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Systems and software engineering — System life cycle processes

Ingénierie des systèmes et du logiciel — Processus du cycle de vie du système

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IEEE
Std 15288-2008

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ISO/IEC 15288:2008(E)
IEEE Std 15288™-2008
(Revision of
IEEE Std 15288-2004)

Systems and software engineering — System life cycle processes

Sponsor

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Abstract: This International Standard establishes a common process framework for describing the life cycle of man-made systems. It defines a set of processes and associated terminology for the full life cycle, including conception, development, production, utilization, support and retirement. This standard also supports the definition, control, assessment, and improvement of these processes. These processes can be applied concurrently, iteratively, and recursively to a system and its elements throughout the life cycle of a system.
Keywords: acquisition, agreement, architectural design, assessment, audit, configuration management, decision management, development, disposal, enabling system, implementation, information management, infrastructure, integration, life cycle, life cycle model, life cycle stages, maintenance, measurement, operation, planning, process, process improvement, process reference model, process tailoring, process view, product, project portfolio, quality management, requirements, retirement, risk management, service, stages, stakeholder requirements, supply, system, system structure, system-of-interest, tailoring, transition, validation, verification

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

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

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ISO/IEC 15288 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Systems and software engineering*.

This second edition cancels and replaces the first edition (ISO/IEC 15288:2002), which has been technically revised.

The IEEE Computer Society collaborated with ISO/IEC JTC 1 in the development of this International Standard. *IEEE Std 15288-2004, Adoption of ISO/IEC 15288:2002, Systems Engineering—System Life Cycle Processes,* was one of the base documents used in the development of this International Standard.

Changes in this revision of ISO/IEC 15288 were developed in conjunction with a corresponding revision of ISO/IEC 12207. The purpose of these revisions is to better align the two International Standards to facilitate their joint use. This alignment takes the first step toward harmonization of the structures and contents of the two International Standards, while supporting the requirements of the assessment community. This alignment provides the foundation to facilitate evolution to an integrated and fully harmonized treatment of life cycle processes.

This International Standard was developed with the following goals:

— provide a common terminology between the revision of the ISO/IEC 15288 and ISO/IEC 12207;

— where applicable, provide common process names and process structure between the revision of the ISO/IEC 15288 and ISO/IEC 12207;

— enable user community to evolve towards fully harmonized standards, while maximizing backward compatibility, and

— leverage ten years of experience with the development and use of ISO/IEC 12207 and ISO/IEC 15288.

A subsequent revision is intended to achieve a fully harmonized view of the system and software life cycle processes. Identified areas to consider in the future include: common process purposes and outcomes, architecture of the standards, level of prescription of activities and tasks, life cycle treatments, treatment of products and services, common verification and validation concepts, common configuration management concepts, deferred recommendations, alignment with other applicable standards, and rationalization of application guides.



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Introduction

The complexity of man-made systems has increased to an unprecedented level. This has led to new opportunities, but also to increased challenges for the organizations that create and utilize systems. These challenges exist throughout the life cycle of a system and at all levels of architectural detail. They arise from several sources:

— There are inherent differences among the hardware, software and human elements from which systems are constructed.

— Almost every present-day system contains, and/or is modelled and supported by computer-based technology.

— There is a lack of harmonization and integration of the involved disciplines, including science, engineering, management and finance.

There is therefore a need for a common framework to improve communication and cooperation among the parties that create, utilize and manage modern systems in order that they can work in an integrated, coherent fashion.

This International Standard provides a common process framework covering the life cycle of man-made systems. This life cycle spans the conception of ideas through to the retirement of a system. It provides the processes for acquiring and supplying systems. In addition, this framework provides for the assessment and improvement of the life cycle processes.

This revised International Standard is an initial step in the SC7 harmonization strategy to achieve a fully integrated suite of system and software life cycle processes and guidance for their application. This revision aligns with the revision to ISO/IEC 12207 within the context of system life cycle processes and applies SC7 guidelines for process definition to support consistency, to improve usability and to align structure, terms, and corresponding organizational and project processes.

The processes in this International Standard form a comprehensive set from which an organization can construct system life cycle models appropriate to its products and services. An organization, depending on its purpose, can select and apply an appropriate subset to fulfil that purpose.

This International Standard can be used in one or more of the following modes:

— By an organization — to help establish an environment of desired processes. These processes can be supported by an infrastructure of methods, procedures, techniques, tools and trained personnel. The organization may then employ this environment to perform and manage its projects and progress systems through their life cycle stages. In this mode this International Standard is used to assess conformance of a declared, established environment to its provisions.

— By a project — to help select, structure and employ the elements of an established environment to provide products and services. In this mode this International Standard is used in the assessment of conformance of the project to the declared and established environment.

— By an acquirer and a supplier — to help develop an agreement concerning processes and activities. Via the agreement, the processes and activities in this International Standard are selected, negotiated, agreed to and performed. In this mode this International Standard is used for guidance in developing the agreement.

— By process assessors — to serve as a process reference model for use in the performance of process assessments that may be used to support organizational process improvement.

This International Standard contains requirements in two clauses: Clause 6, that defines the requirements for the system life cycle processes and Annex A that provides requirements for tailoring of this International Standard. There are also several informative annexes contained in this International Standard:

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— 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 this standard.

— 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 describes relationships to other IEEE standards.

NOTE A future Technical Report (ISO/IEC TR 24748) will describe the relations between this International Standard and ISO/IEC 12207:2008.

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IEEE Introduction

This introduction is not part of IEEE Std 15288™-2008, Systems and Software Engineering — Systems Life Cycle Processes.

IEEE Std 12207™-2008 and IEEE Std 15288™-2008 are identical to ISO/IEC 12207:2008 and ISO/IEC 15288:2008. Therefore, all references to ISO/IEC 12207 or ISO/IEC 15288 apply equally well to their IEEE counterparts. Further details regarding relationships to IEEE standards can be found in Annex F.

This standard replaces IEEE Std 15288™-2004, Adoption of ISO/IEC 15288:2002, Systems Engineering—System Life Cycle Processes. The original ISO/IEC 15288 was published in November 2002 and was the first international standard to provide a comprehensive set of life cycle processes for systems.

This new revision of ISO/IEC 15288 is the product of a coordinated effort by IEEE and ISO/IEC JTC 1/SC 7. The base documents for the revision included the ISO/IEC standard and informative material from the 2004 IEEE adoption. Development of this revision was carefully coordinated with the parallel revision of ISO/IEC 12207:1995 to align structure, terms, and corresponding organizational and project processes.

This revised standard is a step in the SC7 harmonization strategy to achieve a fully integrated suite of system and software life cycle processes and guidance for their application. It is also an important step in the shared strategy of ISO/IEC JTC 1/SC 7 and the IEEE to harmonize their respective collections of standards. The new editions of ISO/IEC 12207 and ISO/IEC 15288, and their identical IEEE editions, will provide a single, shared baseline of systems and software life cycle processes applicable to both ISO/IEC and the IEEE standards collections.

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Systems and software engineering — System life cycle processes

1 Overview

1.1 Scope

This International Standard establishes a common framework for describing the life cycle of systems created by humans. It defines a set of processes and associated terminology. These processes can be applied at any level in the hierarchy of a system's structure. Selected sets of these processes can be applied throughout the life cycle for managing and performing the stages of a system's life cycle. This is accomplished through the involvement of all interested parties, with the ultimate goal of achieving customer satisfaction.

This International Standard also provides processes that support the definition, control and improvement of the life cycle processes used within an organization or a project. Organizations and projects can use these life cycle processes when acquiring and supplying systems.

This International Standard concerns those systems that are man-made and may be configured with one or more of the following: hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operator instructions), facilities, materials and naturally occurring entities.

When a system element is software, the software life cycle processes documented in ISO/IEC 12207:2008 may be used to implement that system element. The two standards are harmonized for concurrent use on a single project or in a single organization. When the system element is hardware, refer to other International Standards outside the scope of SC7.

1.2 Purpose

The purpose of this International Standard is to provide a defined set of processes to facilitate communication among acquirers, suppliers and other stakeholders in the life cycle of a system.

This International Standard applies to organizations in their roles as both acquirers and suppliers. It can be used by a single organization in a self-imposed mode or in a multi-party situation. Parties can be from the same organization or from different organizations and the situation can range from an informal agreement to a formal contract.

The processes in this International Standard can be used as a basis for establishing business environments, e.g., methods, procedures, techniques, tools and trained personnel. Annex A provides normative direction regarding the tailoring of these system life cycle processes.

1.3 Field of application

This International Standard applies to the full life cycle of systems, including conception, development, production, utilization, support and retirement of systems, and to the acquisition and supply of systems, whether performed internally or externally to an organization. The life cycle processes of this International Standard can be applied concurrently, iteratively and recursively to a system and its elements.

There is a wide variety of systems in terms of their purpose, domain of application, complexity, size, novelty, adaptability, quantities, locations, life spans and evolution. This International Standard describes the processes that comprise the life cycle of any man-made system. It therefore applies to one-of-a-kind systems, mass-produced systems and customized, adaptable systems. It also applies to a complete stand-alone system and to systems that are embedded and integrated into larger more complex and complete systems.

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This International Standard provides a process reference model characterized in terms of the process purpose and the process outcomes that result from the successful execution of the activity tasks. This International Standard can therefore be used as a reference model to support process assessment as specified in ISO/IEC 15504-2:2003. Annex B provides information regarding the use of the system life cycle processes as a process reference model. Annex C describes the process constructs for use in the process reference model.

1.4 Limitations

This International Standard does not prescribe a specific system life cycle model, development methodology, method, model or technique. This International Standard does not detail the life cycle processes in terms of methods or procedures required to meet the requirements and outcomes of a process.

This International Standard does not detail documentation in terms of name, format, explicit content and recording media.

This International Standard 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 this International Standard.

2 Conformance

2.1 Intended usage

The requirements in this International Standard are contained in Clause 6 and Annex A. This International Standard provides requirements for a number of processes suitable for usage during the life cycle of a system. It is recognized that particular projects or organizations may not need to use all of the processes provided by this International Standard. Therefore, implementation of this International Standard typically involves selecting a set of processes suitable to the organization or project. There are two ways that an implementation can be claimed to conform with the provisions of this International Standard. Any claim of conformance is cited in only one of the two forms below.

2.2 Full conformance

A claim of full conformance declares the set of processes for which conformance is claimed. Full conformance is achieved by demonstrating that all of the requirements of the declared set of processes have been satisfied using the outcomes as evidence.

2.3 Tailored conformance

When this International Standard is used as a basis for establishing a set of processes that do not qualify for full conformance, the clauses of this International Standard are selected or modified in accordance with the tailoring process prescribed in Annex A. The tailored text, for which tailored conformance is claimed, is declared. Tailored conformance is achieved by demonstrating that requirements for the processes, as tailored, have been satisfied using the outcomes as evidence.

NOTE 1 When this International Standard is used to help develop an agreement between an acquirer and a supplier, clauses of this International Standard can be selected for incorporation in the agreement with or without modification. In this case, it is more appropriate for the acquirer and supplier to claim compliance with the agreement than conformance with this International Standard.

NOTE 2 Any organization (for example, national, industrial association, company) imposing this International Standard, as a condition of trade, should specify and make public the minimum set of required processes, activities, and tasks, which constitute suppliers' conformance with this International Standard.

NOTE 3 Requirements of this International Standard are marked by the use of the verb "shall". Recommendations are marked by the use of the verb "should". Permissions are marked by the use of the verb "may".

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3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 12207:2008, *Systems and software engineering – Software life cycle processes*

4 Terms and definitions

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

4.1
acquirer
stakeholder that acquires or procures a product or service from a supplier

NOTE Other terms commonly used for an acquirer are buyer, customer, owner, or purchaser.

4.2
acquisition
process of obtaining a system product or service

NOTE Adapted from ISO/IEC 12207:2008.

4.3
activity
set of cohesive tasks of a process

4.4
agreement
mutual acknowledgement of terms and conditions under which a working relationship is conducted

4.5
architecture
fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution

[ISO/IEC 42010:2007]

4.6
audit
systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled

[ISO 9000:2005]

4.7
baseline
specification or work product that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development, and that can be changed only through formal change control procedures

4.8
customer
organization or person that receives a product or service

NOTE 1 A customer can be internal or external to the organization.

NOTE 2 Adapted from ISO 9000:2005.

NOTE 3 Other terms commonly used for customer are acquirer, buyer, or purchaser.

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4.9
enabling system
system that supports a system-of-interest during its life cycle stages but does not necessarily contribute directly to its function during operation

NOTE 1 For example, when a system-of-interest enters the production stage, a production-enabling system is required.

NOTE 2 Each enabling system has a life cycle of its own. This International Standard is applicable to each enabling system when, in its own right, it is treated as a system-of-interest.

4.10
facility
physical means or equipment for facilitating the performance of an action, e.g., buildings, instruments, tools

4.11
life cycle
evolution of a system, product, service, project or other human-made entity from conception through retirement

4.12
life cycle model
framework of processes and activities concerned with the life cycle that may be organized into stages, which also acts as a common reference for communication and understanding

4.13
operator
entity that performs the operations of a system

NOTE 1 The role of operator and the role of user may be vested, simultaneously or sequentially, in the same individual or organization.

NOTE 2 An individual operator combined with knowledge, skills and procedures may be considered as an element of the system.

NOTE 3 In the context of this specific definition, the term entity means an individual or an organization.

4.14
organization
person or a group of people and facilities with an arrangement of responsibilities, authorities and relationships

NOTE 1 Adapted from ISO 9000:2005.

NOTE 2 A body of persons organized for some specific purpose, such as a club, union, corporation, or society, is an organization.

NOTE 3 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.

4.15
party
organization entering into an agreement

NOTE In this International Standard, the agreeing parties are called the acquirer and the supplier.

4.16
process
set of interrelated or interacting activities which transforms inputs into outputs

[ISO 9000:2005]

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4.17
process purpose
high level objective of performing the process and the likely outcomes of effective implementation of the process

NOTE The implementation of the process should provide tangible benefits to the stakeholders.

[ISO/IEC 12207:2008]

4.18
process outcome
observable result of the successful achievement of the process purpose

[ISO/IEC 12207:2008]

4.19
product
result of a process

[ISO 9000:2005]

4.20
project
endeavour with defined start and finish criteria undertaken to create a product or service in accordance with specified resources and requirements

NOTE 1 Adapted from ISO 9000:2005.

NOTE 2 A project may be viewed as a unique process comprising co-ordinated and controlled activities and may be composed of activities from the Project Processes and Technical Processes defined in this International Standard.

4.21
project portfolio
collection of projects that addresses the strategic objectives of the organization

4.22
qualification
process of demonstrating whether an entity is capable of fulfilling specified requirements

[ISO/IEC 12207:2008]

4.23
quality assurance
part of quality management focused on providing confidence that quality requirements will be fulfilled

[ISO 9000:2005]

4.24
request for tender
proposal
document used by the acquirer as the means to announce its intention to potential bidders to acquire a specified system product or service

4.25
resource
asset that is utilized or consumed during the execution of a process

NOTE 1 Resources may include diverse entities such as funding, personnel, facilities, capital equipment, tools, and utilities such as power, water, fuel and communication infrastructures.

NOTE 2 Resources may be reusable, renewable or consumable.

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4.26
retirement
withdrawal of active support by the operation and maintenance organization, partial or total replacement by a new system, or installation of an upgraded system

[ISO/IEC 12207:2008]

4.27
security
all aspects related to defining, achieving, and maintaining confidentiality, integrity, availability, non-repudiation, accountability, authenticity, and reliability of a system

NOTE Adapted from ISO/IEC 13335-1: 2004.

4.28
stage
period within the life cycle of an entity that relates to the state of its description or realization

NOTE 1 As used in this International Standard, stages relate to major progress and achievement milestones of the entity through its life cycle.

NOTE 2 Stages may be overlapping.

4.29
stakeholder
individual or organization having a right, share, claim, or interest in a system or in its possession of characteristics that meet their needs and expectations

4.30
supplier
organization or an individual that enters into an agreement with the acquirer for the supply of a product or service

NOTE 1 Other terms commonly used for supplier are contractor, producer, seller or vendor.

NOTE 2 The acquirer and the supplier may be part of the same organization.

4.31
system
combination of interacting elements organized to achieve one or more stated purposes

NOTE 1 A system may be considered as a product or as the services it provides.

NOTE 2 In practice, the interpretation of its meaning is frequently clarified by the use of an associative noun, e.g., aircraft system. Alternatively, the word “system” may be substituted simply by a context-dependent synonym, e.g., aircraft, though this may then obscure a system principles perspective.

4.32
system element
member of a set of elements that constitutes a system

NOTE A system element is a discrete part of a system that can be implemented to fulfil specified requirements. A system element can be hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operator instructions), facilities, materials, and naturally occurring entities (e.g., water, organisms, minerals), or any combination.

4.33
system-of-interest
system whose life cycle is under consideration in the context of this International Standard

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4.34
task
requirement, recommendation, or permissible action, intended to contribute to the achievement of one or more outcomes of a process

4.35
trade-off
decision-making actions that select from various requirements and alternative solutions on the basis of net benefit to the stakeholders

4.36
user
individual or group that benefits from a system during its utilization

NOTE The role of user and the role of operator may be vested, simultaneously or sequentially, in the same individual or organization.

4.37
validation
confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled

[ISO 9000:2005]

NOTE Validation is the set of activities ensuring and gaining confidence that a system is able to accomplish its intended use, goals and objectives (i.e., meet stakeholder requirements) in the intended operational environment.

4.38
verification
confirmation, through the provision of objective evidence, that specified requirements have been fulfilled

[ISO 9000:2005]

NOTE Verification is a set of activities that compares a system or system element against the required characteristics. This may include, but is not limited to, specified requirements, design description and the system itself.

5 Key concepts and application of this International Standard

5.1 System concepts

5.1.1 Introduction

This clause is included to highlight and to help explain essential concepts on which this International Standard is based. Further elaboration of these concepts can be found in ISO/IEC TR 19760, *A Guide for the application of ISO/IEC 15288 System life cycle processes.*

NOTE A future Technical Report (ISO/IEC TR 24748, *Guide for life cycle management*) will also provide further elaboration.

5.1.2 Systems

The systems considered in this International Standard are man-made, created and utilized to provide products and/or services in defined environments for the benefit of users and other stakeholders. These systems may be configured with one or more of the following system elements: hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operator instructions), facilities, materials and naturally occurring entities. In practice, they are thought of as products or services.

The perception and definition of a particular system, its architecture and its system elements depend on an observer's interests and responsibilities. One person's system-of-interest can be viewed as a system element in

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another person's system-of-interest. Furthermore, a system-of-interest can be viewed as being part of the environment of operation for another person's system-of-interest.

