IEEE Standards

IEEE Std 15288™-2004
(Adoption of
ISO/IEC 15288:2002)

15288™

Adoption of ISO/IEC 15288:2002 Systems Engineering—System Life Cycle Processes

IEEE Computer Society

Sponsored by the
Software and Systems Engineering Standards Committee

IEEE

3 Park Avenue, New York, NY 10016-5997, USA

8 June 2005

Print: SH95313
PDF: SS95313

Recognized as an
American National Standard (ANSI)

IEEE Std 15288™-2004
(Adoption of
ISO/IEC Std 15288:2002)

Adoption of ISO/IEC 15288:2002 Systems Engineering—System Life Cycle Processes

Sponsor

Software and Systems Engineering Standards Committee
of the
IEEE Computer Society

Approved 28 April 2005

American National Standards Institute

Approved 8 December 2004

IEEE-SA Standards Board

Abstract: This 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 standard is identical with ISO/IEC 15288:2002 but contains an additional informative annex, Annex E, explaining the relationship of this standard to other IEEE standards.
Keywords: adoption, ISO/IEC, life cycle processes, systems engineering

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Print: ISBN 0-7381-4651-X SH95313
PDF: ISBN 0-7381-4652-8 SS95313

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied "**AS IS**."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board

445 Hoes Lane

Piscataway, NJ 08854

USA

NOTE—Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Introduction

This introduction is not part of IEEE Std 15288-2004, IEEE Adoption of ISO/IEC 15288:2002 Systems Engineering—System Life Cycle Processes.

This standard is identical with ISO/IEC 15288: 2002 but contains an additional informative annex, Annex E, explaining the relationship of this standard to other IEEE standards. The normative reference to ISO/IEC 12207:1995/AMD.1:2002 Information technology—Software life cycle processes—Amendment 1, is substituted by IEEE/EIA 12207.0™-1996, Industry Implementation of International Standard ISO/IEC 12207:1995, Standard for Information Technology—Software Life Cycle Processes.

This adoption is one result of an ongoing harmonization of the standards of the IEEE Computer Society's Software and Systems Engineering Standards Committee (S2ESC) and the corresponding international standards committee, ISO/IEC JTC1/SC7 (Software and Systems Engineering).

Because this standard is an adoption of an existing document, drafting by a Working Group was not required. Representing S2ESC, the adoption project was led by:

James W. Moore

Notice to users

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/index.html. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: http://standards.ieee.org/reading/ieee/interp/index.html.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents or patent applications for which a license may be required to implement an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Participants

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Bakul Banerjee
Edward (Jed) Bartlett
Richard Biehl
Stephen Blanchette
Juris Borzovs
Bruce Bullock
Dino Butorac
Keith Chow
Antonio M. Cicu
Paul Croll
Geoffrey Darnton
Perry DeWeese
Guru Dutt Dhingra
Terry Doran
Audrey Dorofee
Einar Dragstedt
Scott Duncan
Sourav Dutta
Clint Early, Jr.
Christof Ebert
William Eventoff
John Fendrich
Jay Forster
Eva Freund
Roger Fujii
Jean-Denis Gorin
Lewis Gray
Lawrence Gunther
Peter Hung
Mark Henley
John Horch
Peeya Iwagoshi
William Junk
Thomas M. Kurihara
Jörg Kampmann
Piotr Karocki
Subrahmanyam Kommu
Carol A. Long
Joseph Marshall
Edward McCall
James W. Moore
Rajesh Moorkath
Dennis Nickle
Mark Paulk
Lou Pinto
Annette Reilly
Garry Roedler
Terence Rout
James Ruggieri
Helmut S. Andmayr
James Sanders
Robert J. Schaaf
David Schultz
Luca Spotorno
Thomas Starai
John Thywissen
David Walden
John Walz
Paul Work
Oren Yuen
Janusz Zalewski
Li Zhang

When the IEEE-SA Standards Board approved this standard on 8 December 2004, it had the following membership:

Steve M. Mills, *Chair*
Richard H. Hulett, *Vice Chair*
Judith Gorman, *Secretary*

Mark D. Bowman
Dennis B. Brophy
Joseph Bruder
Richard Cox
Bob Davis
Julian Forster*
Joanna N. Guenin
Mark S. Halpin
Raymond Hapeman
William B. Hopf
Lowell G. Johnson
Herman Koch
Joseph L. Koepfinger*
David J. Law
Daleep C. Mohla
Paul Nikolich
T. W. Olsen
Glenn Parsons
Ronald C. Petersen
Gary S. Robinson
Frank Stone
Malcolm V. Thaden
Richard L. Townsend
Joe D. Watson
Howard L. Wolfman

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Alan H. Cookson, *NIST Representative*

Michelle Turner
IEEE Standards Project Editor

Contents

INTERNATIONAL STANDARD

ISO/IEC 15288

First edition
2002-11-01

Systems engineering — System life cycle processes

Ingénierie systèmes — Processus de cycle de vie des systèmes

Reference number
ISO/IEC 15288:2002(E)

PDF disclaimer

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

Adobe is a trademark of Adobe Systems Incorporated.

