iso-risk charts, lessons learned, risk leveraging, warrantees and insurance. 4) Risk tracking—technical performance measures, earned value, measures and risk watch list. 5) Risk resolution—impact model, risk watch list, risk template and risk management matrix.	6.3.4.3 a)
f) Keys to successful risk management include: 1) Right people. People communicate issues, concerns and uncertainties. It is essential to define desired participation, ability and motivation. 2) Right Process. Process transforms uncertainty into acceptable risk through risk management activities including execution and definition. 3) Right Infrastructure. The organizational culture determines how projects use risk management. The infrastructure is typically specified through appropriate policies and standards and includes identification and dissemination of resources (staff, schedule, budget), requirements (contractual, standards) and expected outcomes (cost, benefit).	6.3.4.3 a)

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