The following are key points regarding the characteristics of the systems-of-interest:

a) defined boundaries encapsulate meaningful needs and practical solutions;

b) there is hierarchical or other relationship between system elements;

c) an entity at any level in the system-of-interest can be viewed as a system;

d) a system comprises an integrated, defined set of subordinate system elements;

e) characteristic properties at a system's boundary arise from the interactions among system elements;

f) humans can be viewed as both users external to a system and as system elements (i.e., operators) within a system;

g) a system can be viewed in isolation as an entity, i.e., a product, or as a collection of functions capable of interacting with its surrounding environment, i.e., a set of services.

Whatever the boundaries chosen to define the system, the concepts and models in this International Standard are generic and permit a practitioner to correlate or adapt individual instances of life cycles to its system principles.

In this International Standard humans are considered as users and as elements of a system. In the first case the human user is a beneficiary of the operation of the system. In the second case the human is an operator carrying out specified system functions. An individual can be, simultaneously or sequentially, both a user and an element of a system.

Additional detail and examples regarding the system-of-interest, system, and system element concepts and their application throughout the life cycle can be found in ISO/IEC TR 19760, *A Guide for the application of ISO/IEC 15288 System life cycle processes.*

NOTE A future Technical Report (ISO/IEC TR 24748, *Guide for life cycle management*) will also provide further elaboration.

5.1.3 System Structure

The system life cycle processes in this International Standard are described in relation to a system (see Figure 1) that is composed of a set of interacting system elements, each of which can be implemented to fulfil its respective specified requirements. Responsibility for the implementation of any system element may therefore be delegated to another party through an agreement.

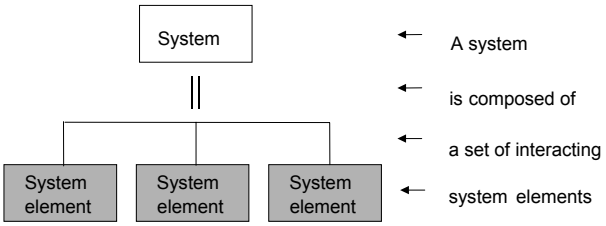

Figure 1 — System and system element relationship

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The relationship between the system and its complete set of system elements can typically be represented in a two-level hierarchy for the simplest of systems-of-interest. For more complex systems-of-interest, a prospective system element may itself need to be considered as a system (that in turn is comprised of system elements) before a complete set of system elements can be defined with confidence (see Figure 2). In this manner, the appropriate system life cycle processes are applied recursively to a system-of-interest to resolve its structure to the point where understandable and manageable system elements can be implemented (made, bought, or reused) from another party. The system of interest may include any type of system or combination of systems. No specific hierarchical or horizontal representation is implied.

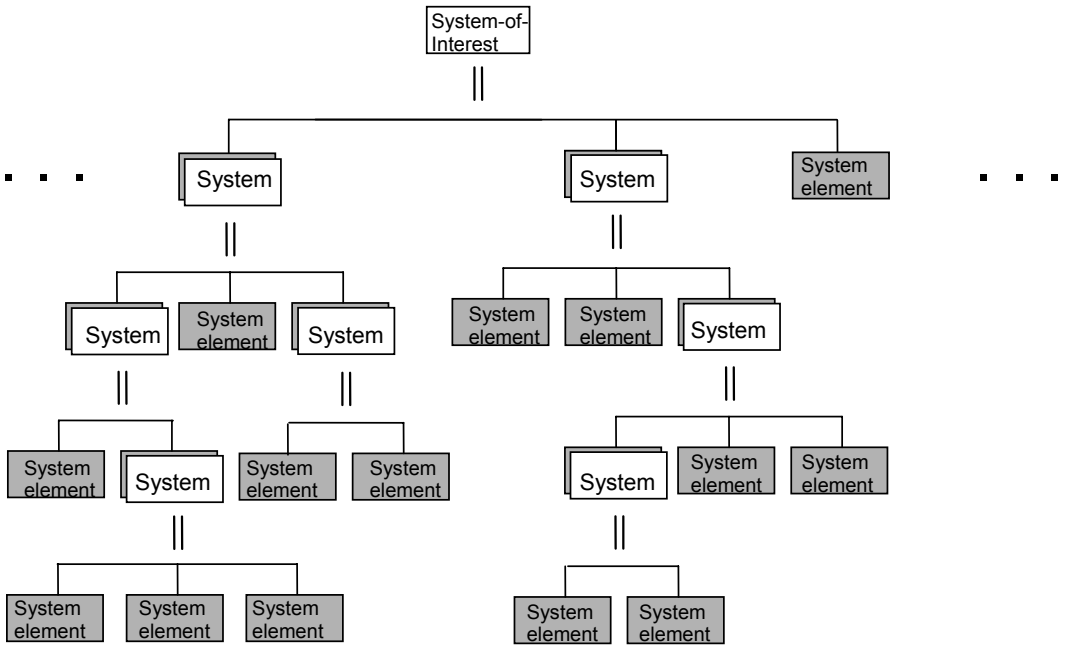

Figure 2 — System-of-interest structure

5.1.4 Enabling systems

Throughout the life cycle of a system-of-interest, essential services are required from systems that are not directly a part of the operational environment, e.g., mass-production system, training system, maintenance system. Each of these systems enables a part, e.g., a stage of the life cycle of the system-of-interest to be conducted. Termed "enabling systems", they facilitate progression of the system-of-interest through its life cycle.

The relationship between the services delivered to the operational environment by the system-of-interest and the services delivered by the enabling systems to the system-of-interest are shown in Figure 3. Enabling systems can be seen to contribute indirectly to the services provided by the system-of-interest. The interrelationships between the system-of-interest and the enabling systems can be bi-directional or a one-way relationship. In addition to interacting with enabling systems, the system-of-interest may also interact with other systems in the operating environment, shown as Systems A, B, and C. Requirements for interfaces with enabling systems and other systems in the operational environment may need to be included in the requirements for the system-of-interest.

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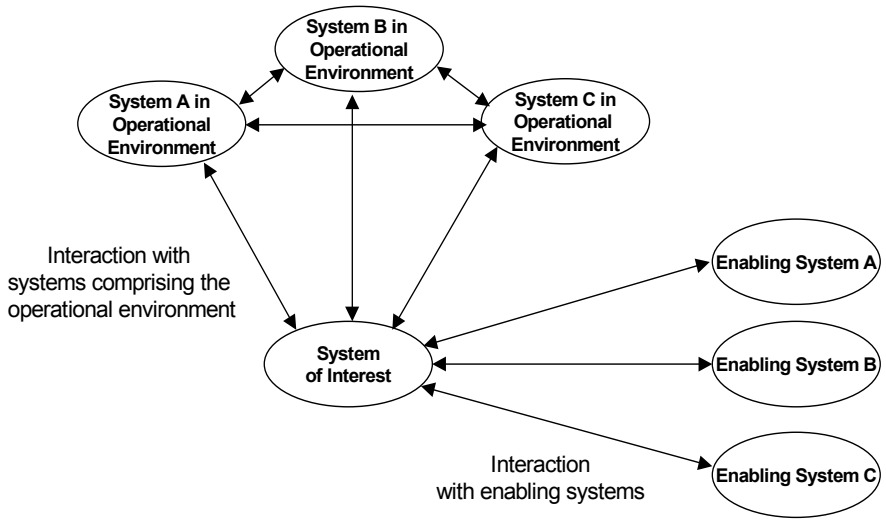

Figure 3 — System-of-interest, its operational environment and enabling systems

During a stage in the system life cycle, the relevant enabling systems and the system-of-interest are considered together. Since they are interdependent, they can also be viewed as a system. Project responsibility for a stage in the life cycle of the system-of-interest thus extends to responsibility for acquiring services from the relevant enabling system. When a suitable enabling system does not already exist, the project that is responsible for the system-of-interest can also be directly responsible for creating and using the enabling system. Creating the enabling systems can be viewed as a separate project and subsequently another system-of-interest.

Additional detail regarding enabling systems can be found in ISO/IEC TR 19760*, A Guide for the application of ISO/IEC 15288 System life cycle processes*.

NOTE A future Technical Report (ISO/IEC TR 24748, *Guide for life cycle management*) will also provide further elaboration.

5.2 Life cycle concepts

5.2.1 System life cycle model

Every system has a life cycle. A life cycle can be described using an abstract functional model that represents the conceptualization of a need for the system, its realization, utilization, evolution and disposal.

A system progresses through its life cycle as the result of actions, performed and managed by people in organizations, using processes for execution of these actions. The detail in the life cycle model is expressed in terms of these processes, their outcomes, relationships and sequence. This International Standard defines a set of processes, termed life cycle processes, that can be used in the definition of the system's life cycle.

5.2.2 System life cycle stages

Life cycles vary according to the nature, purpose, use and prevailing circumstances of the system. Each stage has a distinct purpose and contribution to the whole life cycle and is considered when planning and executing the system life cycle.

The stages represent the major life cycle periods associated with a system and they relate to the state of the system description or the system itself. The stages describe the major progress and achievement milestones of the system through its life cycle. They give rise to the primary decision gates of the life cycle. These decision gates are used by organizations to understand and manage the inherent uncertainties and risks associated with

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costs, schedule and functionality when creating or utilizing a system. The stages thus provide organizations with a framework within which organization management has high-level visibility and control of project and technical processes.

Organizations employ stages differently to satisfy contrasting business and risk mitigation strategies. Using stages concurrently and in different orders can lead to life cycle forms with distinctly different characteristics.

Additional detail regarding life cycle concepts and stages can be found in ISO/IEC TR 19760*, A Guide for the application of ISO/IEC 15288 System life cycle processes.*

NOTE A future Technical Report (ISO/IEC TR 24748, *Guide for life cycle management*) will also provide further elaboration.

5.3 Process concepts

5.3.1 Description of processes

Each process of this standard is described in terms of the following attributes:

— The title conveys the scope of the process as a whole;

— The purpose describes the goals of performing the process;

— The outcomes express the observable results expected from the successful performance of the process;

— The activities are sets of cohesive tasks of a process;

— The tasks are requirements, recommendations, or permissible actions intended to support the achievement of the outcomes.

Additional detail regarding this form of description can be found in ISO/IEC TR 24774, *Guidelines for process definition*.

5.3.2 Processes in this standard

5.3.2.1 Introduction

This International Standard groups the activities that may be performed during the life cycle of a system into four process groups. Each of the life cycle processes within those groups is described in terms of its purpose and desired outcomes and list activities and tasks which need to be performed to achieve those outcomes. The four process groups and the processes included in each group are depicted in Figure 4. The processes described in this International Standard are not intended to preclude or discourage the use of additional processes that organizations find useful. A description of each process group is provided in the four sub-clauses that follow.

To aid the concurrent use of ISO/IEC 15288 and ISO/IEC 12207, corresponding processes of Clause 6 have the same subclause number (at the 6.x.x level).

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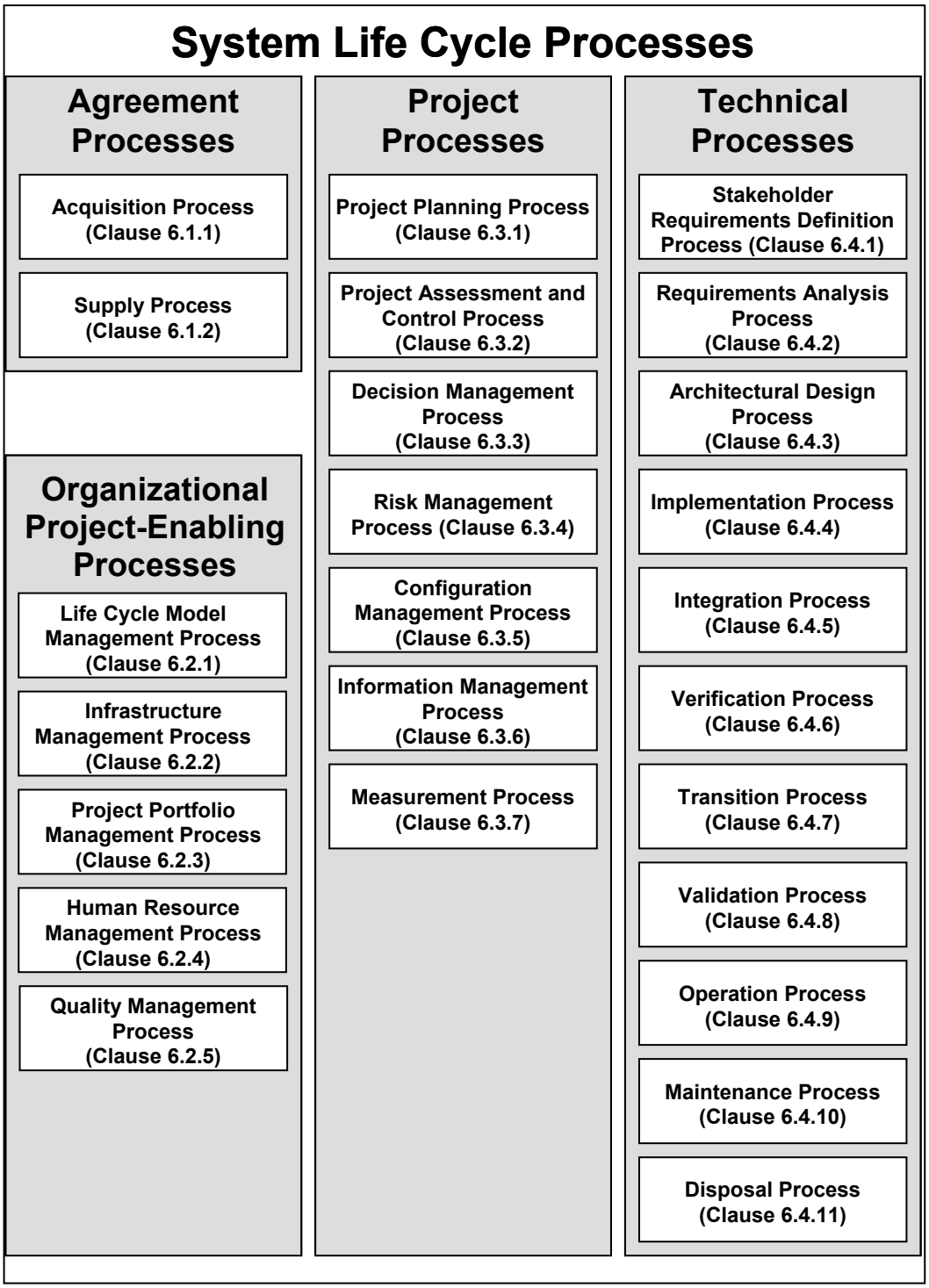

Figure 4 — The system life cycle processes

5.3.2.2 Agreement Processes

Organizations are producers and users of systems. One organization (acting as an acquirer) can task another (acting as a supplier) for products or services. This is achieved using agreements.

Generally, organizations act simultaneously or successively as both acquirers and suppliers of systems. The Agreement Processes can be used with less formality when the acquirer and the supplier are in the same organization. Similarly, they can be used within the organization to agree on the respective responsibilities of organization, project and technical functions. Figure 4 lists the processes contained in this process group.

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5.3.2.3 Organizational Project-Enabling Processes

The Organizational Project-Enabling Processes are concerned with ensuring that the resources needed to enable the project to meet the needs and expectations of the organization's interested parties are met. The Organizational Project-Enabling Processes are typically concerned at a strategic level with the management and improvement of the organization's business or undertaking, with the provision and deployment of resources and assets, and with its management of risks in competitive or uncertain situations.

The Organizational Project-Enabling Processes establish the environment in which projects are conducted. The organization establishes the processes and life cycle models to be used by projects; establishes, redirects, or cancels projects; provides resources required, including human and financial; and sets and monitors the quality measures for systems and other deliverables that are developed by projects for internal and external customers.

The Organizational Project-Enabling Processes create a strong business image for many organizations and imply commercial and profit-making motives. Nevertheless, the Organizational Project-Enabling Processes are equally relevant to non-profit organizations, since they are also accountable to stakeholders, are responsible for resources and encounter risk in their undertakings. This International Standard can be applied to non-profit organizations as well as to profit-making organizations. Figure 4 lists the processes contained in this process group.

5.3.2.4 Project Processes

The Project Processes are concerned with managing the resources and assets allocated by organization management and with applying them to fulfil the agreements into which the organization or organizations enter. They relate to the management of projects, in particular to planning in terms of cost, timescales and achievements, to the checking of actions to ensure that they comply with plans and performance criteria, and to the identification and selection of corrective actions that recover shortfalls in progress and achievement.

Typically several projects will co-exist in any one organization. The Project Processes can be employed at a corporate level to meet internal needs. Figure 4 lists the processes contained in this process group.

5.3.2.5 Technical Processes

The Technical Processes are concerned with technical actions throughout the life cycle. They transform the needs of stakeholders first into a product and then, by applying that product, provide a sustainable service, when and where needed in order to achieve customer satisfaction. The Technical Processes are applied in order to create and use a system, whether it is in the form of a model or is a finished product, and they apply at any level in a hierarchy of system structure. Figure 4 lists the processes contained in this process group.

5.3.3 Process application

The life cycle processes defined in this International Standard can be used by any organization when acquiring, using, creating, or supplying a system. They can be applied at any level in a system's hierarchy and at any stage in the life cycle.

The life cycle processes are based on principles of modularity (maximal cohesiveness of the functions of a process and minimal coupling among processes) and ownership (a process is associated with a responsibility). The functions these processes perform are defined in terms of specific purposes, outcomes and the set of activities and tasks that constitute the process.

Each life cycle process in Figure 4 can be invoked, as required, at any time throughout the life cycle. The order that the processes are presented in this standard does not imply any prescriptive order in their use. However, sequential relationships are introduced by the definition of a life cycle model. The detailed purpose and timing of use of these processes throughout the life cycle are influenced by multiple factors, including social, trading, organizational and technical considerations, each of which can vary during the life of a system. An individual system life cycle is thus a complex system of processes that will normally possess concurrent, iterative, recursive and time dependent characteristics.

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Concurrent use of processes can exist within a project (e.g., when design actions and preparatory actions for building a system are performed at the same time), and between projects (e.g., when system elements are designed at the same time under different project responsibility).

When the application of the same process or set of processes is repeated on the same system, the application is referred to as iterative. The iterative use of processes is important for the progressive refinement of process outputs, e.g., the interaction between successive verification actions and integration actions can incrementally build confidence in the conformance of the product. 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.

The recursive use of processes, i.e., the repeated application of the same process or set of processes applied to successive levels of system elements in a system's structure, is a key aspect of the application of this International Standard. The outputs of processes at any level, whether information, artefacts or services, are inputs to the same processes used at the level below (e.g., during top down design) or level above (e.g., during system realization). The outcomes from one application are used as inputs to the next lower (or higher) system in the system structure to arrive at a more detailed or mature set of outcomes. Such an approach adds value to successive systems in the system structure.

The changing nature of the influences on the system (e.g., operational environment changes, new opportunities for system element implementation, modified structure and responsibilities in organizations) requires continual review of the selection and timing of process use. Process use in the life cycle is thus dynamic, responding to the many external influences on the system. The life cycle approach also allows for incorporating the changes in the next stage. The life cycle stages assist the planning, execution and management of life cycle processes in the face of this complexity in life cycles by providing comprehensible and recognizable high-level purpose and structure. The set of processes within a life cycle stage are applied with the common goal of satisfying the exit criteria for that stage and/or the entry criteria of the formal progress reviews within that stage.

The discussion in this section on iterative and recursive use of the system life cycle processes is not meant to imply any specific hierarchical or horizontal system structure. Additional guidance for system life cycle process application is provided in *ISO/IEC TR 19760, A Guide for the application of ISO/IEC 15288 System life cycle processes*.

NOTE A future Technical Report (ISO/IEC TR 24748, *Guide for life cycle management*) will also provide further elaboration.

5.3.4 Process tailoring

Annex A, which is normative, defines the basic activities needed to perform tailoring of this International Standard. It should be noted that tailoring may diminish the perceived value of a claim of conformance to this standard. This 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 this standard may find it advantageous to claim full conformance to a smaller list of processes rather than tailored conformance to a larger list of processes.

6 System Life Cycle Processes

6.1 Agreement Processes

This subclause specifies the requirements for the establishment of agreements with organizational entities external and internal to the organization.

The Agreement Processes consist of the following:

a) Acquisition Process – used by organizations for acquiring products or services;

b) Supply Process – used by organizations for supplying products or services.

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These processes define the activities necessary to establish an agreement between two organizations. If the Acquisition Process is invoked, it provides the means for conducting business with a supplier: of products that are supplied for use as an operational system, of services in support of operational activities, or of elements of a system being developed by a project. If the Supply Process is invoked, it provides the means for conducting a project in which the result is a product or service that is delivered to the acquirer.

6.1.1 Acquisition Process

6.1.1.1 Purpose

The purpose of the Acquisition Process is to obtain a product or service in accordance with the acquirer's requirements.

6.1.1.2 Outcomes

As a result of the successful implementation of the Acquisition Process:

a) A strategy for the acquisition is established.

b) One or more suppliers are selected.

c) Communication with the supplier is maintained.

d) An agreement to acquire a product or service according to defined acceptance criteria is established.

e) A product or service complying with the agreement is accepted.

f) Payment or other consideration is rendered.

6.1.1.3 Activities and tasks

The acquirer shall implement the following activities and tasks in accordance with applicable organizational policies and procedures with respect to the Acquisition Process.

NOTE The activities and tasks in this process can apply to one or more suppliers.

a) **Prepare for the acquisition.** This activity consists of the following tasks:

1) Establish a strategy for how the acquisition will be conducted.

NOTE This strategy includes reference to the life cycle model, a schedule of milestones and selection criteria if the supplier is external to the acquiring organization.

2) Prepare a request for the supply of a product or service that includes the definition of requirements.

NOTE Provide a definition of requirements to one or more suppliers. If a supplier is external to organization, then the request can include the business practices with which a supplier is expected to comply and the criteria for selecting a supplier.

b) **Advertise the acquisition and select the supplier.** This activity consists of the following tasks:

1) Communicate the request for the supply of a product or service to identified suppliers.

NOTE This may include supply chain management partnering which exchanges information with related suppliers and acquirers to achieve a harmonized or collective approach to common technical and commercial issues.

2) Select one or more suppliers.

NOTE To obtain competitive solicitations, proposals to supply are evaluated and compared against the selection criteria. Where proposals include offerings that are not covered by the criteria, then the proposals are compared with

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each other to determine their order of suitability and thus supplier preference. The justification for rating each proposal is declared and suppliers may be informed why they were or were not selected.

c) **Initiate an agreement.** This activity consists of the following tasks:

1) Negotiate an agreement with the supplier.

NOTE This agreement may range in formality from a written contract to a verbal understanding. Appropriate to the level of formality, the agreement establishes requirements, development and delivery milestones, verification, validation and acceptance conditions, exception-handling procedures, change control procedures and payment schedules, so that both parties of the agreement understand the basis for executing the agreement. Rights and restrictions associated with technical data and intellectual property are noted in the agreement. The negotiation is complete when the acquirer accepts the terms of an agreement offered by the supplier.

2) Commence the agreement with the supplier.

d) **Monitor the agreement.** This activity consists of the following tasks:

1) Assess the execution of the agreement.

NOTE This includes confirmation that all parties are meeting their responsibilities according to the agreement. Projected cost, performance and schedule risks are monitored, and the impact of undesirable outcomes on the organization is evaluated regularly. Variations to the terms of the agreement are negotiated as necessary.

2) Provide data needed by the supplier and resolve issues in a timely manner.

e) **Accept the product or service.** This activity consists of the following tasks:

1) Confirm that the delivered product or service complies with the agreement.

NOTE Exceptions that arise during the conduct of the agreement or with the delivered product or service are resolved according to the procedures established in the agreement.

2) Make payment or provide other agreed consideration to the supplier for the product or service rendered that is required for closure of the agreement.

6.1.2 Supply Process

6.1.2.1 Purpose

The purpose of the Supply Process is to provide an acquirer with a product or service that meets agreed requirements.

6.1.2.2 Outcomes

As a result of the successful implementation of the Supply Process:

a) An acquirer for a product or service is identified.

b) A response to the acquirer's request is made.

c) An agreement to supply a product or service according to defined acceptance criteria is established.

d) Communication with the acquirer is maintained.

e) A product or service conforming to the agreement is supplied according to agreed delivery procedures and conditions.

f) Responsibility for the acquired product or service, as directed by the agreement, is transferred.

g) Payment or other agreed consideration is received.

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6.1.2.3 Activities and tasks

The supplier shall implement the following activities and tasks in accordance with applicable organizational policies and procedures with respect to the Supply Process.

a) **Identify opportunities.** This activity consists of the following task:

1) Determine the existence and identity of an acquirer who has, or who represents an organization or organizations having, a need for a product or service.

NOTE For a product or service developed for consumers, an agent, e.g., a marketing function within the supplier organization, may represent the acquirer.

b) **Respond to a tender.** This activity consists of the following tasks:

1) Evaluate a request for the supply of a product or service to determine feasibility and how to respond.

2) Prepare a response that satisfies the solicitation.

c) **Initiate an agreement.** This activity consists of the following tasks:

1) Negotiate an agreement with the acquirer.

NOTE This agreement may range in formality from a written contract to a verbal understanding. Negotiate the differences, where applicable, between the acquisition request or tasking statement and the capability expressed in the response. The Supplier confirms that the requirements, delivery milestones and acceptance conditions are achievable, that exception handling and change control procedures and payment schedules are acceptable, and that they establish a basis for executing the agreement without unnecessary risks. In the agreement or project plans, the supplier should define or select a life cycle model appropriate to the scope, magnitude, and complexity of the project. Ideally, this is performed by using an organizationally-defined life cycle model.

2) Commence the agreement with acquirer.

d) **Execute the agreement.** This activity consists of the following tasks:

1) Execute the agreement according to the Supplier's established project plans and in accordance with the agreement.

NOTE 1 A supplier may adopt, or agree to use, acquirer processes.

NOTE 2 Communication with the acquirer is maintained throughout the execution of the agreement.

2) Assess the execution of the agreement.

NOTE Projected cost, performance and schedule risks are monitored and communicated to the acquirer as appropriate. The impact of undesirable outcomes on the organization is evaluated.

e) **Deliver and support the product or service.** This activity consists of the following tasks:

1) Deliver the product or service in accordance with the agreement criteria.

2) Provide assistance to the acquirer in support of the delivered system or service in accordance with the agreement criteria.

f) **Close the agreement.** This activity consists of the following tasks**:**

1) Accept and acknowledge payment or other agreed consideration.

2) Transfer the responsibility for the product or service to the acquirer, or other party, as directed by the agreement to obtain closure of the agreement.

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6.2 Organizational Project-Enabling Processes

The Organizational Project-Enabling Processes ensure the organization's capability to acquire and supply products or services through the initiation, support and control of projects. They provide resources and infrastructure necessary to support projects and ensure the satisfaction of organizational objectives and established agreements. They are not intended to be a comprehensive set of business processes that enable strategic management of the organization's business.

The Organizational Project-Enabling Processes consist of the following:

a) Life Cycle Model Management Process;

b) Infrastructure Management Process;

c) Project Portfolio Management Process;

d) Human Resource Management Process;

e) Quality Management Process.

6.2.1 Life Cycle Model Management Process

6.2.1.1 Purpose

The purpose of the Life Cycle Model Management Process is to define, maintain, and assure availability of policies, life cycle processes, life cycle models, and procedures for use by the organization with respect to the scope of this International Standard.

This process provides life cycle policies, processes, models, and procedures that are consistent with the organization's objectives, that are defined, adapted, improved and maintained to support individual project needs within the context of the organization, and that are capable of being applied using effective, proven methods and tools.

6.2.1.2 Outcomes

As a result of the successful implementation of the Life Cycle Model Management Process:

a) Policies and procedures for the management and deployment of life cycle models and processes are provided.

b) Responsibility, accountability, and authority for life cycle management are defined.

c) Life cycle processes, models, and procedures for use by the organization are defined, maintained, and improved.

d) Prioritized process, model, and procedure improvements are implemented.

6.2.1.3 Activities and tasks

The organization shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Life Cycle Model Management Process.

a) **Establish the process.** This activity consists of the following tasks:

   1) Establish policies and procedures for process management and deployment that are consistent with organizational strategies.

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NOTE The actual range and detail of the life cycle implementation within a project will be dependent upon the complexity of the work, the methods used, and the skills and training of personnel involved in performing the work. A project tailors policies and procedures according to its requirements and needs.

2) Establish the processes that implement the requirements of this international standard and are consistent with organizational strategies.

3) Define, integrate, and communicate the roles, responsibilities and authorities to facilitate implementation of processes and the strategic management of life cycles.

4) Define business criteria that control progression through the life cycle.

NOTE Establish the decision-making criteria regarding entering and exiting each life cycle stage, and for other key milestones. Express these in terms of business achievement.

5) Establish standard life cycle models for the organization that are comprised of stages and the purposes and outcomes for each stage.

NOTE The life cycle model comprises one or more stage models, as needed. It is assembled as a sequence of stages that may overlap and/or iterate, as appropriate for the system-of-interest's scope, magnitude, complexity, changing needs and opportunities. Stages are illustrated in a future Technical Report (ISO/IEC TR 24748) using a commonly encountered example of life cycle stages. Specific examples for systems are provided in ISO/IEC TR 19760, *A Guide for the application of ISO/IEC 15288 System life cycle processes.* The life cycle processes and activities are selected, tailored as appropriate and employed in a stage to fulfil the purpose and outcomes of that stage.

b) **Assess the process.** This activity consists of the following tasks:

NOTE ISO/IEC 15504, *Process Assessment*, provides a more detailed set of activities and tasks that are aligned with the tasks shown below.

1) Monitor process execution, analyze process measures, and identify trends with respect to business criteria.

NOTE This should include feedback from the projects regarding the effectiveness and efficiency of the processes.

2) Conduct periodic reviews of the life cycle model used by a project.

NOTE Confirm the continuing suitability, adequacy and effectiveness of the life cycle models used by each project and make improvements as appropriate. This includes the stages, processes and achievement criteria that control progression through the life cycle.

3) Identify improvement opportunities from assessment results.

c) **Improve the process.** This activity consists of the following tasks:

1) Prioritize and plan improvement opportunities.

2) Implement improvement opportunities and communicate results through the organization.

6.2.2 Infrastructure Management Process

6.2.2.1 Purpose

The purpose of the Infrastructure Management Process is to provide the enabling infrastructure and services to projects to support organization and project objectives throughout the life cycle.

This process defines, provides and maintains the facilities, tools, and communications and information technology assets needed for the organization's business with respect to the scope of this International Standard.

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6.2.2.2 Outcomes

As a result of the successful implementation of the Infrastructure Management Process:

a) The requirements for infrastructure to support the organization's projects are defined.

b) The infrastructure elements are identified and specified.

c) Infrastructure elements are developed or acquired.

d) The infrastructure elements are implemented.

e) A stable and reliable infrastructure is maintained and improved.

NOTE The infrastructure may include hardware, software, services, methods, tools, techniques, standards, and facilities for development, operation, or maintenance.

6.2.2.3 Activities and tasks

The organization shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Infrastructure Management Process.

a) **Establish the infrastructure.** This activity consists of the following tasks:

1) Define project infrastructure requirements and business constraints that influence and control provision of infrastructure resources and services for the project.

NOTE Consider the infrastructure resource needs for the project in context with other projects and resource within the organization, as well as policies and strategic plans of the organization. Project plans and future business needs contribute to the understanding of the resource infrastructure that is required. Physical factors, such as facilities, and human factors, such as ambient noise level, of the work environment are defined.

2) Identify, obtain and provide infrastructure resources and services that are needed to implement and support projects.

b) **Maintain the infrastructure.** This activity consists of the following tasks:

1) Continuously or routinely communicate with projects to determine the degree to which delivered infrastructure resources satisfy their needs.

2) Identify and provide improvements or changes to the infrastructure resources as the project requirements change.

6.2.3 Project Portfolio Management Process

6.2.3.1 Purpose

The purpose of the Project Portfolio Management Process is to initiate and sustain necessary, sufficient and suitable projects in order to meet the strategic objectives of the organization.

This process commits the investment of adequate organization funding and resources, and sanctions the authorities needed to establish selected projects. It performs continued qualification of projects to confirm they justify, or can be redirected to justify, continued investment.

NOTE This process is applied within the system context. The projects in question are focused on the systems-of-interest for the organization.

6.2.3.2 Outcomes

As a result of the successful implementation of the Project Portfolio Management Process:

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a) Business venture opportunities, investments or necessities are qualified, prioritized and selected.

b) Resources and budgets for each project are identified and allocated.

c) Project management accountability and authorities are defined.

d) Projects meeting agreement and stakeholder requirements are sustained.

e) Projects not meeting agreement or stakeholder requirements are redirected or terminated.

6.2.3.3 Activities and tasks

The organization shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Project Portfolio Management Process.

a) **Initiate projects.** This activity consists of the following tasks:

1) Identify, prioritize, select and establish new business opportunities, ventures or undertakings consistent with the business strategy and action plans of the organization.

NOTE Prioritize the projects to be started and establish thresholds to determine which projects will be executed.

2) Define projects, accountabilities and authorities.

3) Identify the expected goals, objectives, and outcomes of the projects.

4) Identify and allocate resources for the achievement of project goals and objectives.

5) Identify any multi-project interfaces and dependencies that must be managed or supported by the project.

NOTE This includes the use of enabling systems used by more than one project and the use of common system elements by more than one project.

6) Specify the project reporting requirements and review milestones that will govern the execution of the project.

7) Authorize the project to commence execution of approved project plans, including the technical plans.

b) **Evaluate the portfolio of projects.** This activity consists of the following tasks:

1) Evaluate ongoing projects to confirm that:

i) projects are making progress towards achieving established goals and objectives;

ii) projects are complying with project directives;

iii) projects are being conducted according to system life cycle policies, processes, and procedures;

iv) projects remain viable, as indicated by, for example, continuing need for the service, practicable product implementation, acceptable investment benefits.

2) Act to continue or redirect projects that are satisfactorily progressing or can be expected to progress satisfactorily by appropriate redirection.

c) **Close projects.** This activity consists of the following tasks:

1) Where agreements permit, act to cancel or suspend projects whose disadvantages or risks to the organization outweigh the benefits of continued investments.

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2) After completion of the agreement for products and services, act to close the project per organizational policies and procedures and the agreement.

NOTE Ensure project closure accounts for documentation retention by the organization after the project is closed.

6.2.4 Human Resource Management Process

6.2.4.1 Purpose

The purpose of the Human Resource Management Process is to ensure the organization is provided with necessary human resources and to maintain their competencies, consistent with business needs.

This process provides a supply of skilled and experienced personnel qualified to perform life cycle processes to achieve organization, project and customer objectives.

6.2.4.2 Outcomes

As a result of the successful implementation of the Human Resource Management Process:

a) Skills required by projects are identified.

b) Necessary human resources are provided to projects.

c) Skills of personnel are developed, maintained or enhanced.

d) Conflicts in multi-project resource demands are resolved.

e) Individual knowledge, information and skills are collected, shared, reused and improved throughout the organization.

6.2.4.3 Activities and tasks

The organization shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Human Resource Management Process:

a) **Identify skills.** This activity consists of the following tasks:

1) Identify skill needs based on current and expected projects.

2) Identify and record skills of personnel.

b) **Develop skills.** This activity consists of the following tasks:

1) Establish skills development plan.

NOTE This plan includes types and levels of training, categories of personnel, schedules, resource requirements, and training needs.

2) Obtain or develop training, education or mentoring resources.

NOTE These resources include training materials that are developed by the organization or external parties, training courses that are available from external suppliers, computer based instruction, etc.

3) Provide planned skill development.

4) Maintain records of skill development.

c) **Acquire and provide skills.** This activity consists of the following tasks:

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NOTE This includes: the recruitment and retention of personnel with experience levels and skills necessary to properly staff projects; staff assessment and review, e.g., their proficiency, motivation, ability to work in a team environment, as well as the need to be retrained, reassigned or reallocated.

1) Obtain qualified personnel when skill deficits are identified based on plans.

NOTE This includes using outsourced resources.

2) Maintain and manage the pool of skilled personnel necessary to staff ongoing projects.

3) Make project assignments based on project and staff-development needs.

4) Motivate personnel, e.g., through career development and reward mechanisms.

5) Control multi-project management interfaces to resolve multi-project schedule conflicts:

   i) of capacity in organizational infrastructure and supporting services and resources among ongoing projects;

   ii) from project personnel being over-committed.

d) **Perform knowledge management.** This activity consists of the following tasks:

1) Establish and maintain infrastructure for sharing common and domain information across the organization.

2) Select an appropriate knowledge management strategy.

3) Capture and maintain information for access by the organization per the strategy.

6.2.5 Quality Management Process

6.2.5.1 Purpose

The purpose of the Quality Management Process is to assure that products, services and implementations of life cycle processes meet organization quality objectives and achieve customer satisfaction.

6.2.5.2 Outcomes

As a result of the successful implementation of the Quality Management Process:

a) Organization quality management policies and procedures are defined.

b) Organization quality objectives are defined.

c) Accountability and authority for quality management are defined.

d) The status of customer satisfaction is monitored.

e) Appropriate action is taken when quality objectives are not achieved.

6.2.5.3 Activities and tasks

The organization shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Quality Management Process.

a) **Plan quality management.** This activity consists of the following tasks**:**

1) Establish quality management policies, standards and procedures.

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NOTE A process model for quality management systems can be found in ISO 9001:2000. For organizations wishing to move beyond ISO 9001:2000, in pursuit of continual improvement of performance, guidance is provided in ISO 9004:2000.

2) Establish organization quality management objectives based on business strategy for customer satisfaction.

3) Define responsibilities and authority for implementation of quality management.

b) **Assess quality management.** This activity consists of the following tasks**:**

1) Assess customer satisfaction and report.

NOTE The implementation of this International Standard provides the organization with an approach to achieving customer satisfaction.

2) Conduct periodic reviews of project quality plans.

NOTE Assure that quality objectives based on the stakeholder requirements are established for each project.

3) The status of quality improvements on products and services is monitored.

c) **Perform quality management corrective action.** This activity consists of the following tasks:

1) Plan corrective actions when quality management goals are not achieved.

2) Implement corrective actions and communicate results through the organization.

6.3 Project Processes

The Project Processes are used 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. Individual Project Processes may be invoked at any time in the life cycle and at any level in a hierarchy of projects, as required by project plans or unforeseen events. The Project Processes are applied with a level of rigour and formality that depends on the risk and complexity of the project.

The Project Processes are divided into two categories; Project Management and Project Support. These process categories consist of the following processes:

NOTE This set of project processes, even though further divided into categories, are simply a set of non-engineering processes conducted within the range of responsibility of a project that need to be defined in order that system-specific technical processes can be conducted effectively. They should not be interpreted as being a comprehensive set of processes for project management, as that is not the scope of this standard.

a) **Project Management Processes.** This category consists of the following processes**:**

1) Project Planning Process;

2) Project Assessment and Control Process.

b) **Project Support Processes.** This category consists of the following processes**:**

1) Decision Management Process;

2) Risk Management Process;

3) Configuration Management Process;

4) Information Management Process;

5) Measurement Process.

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The Project Management processes (planning and assessment and control) are key to all management practices. These processes establish the general approach for managing a project or a process. The Project Support processes provide a specific focused set of tasks for performing a specialized management objective. They are all evident in the management of any undertaking, ranging from a complete organization down to a single life cycle process and its tasks. In this International Standard, the project has been chosen as the context for describing processes concerned with planning, execution, and assessment and control.

6.3.1 Project Planning Process

6.3.1.1 Purpose

The purpose of the Project Planning Process is to produce and communicate effective and workable project plans.

This process determines the scope of the project management and technical activities, identifies process outputs, project tasks and deliverables, establishes schedules for project task conduct, including achievement criteria, and required resources to accomplish project tasks.

6.3.1.2 Outcomes

As a result of the successful implementation of the Project Planning Process:

a) Project plans are available.

b) Roles, responsibilities, accountabilities, and authorities are defined.

c) Resources and services necessary to achieve the project objectives are formally requested and committed.

d) Project staff are directed in accordance with the project plans.

e) Plans for the execution of the project are activated.

6.3.1.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Planning Process.

a) **Define the project.** This activity consists of the following tasks**:**

1) Identify the project objectives and constraints.

NOTE Objectives and constraints include performance and other quality aspects, cost, time and stakeholder satisfaction. Each objective is identified with a level of detail that permits selection, tailoring and implementation of the appropriate processes and activities.

2) Define the project scope as established in the agreement.

NOTE The project includes all the relevant activities required to satisfy business decision criteria and complete the project successfully. A project can have responsibility for one or more stages in the complete system life cycle. Planning includes appropriate actions for maintaining project plans, performing assessments and controlling the project.

3) Define and maintain a life cycle model that is comprised of stages using the defined life cycle models of the organization.

4) Establish a work breakdown structure based on the evolving system architecture.

NOTE Each element of the system architecture, and appropriate processes and activities are described with a level of detail that is consistent with identified risks. Related tasks in the work breakdown structure are grouped into

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project tasks according to organizational responsibilities. Project tasks identify every work item being developed or produced and its associated tasks.

b) **Plan the project resources.** This activity consists of the following tasks**:**

1) Define and maintain a project schedule based on project objectives and work estimates.

NOTE This includes definition of the duration, relationship, dependencies and sequence of project activities, achievement milestones, resources employed and the reviews and schedule reserves for risk management necessary to achieve timely completion of the project.

2) Define project achievement criteria for the life cycle stage decision gates, delivery dates and major dependencies on external inputs or outputs.

NOTE The time intervals between internal project reviews are defined in accordance with organizational policy on issues such as business and system criticality, schedule and technical risks.

3) Define the project costs and plan a budget.

NOTE Costs are based on, e.g., the project schedule, labour estimates, infrastructure costs, procurement items, acquired service and enabling system estimates, and budget reserves for risk management.

4) Establish the structure of authorities and responsibilities for project work.

NOTE This includes defining the project organization, staff acquisitions, the development of staff skills and the methods of team working. Responsibilities include the effective use of human resources, drawing on organizational functions that contribute to all stages of the system life cycle. The structure of authority is designated, including, as appropriate, the legally responsible roles and individuals, e.g., design authorization, safety authorization, award of certification or accreditation.

5) Define the infrastructure and services required by the project.

NOTE This includes defining the capacity needed, its availability and its allocation to project tasks. Also included are facilities, tools, communications and information technology assets. The requirements for enabling systems for each life cycle stage within the scope of the project are also specified.

6) Plan the acquisition of materials, goods and enabling system services supplied from outside the project.

NOTE This includes, as necessary, plans for solicitation, supplier selection, acceptance, contract administration and contract closure. The agreement processes are used for the planned acquisitions.

c) **Plan the project technical and quality management.** This activity consists of the following tasks**:**

1) Generate and communicate a plan for technical management and execution of the project, including reviews.

2) Generate a project quality plan.

NOTE This includes defining and documenting project quality objectives that assure that the quality management policies and procedures of the organization are attained. Plan in accordance with ISO 9001:2000 or other quality standards.

d) **Activate the project.** This activity consists of the following tasks**:**

1) Obtain authorization for the project.

2) Submit requests and obtain commitments for necessary resources to perform the project.

3) Initiate the implementation of the project plans to satisfy the objectives and criteria set, exercising control over the project.

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6.3.2 Project Assessment and Control Process

6.3.2.1 Purpose

The purpose of the Project Assessment and Control Process is to determine the status of the project and direct project plan execution to ensure that the project performs according to plans and schedules, within projected budgets, to satisfy technical objectives.

This process evaluates, periodically and at major events, the progress and achievements against requirements, plans and overall business objectives. Information is communicated for management action when significant variances are detected. This process also includes redirecting the project activities and tasks, as appropriate, to correct identified deviations and variations from other project management or technical processes. Redirection may include re-planning as appropriate.

6.3.2.2 Outcomes

As a result of the successful implementation of the Project Assessment and Control Process:

a) Project performance measures or assessment results are available.

b) Adequacy of roles, responsibilities, accountabilities, authorities and resources and services necessary to achieve the project is assessed.

c) Deviations in project performance indicators are analyzed.

d) Affected parties are informed of project status.

e) Corrective action is defined and directed, when project achievement is not meeting planned targets.

f) Project re-planning is initiated when project objectives or constraints have changed, or when planning assumptions are shown to be invalid.

g) Project action to progress (or not) from one scheduled milestone or event to the next is authorized.

h) Project objectives are achieved.

6.3.2.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Project Assessment and Control Process.

a) **Assess the project.** This activity consists of the following tasks:

   1) Assess project status against appropriate project plans to determine actual and projected cost, schedule and quality variations.

   2) Perform quality assurance in accordance with project plans.

   3) Assess the effectiveness of project team structure, roles, responsibilities, accountabilities, and authorities.

   NOTE This includes assessment of the adequacy of team member competencies to perform project roles and accomplish project tasks. Use objective measures wherever possible, e.g., efficiency of resource use, project achievement.

   4) Assess the adequacy and availability of the project's supporting infrastructure.

   NOTE This includes confirming that intra-organizational commitments are satisfied.

   5) Assess project progress using measured achievement and milestone completion.

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NOTE Collect and evaluate at planned times the actual or estimated labour, material and service costs. Compare against defined project measures of achievement. This includes conducting effectiveness assessments to determine the adequacy of the evolving system against requirements. It also includes the readiness of enabling systems to deliver their services when needed.

6) Conduct required management and technical reviews, audits and inspections to determine readiness to proceed to the next stage of the system life cycle or project milestone.

7) Monitor critical processes and new technologies.

NOTE This includes identifying and evaluating technology insertion according to project plans.

8) Analyze measurement results to identify deviations or variations from planned values or status and make appropriate recommendations for corrections.

NOTE This includes, where appropriate, statistical analysis of measures that indicates trends, e.g., fault density to indicate quality of outputs, distribution of measured parameters that indicate process repeatability.

9) Provide periodic status reports and required deviation reports as designated in the agreement, policies and procedures.

b) **Control the project.** This activity consists of the following tasks:

1) Manage project requirements and changes to requirements in accordance with the project plans.

2) Initiate the corrective actions needed to achieve the goals and outputs of project tasks that have deviated outside acceptable or defined limits.

NOTE Corrective action may include re-planning or re-deployment and re-assignment of personnel, tools and project infrastructure assets when inadequacy or unavailability has been detected.

3) Initiate preventive actions, as appropriate, to ensure achievement of the goals and outputs of the project.

4) Initiate problem resolution actions to correct non-conformances.

NOTE This includes performing corrective actions to the implementation and execution of the life cycle processes when non-conformances are traced to them. Actions are documented and reviewed to confirm their adequacy and timeliness.

5) Evolve with time the scope, definition and the related breakdown of the work to be carried out by the project in response to the corrective action decisions taken and the estimated changes they introduce.

6) Initiate change actions when there is a contractual change to cost, time or quality due to the impact of an acquirer or supplier request.

7) Act to correct defective provision of acquired goods and services through constructive interaction with the supplier.

NOTE This may include consideration of modified terms and conditions for supply or initiating new supplier selection.

8) Authorize the project to proceed toward the next milestone or event if justified.

c) Close the project. This activity consists of the following tasks:

1) When all activities and tasks are completed, determine whether the project is complete, taking into account the criteria as specified in the agreement or as part of organization's procedure.

2) Archive the results and records in a suitable environment as specified in the agreement.

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6.3.3 Decision Management Process

6.3.3.1 Purpose

The purpose of the Decision Management Process is to select the most beneficial course of project action where alternatives exist.

This process responds to a request for a decision encountered during the system life cycle, whatever its nature or source, in order to reach specified, desirable or optimized outcomes. Alternative actions are analyzed and a course of action selected and directed. Decisions and their rationale are recorded to support future decision-making.

6.3.3.2 Outcomes

As a result of the successful implementation of the Decision Management Process:

a) A decision management strategy is defined.

b) Alternative courses of action are defined.

c) A preferred course of action is selected.

d) The resolution, decision rationale and assumptions are captured and reported.

6.3.3.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Decision Management Process.

a) **Plan and define decisions.** This activity consists of the following tasks:

1) Define a decision management strategy.

NOTE A decision management strategy includes the identification and allocation of responsibility for, and authority to make, decisions and the identification of decision categories and a prioritization scheme. Decisions may arise as a result of an effectiveness assessment, a technical trade-off, a problem needing to be solved, an action needed as a response to risk exceeding the acceptable threshold, a new opportunity or approval for project progression to the next life cycle stage. Organization or project guidelines should be followed for the determination of the degree of rigor and formality to apply to the decision analysis.

2) Identify the circumstances and need for a decision.

NOTE Record, categorize and promptly and objectively report problems or opportunities and the alternative courses of action that will resolve their outcome.

3) Involve relevant parties in the decision-making in order to draw on experience and knowledge.

b) **Analyze the decision information.** This activity consists of the following tasks:

1) Select and declare the decision management strategy for each decision situation.

2) Identify desired outcomes and measurable success criteria.

3) Evaluate the balance of consequences of alternative actions, using the defined decision management strategy, to arrive at an optimization of, or an improvement in, an identified decision situation.

c) **Track the decision.** This activity consists of the following tasks:

1) Record, track, evaluate and report decision outcomes to confirm that problems have been effectively resolved, adverse trends have been reversed and advantage has been taken of opportunities.

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2) Maintain records of problems and opportunities and their disposition, as stipulated in agreements or organizational procedures and in a manner that permits auditing and learning from experience.

6.3.4 Risk Management Process

6.3.4.1 Purpose

The purpose of the Risk Management Process is to identify, analyze, treat and monitor the risks continuously.

The Risk Management Process is a continuous process for systematically addressing risk throughout the life cycle of a system product or service. It can be applied to risks related to the acquisition, development, maintenance or operation of a system.

6.3.4.2 Outcomes

As a result of the successful implementation of the Risk Management Process:

a) The scope of risk management to be performed is determined.

b) Appropriate risk management strategies are defined and implemented.

c) Risks are identified as they develop and during the conduct of the project.

d) Risks are analyzed, and the priority in which to apply resources to treatment of these risks is determined.

e) Risk measures are defined, applied, and assessed to determine changes in the status of risk and the progress of the treatment activities.

f) Appropriate treatment is taken to correct or avoid the impact of risk based on its priority, probability, and consequence or other defined risk threshold.

6.3.4.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Risk Management Process.

NOTE ISO/IEC 16085, *Risk Management*, provides a more detailed set of activities and tasks that are aligned with the activities and tasks shown below.

a) **Plan risk management.** This activity consists of the following tasks:

1) Define risk management policies.

2) Document the risk management process to be implemented.

3) Identify the responsible parties and their roles and responsibilities.

4) Provide the responsible parties with adequate resources to perform risk management.

5) Define the process for evaluating and improving the Risk Management Process.

NOTE This includes the capture of lessons learned.

b) **Manage the risk profile.** This activity consists of the following tasks:

1) Define and document the context of the Risk Management Process.

NOTE This includes a description of stakeholders' perspectives, risk categories, and a description (perhaps by reference) of the technical and managerial objectives, assumptions and constraints.

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2) Define and document the risk thresholds and conditions under which a level of risk may be accepted.

3) Establish and maintain a risk profile.

NOTE The risk profile records: the risk management context; a record of each risk's state including its probability, consequences, and risk thresholds; the priority of each risk based on risk criteria supplied by the stakeholders; and the risk action requests along with the status of their treatment. The risk profile is updated when there are changes in an individual risk's state. The priority in the risk profile is used to determine the application of resources for treatment.

4) Periodically communicate the relevant risk profile to stakeholders based upon their needs.

c) **Analyze risks.** This activity consists of the following tasks:

1) Identify risks in the categories described in the risk management context.

2) Estimate the probability of occurrence and consequences of each identified risk.

3) Evaluate each risk against its risk thresholds.

4) For each risk that is above its risk threshold, define and document recommended treatment strategies and measures indicating the effectiveness of the treatment alternatives.

NOTE Risk treatment strategies include, but are not limited to, eliminating the risk, reducing its probability of occurrence or severity of consequence, or accepting the risk,

d) **Treat risks.** This activity consists of the following tasks:

1) Provide stakeholders with recommended alternatives for risk treatment in risk action requests.

2) Implement risk treatment alternatives for which the stakeholders determine that actions should be taken to make a risk acceptable.

3) When the stakeholders accept a risk that exceeds its threshold, consider it a high priority and monitor it continuously to determine if any future risk treatment actions are necessary.

4) Once a risk treatment is selected, ensure management actions in accordance with the assessment and control activities in 6.3.2.3 of this standard.

e) **Monitor risks.** This activity consists of the following tasks:

1) Continuously monitor all risks and the risk management context for changes and evaluate the risks when their state has changed.

2) Implement and monitor measures to evaluate the effectiveness of risk treatments.

3) Continuously monitor for new risks and sources throughout the life cycle.

f) **Evaluate the Risk Management Process.** This activity consists of the following tasks:

1) Throughout the life cycle, collect risk information for purposes of improving the Risk Management Process and generating lessons learned.

NOTE The risk information includes the risks identified, their sources, their causes, their treatment, and the success of the treatments selected.

2) Periodically review the Risk Management Process for its effectiveness and efficiency.

3) Periodically review risk information on the risks identified, their treatment, and the success of the treatments for the purposes of identifying systemic project and organizational risks.

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6.3.5 Configuration Management Process

6.3.5.1 Purpose

The purpose of the Configuration Management Process is to establish and maintain the integrity of all identified outputs of a project or process and make them available to concerned parties.

6.3.5.2 Outcomes

As a result of the successful implementation of the Configuration Management Process:

a) A configuration management strategy is defined.

b) Items requiring configuration management are defined.

c) Configuration baselines are established.

d) Changes to items under configuration management are controlled.

e) The configuration of released items is controlled.

f) The status of items under configuration management is made available throughout the life cycle.

6.3.5.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Configuration Management Process.

a) **Plan configuration management.** This activity consists of the following tasks:

1) Define a configuration management strategy.

NOTE This includes defining authorities for the disposition of, access to, release of and control of changes to configuration items; defining the locations and conditions of storage, their environment and, in the case of information, storage media, in accordance with designated levels of integrity, security and safety; defining the criteria or events for commencing configuration control and maintaining baselines of evolving configurations and defining the audit strategy and the responsibilities for ensuring continuous integrity and security of the configuration definition information. Additional guidance regarding configuration management activities can be found in ISO 10007.

2) Identify items that are subject to configuration control.

NOTE Items are distinguished by unique, durable identifiers or markings, where appropriate. The identifiers are in accordance with relevant standards and product sector conventions, such that the items under configuration control are unambiguously traceable to their specifications or equivalent, documented descriptions.

b) **Perform configuration management.** This activity consists of the following tasks:

1) Maintain information on configurations with an appropriate level of integrity and security.

NOTE This includes taking into account the nature of the items under configuration control. Configuration descriptions conform, where possible, to product or technology standards. Ensure that configuration information permits forward and backward traceability to other baselined configuration states. Consolidate the evolving configuration states of configuration items to form documented baselines at designated times or under defined circumstances. Record the rationale for the baseline and associated authorizations in configuration baseline data. Maintain configuration records through the system life cycle and archive them according to agreements, relevant legislation or best industry practice.

2) Ensure that changes to configuration baselines are properly identified, recorded, evaluated, approved, incorporated, and verified.

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NOTE Consolidate the evolving configuration states of configuration items to form documented baselines at designated times or under defined circumstances. Record the steps of configuration, the rationale for the baseline and associated authorizations in configuration baseline data. Maintain configuration records through the system life cycle and archive them according to agreements, relevant legislation or best industry practice. Manage the recording, retrieval and consolidation of the current configuration status and the status of all preceding configurations to confirm information correctness, timeliness, integrity and security. Perform audits to verify conformance of a baseline to drawings, interface control documents and other agreement requirements.

6.3.6 Information Management Process

6.3.6.1 Purpose

The purpose of the Information Management Process is to provide relevant, timely, complete, valid and, if required, confidential information to designated parties during and, as appropriate, after the system life cycle.

This process generates, collects, transforms, retains, retrieves, disseminates and disposes of information. It manages designated information, including technical, project, organizational, agreement and user information.

6.3.6.2 Outcomes

As a result of the successful implementation of the Information Management Process:

a) Information to be managed is identified.

b) The forms of the information representations are defined.

c) Information is transformed and disposed of as required.

d) The status of information is recorded.

e) Information is current, complete and valid.

f) Information is made available to designated parties.

6.3.6.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Information Management Process.

NOTE ISO/IEC 15289 summarizes requirements for information items (documentation) and provides guidance on their development.

a) **Plan information management.** This activity consists of the following tasks:

1) Define the items of information that will be managed during the system life cycle and, according to organizational policy, agreements, or legislation, maintained for a defined period beyond.

2) Designate authorities and responsibilities regarding the origination, generation, capture, archiving and disposal of items of information.

3) Define the rights, obligations and commitments regarding the retention of, transmission of and access to information items.

NOTE Due regard is paid to information and data legislation, security and privacy, e.g., ownership, agreement restrictions, rights of access, intellectual property and patents. Where restrictions or constraints apply, information is identified accordingly. Staff having knowledge of such items of information are informed of their obligations and responsibilities.

4) Define the content, semantics, formats and medium for the representation, retention, transmission and retrieval of information.

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NOTE The information may originate and may terminate in any form (e.g., verbal, textual, graphical, numerical) and may be stored, processed, replicated and transmitted using any medium (e.g., electronic, printed, magnetic, optical). Pay due regard to organization constraints, e.g., infrastructure, inter-organizational communications, distributed project working. Relevant information storage, transformation, transmission and presentation standards and conventions are used according to policy, agreements and legislation constraints.

5) Define information maintenance actions.

NOTE This includes status reviews of stored information for integrity, validity and availability and any needs for replication or transformation to an alternative medium. Consider the need to either retain infrastructure as technology changes so that archived media can be read or the need to re-record archived media using newer technology.

b) **Perform information management.** This activity consists of the following tasks:

1) Obtain the identified items of information.

NOTE This may include generating the information or collecting it from appropriate sources.

2) Maintain information items and their storage records according to integrity, security and privacy requirements.

NOTE Record the status of information items, e.g., version description, record of distribution, security classification. Information should be legible and stored and retained in such a way that it is readily retrievable in facilities that provide a suitable environment, and that prevent damage, deterioration and loss.

3) Retrieve and distribute information to designated parties as required by agreed schedules or defined circumstances.

NOTE Information is provided to designated parties in an appropriate form.

4) Provide official documentation as required.

NOTE Examples of official documentation are certification, accreditation, license and assessment ratings.

5) Archive designated information, in accordance with the audit, knowledge retention, and project closure purposes.

NOTE Select the media, location and protection of the information in accordance with the specified storage and retrieval periods, and with organization policy, agreements and legislation. Ensure arrangements are in place to retain necessary documentation after project closure.

6) Dispose of unwanted, invalid or unverifiable information according to organization policy, and security and privacy requirements.

6.3.7 Measurement Process

6.3.7.1 Purpose

The purpose of the Measurement Process is to collect, analyze, and report data relating to the products developed and processes implemented within the organization, to support effective management of the processes, and to objectively demonstrate the quality of the products.

6.3.7.2 Outcomes

As a result of successful implementation of the Measurement Process:

a) The information needs of technical and management processes are identified.

b) An appropriate set of measures, driven by the information needs are identified and/or developed.

c) Measurement activities are identified and planned.

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d) The required data is collected, stored, analyzed, and the results interpreted.

e) Information products are used to support decisions and provide an objective basis for communication.

f) The measurement process and measures are evaluated.

g) Improvements are communicated to the measurement process owner.

6.3.7.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Measurement Process.

NOTE 1 ISO/IEC 15939, *Measurement Process*, provides a more detailed set of activities and tasks that are aligned with the activities and tasks shown below.

NOTE 2 Clause 8 of ISO 9001:2000 specifies Quality Management System requirements for measurement and monitoring of processes and products.

a) **Plan Measurement.** This activity consists of the following tasks:

1) Describe the characteristics of the organization that are relevant to measurement.

2) Identify and prioritize the information needs.

3) Select and document measures that satisfy the information needs.

4) Define data collection, analysis, and reporting procedures.

5) Define criteria for evaluating the information products and the Measurement Process.

6) Review, approve, and provide resources for measurement tasks.

7) Acquire and deploy supporting technologies.

b) **Perform measurement.** This activity consists of the following tasks:

1) Integrate procedures for data generation, collection, analysis and reporting into the relevant processes.

2) Collect, store, and verify data.

3) Analyze data and develop information products.

4) Document and communicate results to the measurement users.

c) **Evaluate measurement.** This activity consists of the following tasks:

1) Evaluate information products and the Measurement Process.

2) Identify and communicate potential improvements.

6.4 Technical Processes

The Technical Processes are used to define the requirements for a system, to transform the requirements into an effective product, to permit consistent reproduction of the product where necessary, to use the product to provide the required services, to sustain the provision of those services and to dispose of the product when it is retired from service.

The Technical Processes define the activities that enable organization and project functions to optimize the benefits and reduce the risks that arise from technical decisions and actions. These activities enable products

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and services to possess the timeliness and availability, the cost effectiveness, and the functionality, reliability, maintainability, producibility, usability and other qualities required by acquiring and supplying organizations. They also enable products and services to conform to the expectations or legislated requirements of society, including health, safety, security and environmental factors.

The Technical Processes consist of the following processes:

a) Stakeholder Requirements Definition Process;

b) Requirements Analysis Process;

c) Architectural Design Process;

d) Implementation Process;

e) Integration Process;

f) Verification Process;

g) Transition Process;

h) Validation Process;

i) Operation Process;

j) Maintenance Process;

k) Disposal Process.

NOTE For software and hardware system elements, these processes can be applied at recursively lower levels for system design and recursively higher levels for system realization to obviate the need to have separate, discipline-specific processes for stakeholder requirements definition, requirement analysis, architecture design, integration, and verification (qualification testing).

6.4.1 Stakeholder Requirements Definition Process

6.4.1.1 Purpose

The purpose of the Stakeholder Requirements Definition Process is to define the requirements for a system that can provide the services needed by users and other stakeholders in a defined environment.

It identifies stakeholders, or stakeholder classes, involved with the system throughout its life cycle, and their needs, expectations, and desires. It analyzes and transforms these into a common set of stakeholder requirements that express the intended interaction the system will have with its operational environment and that are the reference against which each resulting operational service is validated.

6.4.1.2 Outcomes

As a result of the successful implementation of the Stakeholder Requirements Definition Process:

a) The required characteristics and context of use of services and operational concepts are specified.

b) The constraints on a system solution are defined.

c) Traceability of stakeholder requirements to stakeholders and their needs is achieved.

d) The stakeholder requirements are defined.

e) Stakeholder requirements for validation are identified.

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6.4.1.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Stakeholder Requirements Definition Process.

a) **Elicit stakeholder requirements.** This activity consists of the following tasks:

1) Identify the individual stakeholders or stakeholder classes who have a legitimate interest in the system throughout its life cycle.

NOTE This includes, but is not limited to, users, operators, supporters, developers, producers, trainers, maintainers, disposers, acquirer and supplier organizations, parties responsible for external interfacing entities, regulatory bodies and members of society. Where direct communication is not practicable (e.g., for consumer products and services), representatives or designated proxy stakeholders are selected.

2) Elicit stakeholder requirements from the identified stakeholders.

NOTE Stakeholder requirements describe the needs, wants, desires, expectations and perceived constraints of identified stakeholders. They are expressed in terms of a model that may be textual or formal, that concentrates on system purpose and behaviour, and that is described in the context of the operational environment and conditions. A product quality model and quality requirements, such as found in ISO/IEC 9126-1 and ISO/IEC 25030, may be useful for aiding this activity. Stakeholder requirements include the needs and requirements imposed by society, the constraints imposed by an acquiring organization and the capabilities and operational characteristics of users and operator staff. It is useful to cite sources, including solicitation documents or agreements, and, where possible, their justification and rationale, and the assumptions of stakeholders and the value they place on the satisfaction of their requirements. For key stakeholder needs, the measures of effectiveness are defined so that operational performance can be measured and assessed. If significant risks are likely to arise from issues (i.e., needs, wants, constraints, limits, concerns, barriers, factors or considerations) relating to people (users and other stakeholders) and their involvement in or interaction with a system at any time in the life cycle of that system, recommendations for identifying and treating human-system issues can be found in ISO PAS 18152, *A specification for the process assessment of human-system issues*.

b) **Define stakeholder requirements.** This activity consists of the following tasks:

1) Define the constraints on a system solution that are unavoidable consequences of existing agreements, management decisions and technical decisions.

NOTE These may result from 1) instances or areas of stakeholder-defined solution; 2) implementation decisions made at higher levels of system hierarchical structure; 3) required use of defined enabling systems, resources and staff.

2) Define a representative set of activity sequences to identify all required services that correspond to anticipated operational and support scenarios and environments.

NOTE Scenarios are used to analyze the operation of the system in its intended environment in order to identify requirements that may not have been formally specified by any of the stakeholders, e.g., legal, regulatory and social obligations. The context of use of the system is identified and analyzed. Include in the context analysis the activities that users perform to achieve system objectives, the relevant characteristics of the end users of the system (e.g., expected training, degree of fatigue), the physical environment (e.g., available light, temperature) and any equipment to be used (e.g., protective or communication equipment). The social and organizational influences on users that could affect system use or constrain its design are analyzed when applicable.

3) Identify the interaction between users and the system.

NOTE Usability requirements are determined, establishing, as a minimum, the most effective, efficient, and reliable human performance and human-system interaction. The interaction should take into account human capabilities and skills limitations. Where possible, applicable standards, e.g., ISO 9241, and accepted professional practices are used in order to define:

i) Physical, mental, and learned capabilities.

ii) Work place, environment and facilities, including other equipment in the context of use.

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iii) Normal, unusual, and emergency conditions.

iv) Operator and user recruitment, training and culture.

If usability is important, usability requirements should be planned, specified, and implemented through the life cycle processes, and the following standards or technical reports may be applicable:

i) ISO 9241-11:1998, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 11: Guidance on usability*.

ii) ISO 13407:1999, *Ergonomics — Ergonomics of human-system interaction — Human-centred design process for interactive systems*.

4) Specify health, safety, security, environment and other stakeholder requirements and functions that relate to critical qualities.

NOTE Identify safety risk and, if warranted, specify requirements and functions to provide safety. This includes risks associated with methods of operations and support, health and safety, threats to property and environmental influences. Use applicable standards, e.g., IEC 61508, and accepted professional practices. Identify security risk and, if warranted, specify all applicable areas of system security, including physical, procedural, communications, computers, programs, data and emissions. Identify functions that could impact the security of the system, including access and damage to protected personnel, properties and information, compromise of sensitive information, and denial of approved access to property and information. Specify the required security functions, including mitigation and containment, referencing applicable standards and accepted professional practices where mandatory or relevant.

c) **Analyze and maintain stakeholder requirements.** This activity consists of the following tasks:

1) Analyze the complete set of elicited requirements.

NOTE Analysis includes identifying and prioritizing the conflicting, missing, incomplete, ambiguous, inconsistent, incongruous or unverifiable requirements.

2) Resolve requirements problems.

NOTE This includes requirements that cannot be realized or are impractical to achieve.

3) Feed back the analyzed requirements to applicable stakeholders to ensure that the needs and expectations have been adequately captured and expressed.

NOTE Explain and obtain agreement to the proposals to resolve conflicting, impractical and unrealisable stakeholder requirements.

4) Establish with stakeholders that their requirements are expressed correctly.

NOTE This includes confirming that stakeholder requirements are comprehensible to originators and that the resolution of conflict in the requirements has not corrupted or compromised stakeholder intentions.

5) Record the stakeholder requirements in a form suitable for requirements management through the life cycle and beyond.

NOTE These records establish the stakeholder requirements baseline, and retain changes of need and their origin throughout the system life cycle. They are the basis for traceability to the system requirements and form a source of knowledge for requirements for subsequent system entities.

6) Maintain stakeholder requirements traceability to the sources of stakeholder need.

NOTE The stakeholder requirements are reviewed at key decision times in the life cycle to ensure that account is taken of any changes of need.

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6.4.2 Requirements Analysis Process

6.4.2.1 Purpose

The purpose of the Requirements Analysis Process is to transform the stakeholder, requirement-driven view of desired services into a technical view of a required product that could deliver those services.

This process builds a representation of a future system that will meet stakeholder requirements and that, as far as constraints permit, does not imply any specific implementation. It results in measurable system requirements that specify, from the supplier's perspective, what characteristics it is to possess and with what magnitude in order to satisfy stakeholder requirements.

6.4.2.2 Outcomes

As a result of the successful implementation of the Requirements Analysis Process:

a) The required characteristics, attributes, and functional and performance requirements for a product solution are specified.

b) Constraints that will affect the architectural design of a system and the means to realize it are specified.

c) The integrity and traceability of system requirements to stakeholder requirements is achieved.

d) A basis for verifying that the system requirements are satisfied is defined.

6.4.2.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Requirements Analysis Process.

a) **Define system requirements.** This activity consists of the following tasks:

1) Define the functional boundary of the system in terms of the behaviour and properties to be provided.

NOTE This includes the system's stimuli and its responses to user and environment behaviour, and an analysis and description of the required interactions between the system and its operational environment in terms of interface constraints, such as mechanical, electrical, mass, thermal, data, and procedural flows. This establishes the expected system behaviour, expressed in quantitative terms, at its boundary.

2) Define each function that the system is required to perform.

NOTE 1 This includes how well the system, including its operators, is required to perform that function, the conditions under which the system is to be capable of performing the function, the conditions under which the system is to commence performing that function and the conditions under which the system is to cease performing that function.

NOTE 2 Conditions for the performance of functions may incorporate reference to required states and modes of operation of the system. System requirements depend heavily on abstract representations of proposed system characteristics and may employ multiple modelling techniques and perspectives to give a sufficiently complete description of the desired system requirements.

3) Define necessary implementation constraints that are introduced by stakeholder requirements or are unavoidable solution limitations.

NOTE This includes the implementation decisions that are allocated from design at higher levels in the structure of the system.

4) Define technical and quality in use measures that enable the assessment of technical achievement.

NOTE This includes defining critical performance parameters associated with each effectiveness measure identified in the stakeholder requirements. The critical performance measures are analyzed and reviewed to ensure stakeholder requirements are met and to ensure identification of project cost, schedule or performance risk associated

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with any non-compliance. ISO/IEC 15939 provides a process to identify, define and use appropriate measures. The ISO/IEC 9126 series of standards provides relevant quality measures.

5) Specify system requirements and functions, as justified by risk identification or criticality of the system, that relate to critical qualities, such as health, safety, security, reliability, availability and supportability.

NOTE This includes analysis and definition of safety considerations, including those relating to methods of operation and maintenance, environmental influences and personnel injury. It also includes each safety related function and its associated safety integrity, expressed in terms of the necessary risk reduction, is specified and allocated to designated safety-related systems. Applicable standards are used concerning functional safety, e.g., IEC 61508, and environmental protection, e.g., ISO 14001. Analyze security considerations including those related to compromise and protection of sensitive information, data and material. The security-related risks are defined, including, but not limited to, administrative, personnel, physical, computer, communication, network, emission and environment factors using, as appropriate, applicable security standards.

b) **Analyze and maintain system requirements.** This activity consists of the following tasks:

1) Analyze the integrity of the system requirements to ensure that each requirement, pairs of requirements or sets of requirements possess overall integrity.

NOTE Each system requirement statement is checked to establish that it is unique, complete, unambiguous, consistent with all other requirements, implementable and verifiable. Deficiencies, conflicts and weaknesses are identified and resolved within the complete set of system requirements. The resulting system requirements are analyzed to confirm that they are complete, consistent, achievable (given current technologies or knowledge of technological advances) and expressed at an appropriate level of detail. Refer to ISO/IEC 26702:2007*, IEEE Standard for Application and Management of the Systems Engineering Process* for additional detailed guidance regarding the attributes and qualities of good requirements.

2) Feed back the analyzed requirements to applicable stakeholders to ensure that the specified system requirements adequately reflect the stakeholder requirements to address the needs and expectations.

NOTE Confirmation is made that they are a necessary and sufficient response to stakeholder requirements and a necessary and sufficient input to other processes, in particular architectural design.

3) Demonstrate traceability between the system requirements and the stakeholder requirements.

NOTE Maintain mutual traceability between the system requirements and the stakeholder requirements, i.e., all achievable stakeholder requirements are met by one or more system requirements, and all system requirements meet or contribute to meeting at least one stakeholder requirement. The system requirements are held in an appropriate data repository that permits traceability to stakeholder needs and architectural design.

4) Maintain throughout the system life cycle the set of system requirements together with the associated rationale, decisions and assumptions.

6.4.3 Architectural Design Process

6.4.3.1 Purpose

The purpose of the Architectural Design Process is to synthesize a solution that satisfies system requirements.

This process encapsulates and defines areas of solution expressed as a set of separate problems of manageable, conceptual and, ultimately, realizable proportions. It identifies and explores one or more implementation strategies at a level of detail consistent with the system's technical and commercial requirements and risks. From this, an architectural design solution is defined in terms of the requirements for the set of system elements from which the system is configured. The specified design requirements resulting from this process are the basis for verifying the realized system and for devising an assembly and verification strategy.

6.4.3.2 Outcomes

As a result of the successful implementation of the Architectural Design Process:

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a) An architectural design baseline is established.

b) The implementable set of system element descriptions that satisfy the requirements for the system are specified.

c) The interface requirements are incorporated into the architectural design solution.

d) The traceability of architectural design to system requirements is established.

e) A basis for verifying the system elements is defined.

f) A basis for the integration of system elements is established.

6.4.3.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Architectural Design Process.

NOTE For more information on architecture representation, refer to ISO/IEC 42010, *Architecture Description of Software-Intensive Systems.*

a) **Define the architecture.** This activity consists of the following tasks:

1) Define appropriate logical architectural designs.

NOTE This includes identifying and defining derived requirements for describing functional and performance requirements, services and attributes, timeline requirements, data flow requirements, etc., as appropriate to a logical architecture. Prior to partitioning logical architecture to physical elements, conflicts among and between various logical descriptions are resolved and each logical architecture is shown to be complete and consistent by making mutual traceability checks with the defined system requirements.

2) Partition the system functions identified in requirements analysis and allocate them to elements of system architecture. Generate derived requirements as needed for the allocations.

3) Define and document the interfaces between system elements and at the system boundary with external systems.

NOTE Definitions are made with a level of detail and control appropriate to the creation, use and evolution of the system entity and with interface documentation from parties responsible for external interfacing entities. Human-system and human-human interfaces are also defined and controlled. Interface definitions conform to recognized product sector or international standards where these exist, e.g., ISO 9241 for human-computer interface or the Open System Interconnect seven layer model for data communications in ISO/IEC 7498-1.

b) **Analyze and evaluate the architecture.** This activity consists of the following tasks:

1) Analyze the resulting architectural design to establish design criteria for each element.

NOTE The design criteria include the physical, performance, behavioural, durability and sustainable service characteristics. Typically, Stakeholder Requirements Definition, Requirements Analysis and Architectural Design Processes are recursively applied to successive levels of detail in the system architecture until elements are capable of being, purchased, re-used or built using a development standard such as ISO/IEC 12207:2008 for software.

2) Determine which system requirements are allocated to operators.

NOTE 1 This determination takes account of the context of use factors and considers, as a minimum, the following factors for the most effective, efficient and reliable human-machine interaction:

i) Limitations of human capabilities;

ii) Human actions critical to safety and how the consequences of error are addressed;

iii) Integration of human performance into systems and their operation.

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NOTE 2 Guidance on user-centred design is given in ISO 13407.

3) Determine whether hardware and software elements that satisfy the design and interface criteria are available off-the-shelf.

NOTE This includes evaluation of design elements that are not readily available in order to determine if an element is to be developed, or if existing system elements will be re-used or adapted. Establish the costs, schedule, and technical risks associated with these make/modify/buy decisions.

4) Evaluate alternative design solutions, modelling them to a level of detail that permits comparison against the specifications expressed in the system requirements and the performance, costs, time scales and risks expressed in the stakeholder requirements.

NOTE This includes:

i) assessing and communicating the emergence of adverse system properties resulting from the interaction of candidate system elements or from changes in a system element;

ii) ensuring that the constraints of enabling systems are taken account of in the design;

iii) performing effectiveness assessments, trade-off analyses and risk analyses that lead toward realizing a feasible, effective, stable and optimized design.

c) **Document and maintain the architecture.** This activity consists of the following tasks:

1) Specify the selected physical design solution as an architectural design baseline in terms of its functions, performance, behaviour, interfaces and unavoidable implementation constraints.

NOTE These specifications are the basis of the system solution and an origin for system element acquisition agreements, including acceptance criteria. They may be in the form of sketches, drawings or other descriptions appropriate to the maturity of the development effort, e.g., feasibility design, conceptual design, pre-fabrication design. They are the basis for deciding whether to produce, re-use or acquire system elements, for verifying the system elements and for defining an integration strategy for the system.

2) Record the architectural design information.

NOTE This records the structural and functional partitioning, interface and control definitions and the design decisions and conclusions, with traceability to the requirements baseline. The architectural design baseline enables review in the event of change throughout the life cycle, as well as providing information for any subsequent re-use of the architecture. It is also the information source from which tests during integration are defined.

3) Maintain mutual traceability between specified design and system requirements.

6.4.4 Implementation Process

6.4.4.1 Purpose

The purpose of the Implementation Process is to realize a specified system element.

This process transforms specified behaviour, interfaces and implementation constraints into fabrication actions that create a system element according to the practices of the selected implementation technology. The system element is constructed or adapted by processing the materials and/or information appropriate to the selected implementation technology and by employing appropriate technical specialties or disciplines. This process results in a system element that satisfies specified design requirements through verification and stakeholder requirements through validation.

6.4.4.2 Outcomes

As a result of the successful implementation of the Implementation Process:

a) An implementation strategy is defined.

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b) Implementation technology constraints on the design are identified.

c) A system element is realized.

d) A system element is packaged and stored in accordance with an agreement for its supply.

6.4.4.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Implementation Process.

a) **Plan the implementation.** This activity consists of the following tasks:

1) Generate an implementation strategy.

NOTE This includes implementation procedures, fabrication processes, tools and equipment, implementation tolerances and verification uncertainties. In the case of repeated system element implementation, e.g., mass production, replacement system elements, the implementation procedures and fabrication processes are defined to achieve consistent and repeatable producibility.

2) Identify the constraints that the implementation strategy and implementation technology impose on the design solution.

NOTE This includes current or anticipated limitations of the chosen implementation technology, acquirer furnished materials or system elements for adaptation and limitations resulting from the use of required implementation enabling systems.

b) **Perform implementation.** This activity consists of the following tasks:

1) Realize or adapt system elements using the implementation enabling systems and specified materials according to the defined implementation procedures for hardware fabrication, software creation and/or operator training.

NOTE Adaptation includes configuration of hardware and software elements that are reused or acquired. Realization or adaptation is conducted with regard to standards that govern applicable safety, security, privacy and environmental guidelines or legislation and the practices of the relevant implementation technology.

i) Hardware Fabrication

Fabricate hardware elements using the conditioning, forming and fabrication techniques relevant to the physical implementation technology and materials selected. As appropriate, hardware elements are tested to confirm specified product quality characteristics.

ii) Software Creation

Develop software elements and, as appropriate, compile, inspect and test to assure their conformance to the design criteria. ISO/IEC 12207:2008 applies to system elements realized in software.

iii) Operator Training

Deliver appropriate training to prepare operators for performing tasks in accordance with required performance standards and operational procedures and, as appropriate, confirm that the specified range and level of competence has been attained. This may include awareness of the operational environment, including appropriate failure detection and isolation instruction.

2) Record evidence that the system element meets supplier agreements, legislation and organizational policy.

NOTE This provides objective evidence that the requirements from architectural design have been fulfilled by the implemented system element. Evidence is provided in accordance with supply agreements, legislation and organization policy,

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3) Package the system element and store as appropriate.

NOTE Contain the system element in order to achieve continuance of its characteristics. Conveyance and storage media, and their durations, influence the specified containment.

6.4.5 Integration Process

6.4.5.1 Purpose

The purpose of the Integration Process is to assemble a system that is consistent with the architectural design.

This process combines system elements to form complete or partial system configurations in order to create a product specified in the system requirements.

6.4.5.2 Outcomes

As a result of the successful implementation of the Integration Process:

a) A system integration strategy is defined.

b) Unavoidable constraints of integration that influence requirements are defined.

c) A system capable of being verified against the specified requirements from architectural design is assembled and integrated.

d) Non-conformances due to integration actions are recorded.

6.4.5.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Integration Process.

a) **Plan integration.** This activity consists of the following tasks:

1) Define an assembly sequence and strategy that minimizes system integration time, costs, and risks.

NOTE This strategy may permit verification against a sequence of progressively more complete system element configurations. It is dependent on system element availability and is consistent with a fault isolation and diagnosis strategy. Wherever possible, an integrated configuration includes its human operators. Successive applications of the Integration Process and the Verification Process, and when appropriate the Validation Process, are repeated for systems at successive levels until the system-of-interest has been realized.

2) Identify the constraints on the design arising from the integration strategy.

NOTE This includes factors such as accessibility, integration enabling systems and required interfacing/interconnections for intermediate assembly configurations.

b) **Perform integration.** This activity consists of the following tasks:

1) Obtain integration enabling systems and specified materials according to the defined integration procedures.

NOTE The enabling system for integration may include integration facilities, jigs, conditioning facilities and assembly equipment. Integration enabling system requirements, constraints and other limitations are defined.

2) Obtain system elements in accordance with agreed schedules.

NOTE System elements can be received from suppliers or be withdrawn from storage. System elements are handled in accordance with relevant health, safety, security and privacy considerations.

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3) Assure that the system elements have been verified and validated against acceptance criteria specified in an agreement.

NOTE System elements that do not pass verification are identified as such and handled in accordance with defined procedures.

4) Integrate system elements in accordance with applicable interface control descriptions and defined assembly procedures, using the specified integration facilities.

5) Analyze, record, and report integration information, including results of integration actions, non-conformances, and corrective actions taken.

NOTE This includes resolution of problems due to the integration strategy, the integration enabling systems or manual assembly errors. The data is analyzed to enable corrective or improvement actions to the integration strategy and its execution. Lessons learned should also be recorded.

6.4.6 Verification Process

6.4.6.1 Purpose

The purpose of the Verification Process is to confirm that the specified design requirements are fulfilled by the system.

This process provides the information required to effect the remedial actions that correct non-conformances in the realized system or the processes that act on it.

6.4.6.2 Outcomes

As a result of the successful implementation of the Verification Process:

a) A verification strategy is defined.

b) Verification constraints are provided as inputs to requirements.

c) Data providing information for corrective action is reported.

d) Objective evidence that the realized product satisfies the system requirements and the architectural design is provided.

6.4.6.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Verification Process.

a) **Plan verification.** This activity consists of the following tasks:

1) Define the strategy for verifying the system entities throughout the life cycle.

NOTE This strategy applies to the system and to its descriptions, e.g., requirements, design definitions. It includes the context and purpose for each instance of verification action, e.g., verifying the design, ability to build the design correctly, ability to reproduce the system, ability to correct a fault arising, ability to predict failures. Verification demonstrates, through assessment of the product, that the system is made "right", i.e., fulfils the specified design against which the product was realized. During verification, wherever possible, the system includes its human operators. The nature and scope of the verification action, e.g., review, inspection, audit, comparison, static test, dynamic test, demonstration (or a combination of these) depend on whether a model, prototype or actual product is being verified, and on the perceived risks, e.g., safety, commercial criticality.

2) Define a verification plan based on system requirements.

NOTE The plans account for the sequence of configurations defined in the integration strategy and, where appropriate, take account of disassembly strategies for fault diagnosis. The schedule typically defines risk-managed verification steps that progressively build confidence in compliance of the fully configured product.

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3) Potential constraints on design decisions are identified and communicated.

NOTE This includes practical limitations of accuracy, uncertainty, repeatability that are imposed by the verification enabling systems, the associated measurement methods, the need for system integration, and the availability, accessibility and interconnection with enabling systems.

b) **Perform verification.** This activity consists of the following tasks:

1) Ensure that the enabling system for verification is available and associated facilities, equipment and operators are prepared to conduct the verification.

2) Conduct verification to demonstrate compliance to the specified design requirements.

NOTE Non-compliance identifies the existence of random faults and/or design errors, and corrective actions are initiated as appropriate. Verification is undertaken in a manner, consistent with organizational constraints, such that uncertainty in the replication of verification actions, conditions and outcomes is minimized. Approved records of verification actions and outcomes are made.

3) Make available verification data on the system.

NOTE This is conducted in accordance with agreements and legal, regulatory or product sector requirements.

4) Analyze, record and report verification, discrepancy and corrective action information.

NOTE In accordance with agreement terms or organizational objectives, conduct verification to isolate that part of the system that is giving rise to a non-conformance. Fault diagnosis is conducted to a level of resolution consistent with cost effective remedial action, including re-verification following defect correction, and/or organizational quality improvement actions. Verification data is collected, classified and collated according to criteria defined in the verification strategy. This categorizes non-conformances according to their source and corrective action and owner. The verification data is analyzed to detect essential features such as trends and patterns of failure, evidence of design errors and emerging threats to services.

6.4.7 Transition Process

6.4.7.1 Purpose

The purpose of the Transition Process is to establish a capability to provide services specified by stakeholder requirements in the operational environment.

This process installs a verified system, together with relevant enabling systems, e.g., operating system, support system, operator training system, user training system, as defined in agreements. This process is used at each level in the system structure and in each stage to complete the criteria established for exiting the stage. It includes preparing applicable storage, handling, and shipping enabling systems.

6.4.7.2 Outcomes

As a result of the successful implementation of the Transition Process:

a) A system transition strategy is defined.

b) A system is installed in its operational location.

c) A system, when operated, is capable of delivering specified services.

d) The configuration as installed is recorded.

e) Corrective action reports are recorded.

f) A service is sustainable by enabling systems.

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6.4.7.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Transition Process.

a) **Plan the transition.** This activity consists of the following tasks:

1) Prepare a transition strategy.

NOTE The transition strategy includes installation and commissioning of the system in accordance with agreements. Wherever possible this includes human operators.

2) Prepare the site of operation in accordance with installation requirements.

NOTE Site preparation is conducted in accordance with applicable health, safety, security and environmental regulations.

b) **Perform the transition.** This activity consists of the following tasks:

1) Deliver the system for installation at the correct location and time.

NOTE It may be necessary to account for intermediate storage prior to delivery.

2) Install the system in its operational location and interfaced to its environment according to its system specification.

NOTE The system is configured with required operational data.

3) Demonstrate proper installation of the system.

NOTE Acceptance tests defined in the agreement to deliver can demonstrate satisfactory installation. Where the exact location or environment of operation is not available, a representative example is selected.

4) Activate the system.

5) Demonstrate the installed system is capable of delivering its required services.

NOTE Acceptance tests, as specified in agreements, can define the criteria that demonstrate that the system entity possesses the capability to deliver the required services when installed in its operational location and staffed by operators.

6) Demonstrate the services provided by the system are sustainable by the enabling systems.

7) Analyze, record, and report the transition information, including results of transition actions, non-conformances, and corrective actions taken.

NOTE Post-implementation reporting includes flaws in the system requirements as well as technical features. Where inconsistencies exist at the interface between the system, its specified operational environment and any systems that enable the utilization stage, the deviations lead to corrective actions and/or requirement changes. Lessons learned should also be recorded.

6.4.8 Validation Process

6.4.8.1 Purpose

The purpose of the Validation Process is to provide objective evidence that the services provided by a system when in use comply with stakeholders' requirements, achieving its intended use in its intended operational environment.

This process performs a comparative assessment and confirms that the stakeholders' requirements are correctly defined. Where variances are identified, these are recorded and guide corrective actions. System validation is ratified by stakeholders.

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6.4.8.2 Outcomes

As a result of the successful implementation of the Validation Process:

a) A validation strategy is defined.

b) The availability of services required by stakeholders is confirmed.

c) Validation data is provided.

d) Data capable of providing information for corrective action is reported.

6.4.8.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Validation Process.

a) **Plan validation.** This activity consists of the following tasks:

1) Define the strategy for validating the services in the operational environment and achieving stakeholder satisfaction.

NOTE Validation demonstrates, through assessment of the services presented to the stakeholders, that the "right" system entity has been created, i.e., is fit for its purpose and satisfies the customer. Validation takes place from the earliest stage of a life cycle. For example paper prototypes, simulations or mock-ups of the system under development in a corresponding representation of its environment may be used to validate at the concept stage. The nature and scope of the validation action depends on whether a model, prototype or actual system is being validated, on risks, (e.g., novelty, safety, technical and commercial criticality issues), on the agreement and organizational constraints, and on the stakeholder requirements. The supplier, the acquirer, or an agent of the acquirer may do validation of the realized product. The responsibility is designated in the agreement.

2) Prepare a validation plan.

NOTE Validation is based on the stakeholder requirements. Where appropriate, define validation steps, e.g., various operational states, scenarios and missions that progressively build confidence in conformance of the installed system and assist diagnosis of any discrepancies. Methods and techniques needed to implement the validation strategy are specified, as are the purpose, conditions and conformance criteria for each validation. Where stakeholder requirements cannot be specified comprehensively or change frequently, repeated validation of (often rapidly developed) increments in system evolution may be employed to refine stakeholder requirements and mitigate risks in the correct identification of need, e.g., ISO 13407 describes an iterative life cycle that involves users.

b) **Perform validation.** This activity consists of the following tasks:

1) Ensure that any operators, enabling system for validation and associated facilities are ready in order to conduct validation.

2) Conduct validation to demonstrate conformance of services to stakeholder requirements.

NOTE Validation is undertaken in a manner, consistent with organizational constraints, such that uncertainty in the replication of validation actions, conditions and outcomes is minimized. Objectively record and approve validation actions and results. Validation may also be conducted to confirm that the system not only satisfies all operational, functional and usability requirements, but also satisfies the often less formally expressed, but sometimes overriding, attitudes, experience and subjective tests that comprise customer satisfaction.

3) Make available validation data on the system according to legal, regulatory or product sector requirements.

4) As appropriate to agreement terms or organizational objectives, conduct validation to isolate that part of the system giving rise to a non-conformance.

NOTE Fault diagnosis is conducted to a level of resolution consistent with cost effective remedial action, including re-validation following defect correction and/or organizational quality improvement actions.

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5) Analyze, record and report validation data according to criteria defined in the validation plan.

NOTE This activity categorizes non-conformances according to their source and corrective action owner. The validation data is analyzed to detect essential features such as trends and patterns of failure, evidence of design errors and emerging threats to services.

6.4.9 Operation Process

6.4.9.1 Purpose

The purpose of the Operation Process is to use the system in order to deliver its services.

This process assigns personnel to operate the system, and monitors the services and operator-system performance. In order to sustain services it identifies and analyzes operational problems in relation to agreements, stakeholder requirements and organizational constraints.

6.4.9.2 Outcomes

As a result of the successful implementation of the Operation Process:

a) An operation strategy is defined.

b) Services that meet stakeholder requirements are delivered.

c) Approved corrective action requests are satisfactorily completed.

d) Stakeholder satisfaction is maintained.

6.4.9.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Operation Process.

a) **Prepare for operation.** This activity consists of the following tasks:

1) Prepare a strategy for operation.

NOTE This defines 1) The availability of services as they are introduced, routinely operated and withdrawn from service. Where appropriate, it includes co-ordination with pre-existing, concurrent or continuing services delivered by other systems that provide identical or similar services. 2) The staffing strategy and schedules for operators. 3) Where appropriate, the release and re-acceptance criteria and schedules of the system to permit modifications that sustain existing or enhanced services.

2) Obtain other services related to operation of the system.

3) Assign trained, qualified personnel to be operators.

NOTE This may include awareness of the system in its operational environment and a defined programme of familiarization, with appropriate failure detection and isolation instruction. Operator knowledge, skill and experience requirements guide the personnel selection criteria, and where relevant, their authorization to operate is confirmed. Selection and training of instructors to perform training that employs the operational system may be an aspect of staffing. A training mode of the operational system may impact service availability.

b) **Perform operational activation and check-out.** This activity consists of the following task:

1) Activate the system in its intended operational situation to deliver instances of service or continuous service according to its intended purpose.

NOTE Where agreed, maintain continuous service capacity and quality when the system replaces an existing system that is being retired. During a specified period of changeover or concurrent operation, manage the transfer of services so that continuing conformance to persistent stakeholder needs is achieved.

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c) **Use system for operations.** This activity consists of the following tasks:

1) Consume materials, as required, to sustain the services.

NOTE This includes energy sources for hardware and provisions for operators.

2) Monitor operation to ensure that the system is operated in accordance with the operations plans, in a safe manner and compliant with legislated guidelines concerning occupational safety and environmental protection.

3) Monitor the system operation to confirm that service performance is within acceptable parameters.

NOTE The system may exhibit unacceptable performance when system elements implemented in hardware have exceeded their useful life or the system's operational environment affects the operating and maintenance personnel (including staff turnover, operator stress and fatigue).

d) **Perform operational problem resolution.** This activity consists of the following tasks:

1) Perform failure identification actions when a non-compliance has occurred in the delivered services.

2) Determine the appropriate course of action when corrective action is required to remedy failings due to changed need.

NOTE The appropriate course of action may include, but not be limited to, introducing minor hardware or software adaptations or modified operator action, changes to the stakeholder requirements, changes to the design and/or implementation of the system, or tolerating diminished services.

3) Introduce remedial changes to operating procedures, the operational environment, human-machine interfaces and operator training as appropriate when human error contributed to failure.

e) **Support the customer.** This activity consists of the following task:

1) Continuously or routinely communicate with users to determine the degree to which delivered services satisfy their needs.

NOTE The results are analysed and required action to restore or amend services in order to provide continued stakeholder satisfaction is identified. Wherever possible the benefit of such action is agreed with stakeholders or their representatives.

6.4.10 Maintenance Process

6.4.10.1 Purpose

The purpose of the Maintenance Process is to sustain the capability of the system to provide a service.

This process monitors the system's capability to deliver services, records problems for analysis, takes corrective, adaptive, perfective and preventive actions and confirms restored capability.

6.4.10.2 Outcomes

As a result of the successful implementation of the Maintenance Process:

a) A maintenance strategy is developed.

b) Maintenance constraints are provided as inputs to requirements.

c) Replacement system elements are made available.

d) Services meeting stakeholder requirements are sustained.

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e) The need for corrective design changes is reported.

f) Failure and lifetime data is recorded.

6.4.10.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Maintenance Process.

a) **Plan maintenance.** This activity consists of the following tasks:

1) Prepare a maintenance strategy.

NOTE This defines schedules and resources required to perform corrective and preventive maintenance in conformance with operational availability requirements. It should include:

i) The corrective and preventive maintenance strategy to sustain service in the operational environment in order to achieve customer satisfaction;

ii) The scheduled preventive maintenance actions that reduce the likelihood of system failure without undue loss of services, e.g., suspension or restriction of the services;

iii) The number and type of replacement system elements to be stored, their storage locations and conditions, their anticipated replacement rate, their storage life and renewal frequency;

iv) The skill and personnel levels required to effect repairs and replacements, accounting for maintenance staff requirements and any relevant legislation regarding health and safety, security and the environment. These procedures include disassembly strategy, fault diagnosis techniques, re-assembly and testing sequences.

2) Define the constraints on system requirements that are unavoidable consequences of the maintenance strategy.

NOTE These may result from the need to 1) re-use existing maintenance enabling systems; 2) re-use existing holdings of replaceable system element and accommodate re-supply limitations; 3) conduct maintenance in specific locations or environments.

b) **Perform maintenance.** This activity consists of the following tasks:

1) Obtain the enabling systems, system elements and services to be used during maintenance of the system.

2) Implement problem reporting and incident recording to guide diagnosis of individual events and histories to support future corrective, adaptive, perfective and preventive maintenance.

3) Implement the procedures for correction of random faults and/or scheduled replacement of system elements.

NOTE For random system failures, the fault is isolated down to the planned level of system element replacement, the system element is replaced and correct system performance is verified. Actions are recorded in order to estimate the useful life of degradable system elements.

4) Initiate corrective action to remedy previously undetected design errors.

NOTE Record and communicate to relevant parties the need for potential corrective action to development, e.g., defect, and/or to production actions. This can have consequences on relevant enabling systems.

5) Confirm that logistics actions satisfy the required replenishment levels so that stored system elements meet repair rates and planned schedules.

NOTE Monitor the quality and availability of spares, their transportation and their continued integrity during storage. Acquire, train and accredit, as necessary, personnel to maintain operator numbers and skills.

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6) Perform preventive maintenance by replacing or servicing system elements prior to failure, according to planned schedules and maintenance procedures.

7) Perform failure identification actions when a non-compliance has occurred in the system.

8) Maintain a history of problem reports, corrective actions and trends to inform operations and maintenance personnel, and other projects that are creating or utilizing similar system entities.

6.4.11 Disposal Process

6.4.11.1 Purpose

The purpose of the Disposal Process is to end the existence of a system entity.

This process deactivates, disassembles and removes the system and any waste products, consigning them to a final condition and returning the environment to its original or an acceptable condition. This process destroys, stores or reclaims system entities and waste products in an environmentally sound manner, in accordance with legislation, agreements, organizational constraints and stakeholder requirements. Where required, it maintains records in order that the health of operators and users, and the safety of the environment, can be monitored.

6.4.11.2 Outcomes

As a result of the successful implementation of the Disposal Process:

a) A system disposal strategy is defined.

b) Disposal constraints are provided as inputs to requirements.

c) The system elements or waste products are destroyed, stored, reclaimed or recycled.

d) The environment is returned to its original or an agreed state.

e) Records allowing knowledge retention of disposal actions and the analysis of long-term hazards are available.

6.4.11.3 Activities and tasks

The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Disposal Process.

a) **Plan disposal.** This activity consists of the following tasks:

1) Define a disposal strategy for the system, to include each system element and any resulting waste products.

NOTE This defines schedules, actions and resources that: 1) permanently terminate the system's delivery of services; 2) transform the system into, or retain it in, a socially and physically acceptable state, thereby avoiding subsequent adverse effects on stakeholders, society and the environment; 3) take account of the health, safety, security and privacy applicable to disposal actions and to the long term condition of resulting physical material and information.

2) Unavoidable constraints on the system design arising from the disposal strategy are communicated.

NOTE This includes issues of disassembly, including their associated enabling systems, access to and availability of storage locations and available skill levels.

3) Specify containment facilities, storage locations, inspection criteria and storage periods if the system is to be stored.

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b) **Perform disposal.** This activity consists of the following tasks:

1) Acquire the enabling systems or services to be used during disposal of a system.

2) Deactivate the system to prepare it for removal from operation.

NOTE Interfaces to other systems are considered, e.g., power, fuel, are disconnected in accordance with disassembly instructions and relevant health, safety, security and privacy legislation.

3) Withdraw operating staff from the system and record relevant operating knowledge.

NOTE This is conducted in accordance with relevant safety, security, privacy and environmental standards, directives and laws.

4) Disassemble the system into manageable elements to facilitate its removal for reuse, recycling, reconditioning, overhaul, archiving or destruction.

5) Remove the system from the operational environment for reuse, recycling, reconditioning, overhaul or destruction.

NOTE This is conducted in accordance with relevant safety, security, privacy and environmental standards, directives and laws. Elements of the system that have useful life remaining, either in their current condition or following overhaul, are transferred to other systems-of-interest or organizations. Where appropriate, recondition system elements to extend their useful life. Reallocate, redeploy or retire operators.

6) Conduct destruction of the system, as necessary, to reduce the amount of waste treatment or to make the waste easier to handle.

NOTE This activity includes obtaining the destruction services required in order to melt, crush, incinerate or demolish the system or its elements as necessary. Act to safeguard and secure knowledge and skills possessed by operators.

c) **Finalize the disposal.** This activity consists of the following tasks:

1) Confirm that no detrimental health, safety, security and environmental factors exist following disposal.

2) Archive information gathered through the lifetime of the system to permit audits and reviews in the event of long-term hazards to health, safety, security and the environment, and to permit future system creators and users to build a knowledge base from past experiences.

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Annex A
(normative)
Tailoring Process

A.1 Introduction

This Annex provides requirements for the tailoring of this International Standard.

NOTE 1 Tailoring is not a requirement for conformance to the standard. In fact, tailoring is not permitted if a claim of "full conformance" is to be made. If a claim of "tailored conformance" is made, then this process is applied to perform the tailoring.

NOTE 2 Additional guidance for tailoring can be found in a future Technical Report (*ISO/IEC TR 24748, Guide for life cycle management*).

A.2 Tailoring Process

A.2.1 Purpose

The purpose of the Tailoring Process is to adapt the processes of this International Standard to satisfy particular circumstances or factors that:

a) Surround an organization that is employing this International Standard in an agreement;

b) Influence a project that is required to meet an agreement in which this International Standard is referenced;

c) Reflect the needs of an organization in order to supply products or services.

A.2.2 Outcomes

As a result of the successful implementation of the Tailoring Process:

a) Modified or new life cycle processes are defined to achieve the purposes and outcomes of a life cycle model.

A.2.3 Activities and tasks

If this International Standard is tailored, then the organization or project shall implement the following tasks in accordance with applicable policies and procedures with respect to the Tailoring Process, as required.

a) Identify and document the circumstances that influence tailoring. These influences include, but are not limited to:

   1) stability of, and variety in, operational environments;

   2) risks, commercial or performance, to the concern of interested parties;

   3) novelty, size and complexity;

   4) starting date and duration of utilization;

   5) integrity issues such as safety, security, privacy, usability, availability;

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6) emerging technology opportunities;

7) profile of budget and organizational resources available;

8) availability of the services of enabling systems;

9) roles and responsibilities in the overall life cycle of the system;

10) the need to conform to other standards.

b) In the case of properties critical to the system, take due account of the life cycle structures recommended or mandated by standards relevant to the dimension of the criticality.

c) Obtain input from all parties affected by the tailoring decisions. This includes, but may not be limited to:

1) the system stakeholders;

2) the interested parties to an agreement made by the organization;

3) the contributing organizational functions.

d) Make tailoring decisions in accordance with the Decision Management Process to achieve the purposes and outcomes of the selected life cycle model.

NOTE 1 Organizations establish standard life cycle models as a part of the Life Cycle Model Management Process. It may be appropriate for an organization to tailor processes of this International Standard in order to achieve the purposes and outcomes of the stages of a life cycle model to be established.

NOTE 2 Projects select an organizationally-established life cycle model for the project as a part of the Project Planning Process. It may be appropriate to tailor organizationally adopted processes to achieve the purposes and outcomes of the stages of the selected life cycle model.

NOTE 3 In cases where projects are directly applying this International Standard, it may be appropriate to tailor processes of this International Standard in order to achieve the purposes and outcomes of the stages of a suitable life cycle model.

e) Select the life cycle processes that require tailoring and delete selected outcomes, activities, or tasks.

NOTE 1 Irrespective of tailoring, organizations and projects are always permitted to implement processes that achieve additional outcomes or implement additional activities and tasks beyond those required for conformance to this standard.

NOTE 2 An organization or project may encounter a situation where there is the desire to modify a provision of this International Standard. Modification should be avoided because it may have unanticipated consequences on other processes, outcomes, activities or tasks. If necessary, modification is performed by deleting the provision (making the appropriate claim of tailored conformance) and, with careful consideration of consequences, implementing a process that achieves additional outcomes or performs additional activities and tasks beyond those of the tailored standard.

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Annex B
(informative)
Process Reference Model for Assessment Purposes

B.1 Introduction

It is understood that some users of this International Standard may desire to assess the implemented processes in accordance with ISO/IEC 15504-2, Information Technology — Process Assessment — Part 2: Performing an assessment. This annex provides a Process Reference Model suitable for use in conjunction with that standard.

The Process Reference Model is composed of the processes in the body of this International Standard, including the name, statement of purpose, and statement of outcomes for each process. Clause B.3 identifies the processes in the process reference model and the clauses in which they are defined.

B.2 Conformance with ISO/IEC 15504-2

B.2.1 General

The Process Reference Model included in this annex is suitable for use in process assessment performed in accordance with ISO/IEC 15504-2, Information Technology — Process Assessment — Part 2: Performing an assessment.

ISO/IEC 15504-2 subclause 6.2 places requirements on process reference models suitable for assessment by that standard. The following sections quote the requirements for process reference models and describe how these are met by this international standard. In each of the following clauses the *italicized* text quotes the requirement from the text of ISO/IEC 15504-2 and the non-italicized (upright) text describes the manner in which the requirement is satisfied in this International Standard.

B.2.2 Requirements for Process Reference Models

A Process Reference Model shall contain:

a) *A declaration of the domain of the Process Reference Model.* This is provided in Clause 1.

b) *A description, meeting the requirements of subclause 6.2.4 of this International Standard* [15504]*, of the processes within the scope of the Process Reference Model.* This is provided in Annex B.3.

c) *A description of the relationship between the Process Reference Model and its intended context of use.* This is provided by Clause 5.

d) *A description of the relationship between the processes defined within the Process Reference Model.* This is provided in Annex B.3 in the description of each process. For example, some process descriptions include the statement that the process contains lower-level processes.

The Process Reference Model shall document the community of interest of the model and the actions taken to achieve consensus within that community of interest:

a) *The relevant community of interest shall be characterized or specified.* The relevant community of interest is the users of ISO/IEC 15288 and ISO/IEC 12207.

b) *The extent of achievement of consensus shall be documented.* Both ISO/IEC 15288 and ISO/IEC 12207 are international standards satisfying the consensus requirements of ISO/IEC JTC1.

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c) *If no actions are taken to achieve consensus, a statement to this effect shall be documented.* (Not applicable.)

The processes defined within a Process Reference Model shall have unique process descriptions and identification. The process descriptions are unique. The identification is provided by unique names and by the clause numbering of this annex.

B.2.3 Process descriptions

The fundamental elements of a Process Reference Model are the descriptions of the processes within the scope of the model. The process descriptions in the Process Reference Model incorporate a statement of the purpose of the process which describes at a high level the overall objectives of performing the process, together with the set of outcomes which demonstrate successful achievement of the process purpose. These process descriptions shall meet the following requirements:

a) a process shall be described in terms of its purpose and outcomes;

b) in any process description the set of process outcomes shall be necessary and sufficient to achieve the purpose of the process;

c) process descriptions shall be such that no aspects of the Measurement Framework as described in Clause 5 of [ISO/IEC 15504-2] beyond level 1 are contained or implied.

An outcome statement describes one of the following:

- *Production of an artefact;*
- *A significant change of state;*
- *Meeting of specified constraints, e.g., requirements, goals, and objectives..*

These requirements are met by the process descriptions in this annex. Some outcomes might be interpreted as contributing to levels of capability above level 1. However, conforming implementation of the relevant processes does not require achievement of these higher levels of capability.

B.3 The Process Reference Model

The Process Reference Model (PRM) is composed of the statement of purpose and outcomes of each of the processes included in Clause 6 of this International Standard. The PRM for the system life cycle is composed of the set of processes in Figure 4.

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Annex C
(informative)
Process Integration and Process Constructs

C.1 Introduction

A harmonization project within ISO/IEC JTC 1/SC 7—a parallel, carefully coordinated revision of ISO/IEC 15288 and ISO/IEC 12207, and development of the Technical Report ISO/IEC 24748, which provides guidelines to both of these International Standards—is the first, large step towards an integrated set of standards describing system and software life cycles. Concepts of continuous process improvement and capability assessment are now well established and recognized, and are being standardized in the ISO/IEC 15504 series of standards. The Process Reference Models in Annex B of ISO/IEC 15288 and ISO/IEC 12207 are intended to be used in conjunction with the ISO/IEC 15504 series of standards for capability assessment of the life cycle processes. Capability determination of processes requires that the process descriptions include a clear statement of the purpose of the process and a description of the expected outcomes. Consistent implementation of the processes is aided by having activities, tasks, and implementation notes defined. Thus, the life cycle processes in both life cycle standards have adopted common process constructs, as defined in Clause C.2, Process constructs and their usage, and is consistent with the process definition guidance contained in ISO/IEC TR 24774, Process definition guide.

C.2 Process constructs and their usage

The process descriptions in this International Standard follow clearly defined rules. Firstly, they were grouped in a logical fashion. Those groupings are dictated by:

— Logical relations among the processes

— Responsibility for execution of the processes

This International Standard groups the activities that may be performed during the life cycle of the system into four Process Groups. The top level description of these groups can be found in subclause 5.3.2. Each life cycle process within those groups is described in terms of its purpose and desired outcomes and lists the activities and tasks which need to be performed to achieve those outcomes.

a) Agreement Processes – two processes (subclause 6.1)

b) Project-Enabling Processes – five processes (subclause 6.2)

c) Project Processes – seven processes (subclause 6.3)

d) Technical Processes – eleven processes (subclause 6.4)

Consistent application of process description rules allows for the normalized clause numbering. Within this International Standard a clause numbered as 6.x denotes a process group and 6.x.y denotes a process within that group. Clauses numbered as 6.x.y.1 describe the purpose of a process, clauses numbered 6.x.y.2 describe the outcomes of a process, and clauses numbered as 6.x.y.3 describe the activities and tasks of a process. Clauses numbered as 6.x.y.3.z list activities of a process and clauses numbered as 6.x.y.3.z.α list the tasks within an activity.

Figure C.1 is a UML representation of process constructs used in this International Standard and in ISO/IEC 12207:2008.

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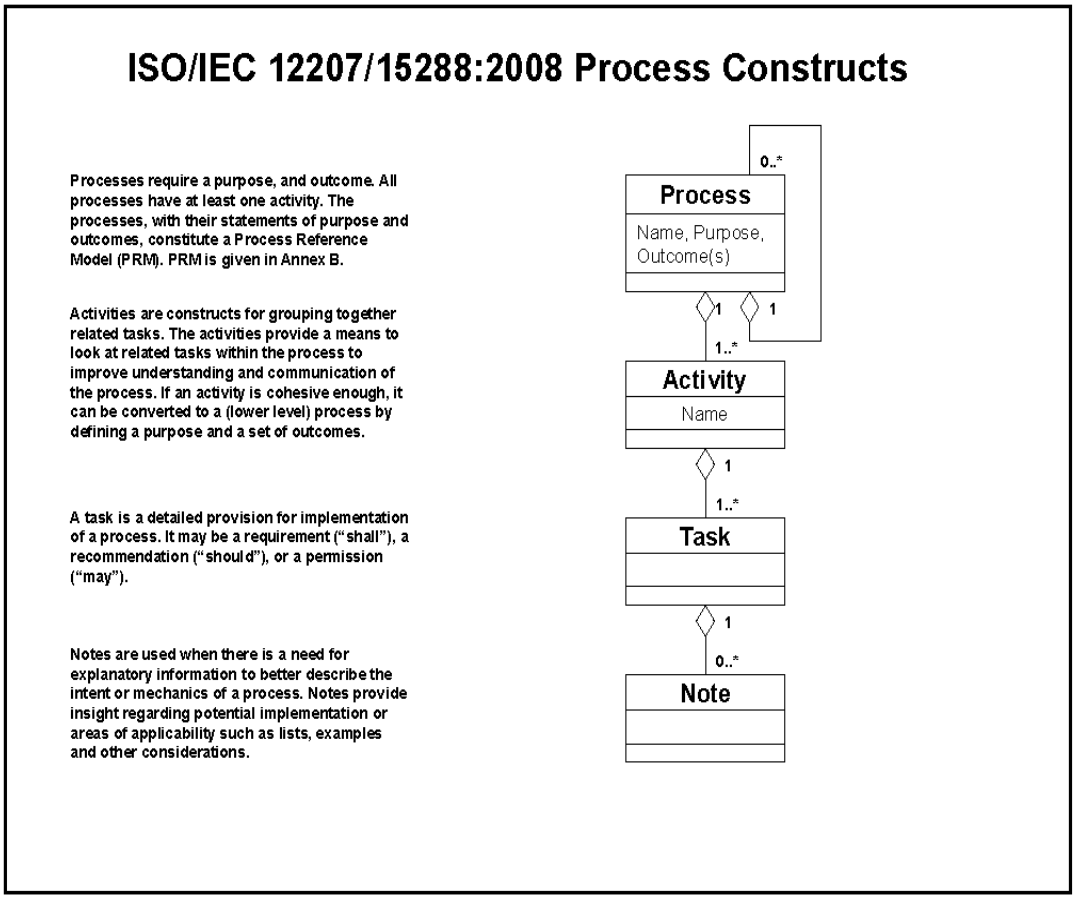

Figure C.1 — ISO/IEC 12207/15288 Process Constructs

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Annex D
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Process views

D.1 Introduction

There are instances where those representing a particular engineering interest would like to see gathered in a single place the set of process activities that directly and succinctly address their concern. For such interests, a ***process view*** can be developed to organize processes, activities, and tasks selected from ISO/IEC 15288 or ISO/IEC 12207 to provide a focus to their particular concern in a manner that cuts across all or parts of the life cycle. This annex provides a process viewpoint that may be used to define process views in these instances,

D.2 Definition

View: a representation of a whole system from the perspective of a related set of concerns.

[ISO/IEC 42010:2007, IEEE Std 1471-2000]

Viewpoint: a specification of the conventions for constructing and using a view. A pattern or template from which to develop individual views by establishing the purposes and audiences for a view and the techniques for its creation and analysis.

[ISO/IEC 42010:2007, IEEE Std 1471-2000]

Note: In this case, the "system" referenced in the definition is the collection of life cycle processes provided by ISO/IEC 15288 and ISO/IEC 12207.

D.3 The process view concept

There may be cases where a unified focus is needed for activities and tasks that are selected from disparate processes to provide visibility to a significant concept or thread that cuts across the processes employed across the life cycle. It is useful to advise users of the standards how to identify and define these activities for their use, even though they cannot locate a single process that addresses their specific concern.

For this purpose, the concept of a ***process view*** has been formulated. Like a process, the description of a process view includes a statement of purpose and outcomes. Unlike a process, the description of a process view does not include activities and tasks. Instead, the description includes guidance explaining how the outcomes can be achieved by employing the activities and tasks of the various processes in ISO/IEC 15288 and ISO/IEC 12207. Process views can be constructed using the process viewpoint template found in D.3.1.

D.3.1 Process viewpoint

A process view conforms to a process viewpoint. The process viewpoint provided here can be used to create process views.

The Process viewpoint is defined by:

— its stakeholders: users of the standard;

— the concerns it frames: the processes needed to reflect a particular engineering interest;

— the contents of resulting process views should include:

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— process view name;

— process view purpose;

— process view outcomes; and

— identification and description of the processes, activities and tasks which implement the process view, and references to the sources for these processes, activities and tasks in other standards.

NOTE The requirements for documenting viewpoints are found in ISO/IEC 42010, subclause 5.3. This description is consistent with those requirements.

NOTE Clause D.4 contains an example of applying this viewpoint.

D.4 Process view for specialty engineering

This section provides an example of applying the process viewpoint to yield 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.

This example treats the cluster of interests, generally called specialty engineering, which includes but is not limited to such areas as availability, maintainability, reliability, safety, security, human factors, and usability. These "ilities" are sometimes referred to as "quality characteristics". These characteristics determine how well the product meets its specified requirements in an area selected for focus.

Note that this is a generalized example that is provided for illustrative purposes and covers a broad set of functional and non-functional characteristics. It provides a broad view across the processes. For actual usage, a process view should be created for the specific specialty engineering concern.

Name: Specialty Engineering Process View

Purpose: The purpose of the Specialty Engineering Process View is to provide objective evidence that the system achieves satisfactory levels of certain characteristics selected for special attention.

Outcomes:

a) Product quality characteristics are selected for special attention.

b) Requirements for the achievement of the characteristics are defined.

c) Measures for the requirements are selected and related to the desired characteristics.

d) Approaches for achieving the desired characteristics are designed and implemented.

e) The extent of achievement of the requirements is continuously monitored and communicated to stakeholders and managers.

f) The artefacts for documenting and communicating the extent of achievement are specified, developed and maintained.

NOTE The outcomes permit the possibility that the desired characteristics cannot be directly measured but instead might be argued and inferred based on other product or process characteristics that can be measured.

Processes, Activities and Tasks:

This process view can be implemented using the following processes, activities, and tasks from ISO/IEC 15288:

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a) The Stakeholder Requirements Definition Process (6.4.1) provides for the selection and definition of characteristics, including quality characteristics, and an artefact for documenting them. The activities and the documentation are useful in defining and recording requirements for special characteristics. Relevant activities and tasks include (a)(1) and (2); (b)(2) and (4); and (c)(5).

NOTE ISO/IEC 25030, Software Engineering — Software product quality requirements and evaluation (SQuaRE) — Quality requirements, may be useful in specifying software product quality requirements.

b) The Requirements Analysis Process (6.4.2) provides for the selection of measures for the specialty requirements. Relevant activities and tasks include (a)(4) and (5).

NOTE ISO/IEC 25030, Software Engineering — Software product quality requirements and evaluation (SQuaRE) — Quality requirements, may be useful in specifying software product quality requirements.

c) The Architectural Design Process (6.4.3) provides for the creation of design criteria for the specialty characteristics and the evaluation of alternative designs with respect to those criteria. Relevant activities and tasks include (b)(1) and (4).

d) The Implementation Process (6.4.4) provides for recording the evidence that specialty requirements have been met. Relevant activities and tasks include (b)(2).

e) The Integration Process (6.4.5) provides for planning the integration, including the considerations for specialty characteristics, and the assurance that the achievement of the characteristics is verified and recorded. Relevant activities and tasks include (a)(1); and (b)(3) and (5).

f) The Verification process (6.4.6), provides for the planning and execution of a strategy to perform verification, including the specialty properties. The selected verification strategy may introduce design constraints that could affect the achievement of the properties. Relevant activities and tasks include (a)(1) and (3); and (b)(2), (3), and (4).

g) The Transition Process (6.4.7) provides for installing the system in its operational environment. Because some specialty properties involve a trade-off between design constraints and operational constraints, attention to installation is often important. Relevant activities and tasks include (b) (2), (3), (5), and (6).

h) The Validation Process (6.4.8) provides evidence that the services provided by the system meet the stakeholders' needs, including the specialty properties. Relevant activities and tasks include (b)(3) and (5).

i) The Operation Process (6.4.9) provides for usage of the system. Assuring that the specialty requirements are appropriately achieved involves monitoring the operation of the system. Relevant activities and task include (c)(2); and (d)(1) and (2).

j) The Maintenance process (6.4.10) sustains the capabilities of the system, including its specialty properties. Relevant activities and tasks include (b)(3), (4), and (8).

k) The Disposal Process (6.4.11) ends the existence of a system. The inherent need to anticipate disposal may place constraints on its development. In fact, these constraints may themselves be the subject of specialty engineering. Relevant activities and tasks include (a)(2) and (c)(2).

l) The Project Assessment and Control Process (6.3.2) provides for monitoring the extent of achievement of the requirements and communicating the results to stakeholders and managers. Relevant activities and tasks include (a)(8) and (9).

m) The Information Management Process (6.3.6), in its entirety, provides for the specification, development and maintenance of artefacts for documenting and communicating the extent of achievement. It should be noted that artefacts used for the purpose of specialty engineering are sometimes specialized in nature. Sources for the description of these artefacts include industry associations, regulators, and specific standards.

n) The Measurement Process (6.3.7), in its entirety, provides for defining an approach that relates measures to the desired specialty characteristics.

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Annex E
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ISO/IEC 15288 and ISO/IEC 12207 process alignment

E.1 Introduction

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

E.2 Alignment description

The alignment of the processes of the following subclauses is straightforward and obvious. ISO/IEC 12207 and ISO/IEC 15288 use the same process names and the same clause numbers for the individual processes:

- 6.1 Agreement Processes
- 6.2 Organizational Project-Enabling Processes
- 6.3 Project Processes

In each case, the process in ISO/IEC 12207 is intended to be a software specialization of a more general process in ISO/IEC 15288.

Subclause 6.4 of each standard contains "Technical Processes". The two standards use slightly different names for these processes. In some cases, the process in ISO/IEC 12207 is a software specialization of the process in ISO/IEC 15288. In other cases, the process in ISO/IEC 12207 merely contributes to the achievement of one or more outcomes of the corresponding process in ISO/IEC 15288. Table E.1 below lists the processes and notes the nature of their relationship.

Clause	Process Name in ISO/IEC 15288	Process Name in ISO/IEC 12207	Relationship
6.4	Technical Processes	Technical Processes	
6.4.1	Stakeholder Requirements Definition	Stakeholder Requirements Definition	Specialization
6.4.2	Requirements Analysis	System Requirements Analysis	Specialization
6.4.3	Architectural Design	System Architectural Design	Specialization
6.4.4	Implementation	Implementation	Specialization
6.4.5	Integration	System Integration	Specialization
6.4.6	Verification	System Qualification Testing Note 1	Contributes to outcomes
6.4.7	Transition	Software Installation Software Acceptance Support	Contributes to outcomes Contributes to outcomes
6.4.8	Validation	Software Acceptance Support Note 2	May contribute to outcomes
6.4.9	Operation	Software Operation	Specialization
6.4.10	Maintenance	Software Maintenance	Specialization
6.4.11	Disposal	Software Disposal	Specialization

Figure E.1 — Alignment of Technical Processes for ISO/IEC 15288 and ISO/IEC 12207

Finally, Clause 7 of ISO/IEC 12207 contains only processes that are specific to software.

NOTE 1 Although in ISO/IEC 12207 the Software Verification Process remains allocated as a supporting process and placed in the Software Support Process Group of Clause 7, if the process is implemented for a system element of software (a software item), the process may contribute to one or more outcomes of the Verification Process of ISO/IEC 15288.

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NOTE 2 Although in ISO/IEC 12207 the Software Validation Process remains allocated as a supporting process and placed in the Software Support Process Group of Clause 7, if the process is implemented for a system element of software (a software item), the process may contribute to one or more outcomes of the Validation Process of ISO/IEC 15288.

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Annex F
(informative)
Relationship to other IEEE standards

F.1 Introduction

Relationships to other ISO/IEC standards are described in the body of this standard. The purpose of this informative annex is to describe relationships to other IEEE standards.

F.2 Relationship of IEEE Std 12207 and IEEE Std 15288

IEEE Std 12207-2008 is identical to ISO/IEC 12207:2008. IEEE Std 15288-2008 is identical to ISO/IEC 15288:2008.

Therefore, any references to the ISO/IEC standards can be considered equally correctly as references to the corresponding IEEE standards. Furthermore, the IEEE standards can be validly applied in any situation where the ISO/IEC standards might be applied.

F.3 Other relevant IEEE standards

IEEE has several standards related to system life cycle processes:

— IEEE Std 1220™-2005, IEEE Standard for Application and Management of the Systems Engineering Process.

— IEEE Std 1228™-1994, IEEE Standard for Software Safety Plans.

— IEEE Std 1233™, 1998 Edition (R2002), IEEE Guide for Developing System Requirements Specifications.

— IEEE Std 1362™-1998, IEEE Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document.

— IEEE Std 1471™-2000, IEEE Recommended Practice for Architectural Description for Software-Intensive Systems.

F.4 Relationship of IEEE Std 1220

Since 1994, in various versions, IEEE has maintained its own standard for the "Systems Engineering Process" (SEP), a phrase not used in ISO/IEC 15288. IEEE Std 1220-2005, Standard for the Application and Management of the Systems Engineering Process, has the following abstract:

> *The interdisciplinary tasks, which are required throughout a system's life cycle to transform customer needs, requirements, and constraints into a system solution, are defined. In addition, the requirements for the systems engineering process and its application throughout the product life cycle are specified. The focus of this standard is on engineering activities necessary to guide product development while ensuring that the product is properly designed to make it affordable to produce, own, operate, maintain, and eventually to dispose of, without undue risk to health or the environment.*

Explaining the relationship between ISO/IEC 15288 and IEEE Std 1220 requires considering both the life cycle processes and life cycle stages provided by 15288. In short, ISO/IEC 15288 takes a broad and general view of the entire life cycle of the system, while IEEE Std 1220 focuses on the development of a system, including making plans and providing processes to deal with the remainder of the system's life.

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IEEE Std 1220 provides requirements for an integrated technical approach to defining and developing system products. The SEP is applied recursively to the development of a system, its components and its support processes. The standard can also be applied to incremental improvements of existing systems.

Although 1220 and 15288 are both applied in a recursive fashion, the object of the recursion is different. A system in its simplest form is comprised of a set of interacting system elements. Recursive application of 15288 creates a hierarchy of systems and system elements with the uppermost level being the system-of-interest. An application of 1220 defines a “building block”. Recursive application of 1220 creates a hierarchy of these building blocks. Essentially a system is composed of a product (composed of subsystems and other components), and a set of "processes" to support the development, test, manufacturing, distribution, support, operations, training and disposal of the product and its subsystems. Once defined, these "processes" are treated as systems in their own right. The 15288 standard does not share this integral supporting process structure, but provides a similar concept of distinct “enabling systems”, which complement the system-of-interest during its life cycle stages, but do not necessarily contribute directly to its function during operation.

So the SEP of IEEE Std 1220 applies to the development of a system. Its treatment of later phases—such as production and retirement—consists of planning rather than execution.

IEEE Std 1220-2005 has been adopted by ISO/IEC JTC 1 via the fast-track process as ISO/IEC 26702. It is anticipated that IEEE and ISO/IEC JTC 1/SC 7 will cooperate in revising it for improved fit with ISO/IEC 15288.

F.5 Relationship of IEEE Std 1228

The purpose of the 15288 Implementation Process is to produce a specified system element. For software elements, the 12207 standard provides appropriate processes to implement the element. An additional standard is relevant to the implementation of systems with safety requirements, because it requires interaction with System Processes: IEEE Std 1228™-1994, IEEE Standard for Software Safety Plans. The standard requires that the Software Safety Plan exist within a more general system-wide safety program. In particular, the Software Safety Plan provides for “safety analyses preparation” when the system is designed.

Its abstract describes the standard:

> *The minimum acceptable requirements for the content of a software safety plan are established. This standard applies to the software safety plan used for the development, procurement, maintenance, and retirement of safety-critical software. This standard requires that the plan be prepared within the context of the system safety program. Only the safety aspects of the software are included. This standard does not contain special provisions required for software used in distributed systems or in parallel processors.*

In describing the software safety plan, the standard places implicit requirements on the activities of the software development. Other IEEE standards are cited where appropriate.

F.6 Relationship of IEEE Std 1233

The purpose of the 15288 Requirements Analysis process is to transform the stakeholder, requirement-driven view of desired services into a technical view of a required product that could deliver those services. IEEE has a relevant standard: IEEE Std 1233, 1998 Edition, IEEE Guide for Developing System Requirements Specifications. Its abstract reads as follows:

> *Guidance for the development of the set of requirements, System Requirements Specification (SyRS), that will satisfy an expressed need is provided. Developing an SyRS includes the identification, organization, presentation, and modification of the requirements. Also addressed are the conditions for incorporating operational concepts, design constraints, and design configuration requirements into the specification. This guide also covers the necessary characteristics and qualities of individual requirements and the set of all requirements.*

The standard discusses the Requirements Specification document and the activities performed to create the document, and it provides guidance in performing the activities well.

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F.7 Relationship of IEEE Std 1362

The purpose of the 15288 Stakeholder Requirements Definition Process is to define the requirements for a system that can provide the services needed by users and other stakeholders in a defined environment. It provides for outcomes including:

a) The required characteristics and context of use of services are specified.

b) The constraints on a system solution are defined.

c) Traceability of stakeholder requirements to stakeholders and their needs is achieved.

IEEE has a standard that may be useful in achieving these outcomes: IEEE Std 1362-1998, IEEE Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document. Its abstract states:

> *The format and contents of a concept of operations (ConOps) document are described. A ConOps is a user-oriented document that describes system characteristics for a proposed system from the users' viewpoint. The ConOps document is used to communicate overall quantitative and qualitative system characteristics to the user, buyer, developer, and other organizational elements (for example, training, facilities, staffing, and maintenance). It is used to describe the user organization(s), mission(s), and organizational objectives from an integrated systems point of view.*

IEEE Std 1362 provides a guide to the content of a Concept of Operations document as well as guidance in developing the document. IEEE Std 1362 works from the assumption that a new system is replacing an existing one of some sort. So, the ConOps document is intended to describe an existing system, its changes, and the new system from the point of view of the user. It provides a place to describe user needs without being overly technical or overly quantitative, so that end-users can participate in the approval of the concept.

F.8 Relationship of IEEE Std 1471

The purpose of the 15288 Architectural Design Process is to synthesize a solution that satisfies the system requirements. A system in its simplest form is comprised of a set of interacting system elements. Recursive application of 15288 creates a hierarchy of systems and system elements with the uppermost system being the system-of-interest. Recursion is applied until each system has been broken down to its simplest form. IEEE has a recommended practice for the characteristics of an architectural description: IEEE Std 1471-2000, IEEE Recommended Practice for Architectural Description of Software Intensive Systems. Its abstract states:

> *This recommended practice addresses the activities of the creation, analysis, and sustainment of architectural descriptions. A conceptual framework for architectural design is established. The content of an architectural description is defined. Annexes provide the rationale for key concepts and terminology, the relationships to other standards, and examples of usage.*

A central idea of the standard is that the description of an architecture should be expressed by describing multiple views each governed by a defined viewpoint to deal with various concerns of stakeholders. The standard does not provide the viewpoints; they should be selected based on the needs of the system. The Note of subclause 5.5.4.3(a) of 15288 anticipates multiple views and viewpoints when it mentions "various logical descriptions."

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Annex G
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Annex H
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List of participants

IEEE Participants

At the time this standard was completed, the Working Group for Life Cycle Processes had the following membership:

James W. Moore, *IEEE Liaison to ISO/IEC JTC 1/SC 7*
Garry Roedler, *Editor*
Cheryl Jones, *Co-editor*

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

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