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

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

Printed in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

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

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

Annex A forms a normative part of this International Standard. Annexes B, C and D are for information only.

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 structural 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 co-operation 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.

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.

This International Standard contains requirements in three Clauses: Clause 5, that defines the requirements for the system life cycle processes, Clause 6, that defines the requirements for stages in a life cycle, and Annex A, that provides requirements for tailoring of this International Standard. Three informative annexes are also contained in this International Standard: Annex B, that provides an example of the use of stages in life cycles, Annex C, that shows its relationship with ISO/IEC 12207:1995/AMD.1:2002 Information technology — Software life cycle processes, and Annex D, that describes the key concepts that it uses. Readers new to this International Standard are advised to consult Annex D to gain an appreciation of these concepts.

Systems engineering — System life cycle processes

1 Scope

1.1 Purpose

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, humans, processes (e.g. review process), procedures (e.g. operator instructions), facilities and naturally occurring entities (e.g. water, organisms, minerals).

1.2 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.

This International Standard applies to organizations in their role as both acquirers and suppliers. It can be used by a single party 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, techniques, tools and trained personnel. It provides a process reference model characterized in terms of the process purpose and the process outcomes that result from their successful implementation. This International Standard can therefore be used as a reference model to support process assessment as specified in ISO/IEC TR 15504-2.

1.3 Limitations

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 5, 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 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 When this 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.

3 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 12207:1995/AMD.1:2002 *Information technology — Software life cycle processes — Amendment 1*

4 Terms and definitions

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

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

NOTE Other terms commonly used for an acquirer are buyer, customer, purchaser. The acquirer may at the same time be the owner, user or operating organization.

4.2
activity
a set of actions that consume time and resources and whose performance is necessary to achieve, or contribute to, the realization of one or more outcomes

4.3
agreement
the mutual acknowledgement of terms and conditions under which a working relationship is conducted

4.4
baseline
a specification or 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

4.5
enabling system
a system that complements 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, an enabling production 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.

4.6
enterprise
that part of an organization with responsibility to acquire and to supply products and/or services according to agreements

NOTE An organization may be involved in several enterprises and an enterprise may involve one or more organizations.

4.7
facility
the physical means or equipment for facilitating the performance of an action, e.g. buildings, instruments, tools

4.8
life cycle model
a framework of processes and activities concerned with the life cycle, which also acts as a common reference for communication and understanding

4.9
operator
an individual who, or an organization that, contributes to the functionality of a system and draws on knowledge, skills and procedures to contribute the function

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.

4.10
organization
a group of people and facilities with an arrangement of responsibilities, authorities and relationships

[ISO 9000:2000]

4.11
process
set of interrelated or interacting activities which transforms inputs into outputs

[ISO 9000:2000]

4.12
project
an endeavour with defined start and finish dates undertaken to create a product or service in accordance with specified resources and requirements

NOTE 1 Adapted from ISO 9000: 2000 and the PMBOK Guide(2000).

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..

4.13
resource
an asset that is utilized or consumed during the execution of a process

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

NOTE 2 Resources may be reusable, renewable or consumable.

4.14
stage
a period within the life cycle of a system that relates to the state of the system description or the system itself

NOTE 1 Stages relate to major progress and achievement milestones of the system through its life cycle.

NOTE 2 Stages may be overlapping.

4.15
stakeholder
a party having a right, share or claim in a system or in its possession of characteristics that meet that party's needs and expectations

4.16
supplier
an organization or an individual that enters into an agreement with the acquirer for the supply of a product or service

4.17
system
a 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.

4.18
system element
a 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

4.19
system-of-interest
the system whose life cycle is under consideration in the context of this International Standard

4.20
system life cycle
the evolution with time of a system-of-interest from conception through to retirement

4.21
trade-off
decision-making actions that select from various requirements and alternative solutions on the basis of net benefit to the stakeholders

4.22
user
individual who 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.

4.23
validation
confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled

[ISO 9000: 2000]

NOTE Validation in a system life cycle context is the set of activities ensuring and gaining confidence that a system is able to accomplish its intended use, goals and objectives.

4.24
verification
confirmation, through the provision of objective evidence, that specified requirements have been fulfilled

[ISO 9000: 2000]

NOTE Verification in a system life cycle context is a set of activities that compares a product of the system life cycle against the required characteristics for that product. This may include, but is not limited to, specified requirements, design description and the system itself.

5 System Life Cycle Processes

5.1 Introduction

This clause describes the requirements for the life cycle processes. It defines their purposes and outcomes, and the activities required to achieve them. An organization conducts the life cycle processes selectively to fulfil the purpose and outcomes of life cycle stages.

The life cycle processes are described in four process groups as follows:

Agreement processes;

Enterprise processes;

Project processes;

Technical processes.

NOTE Each life cycle process may be invoked, as required, at any time throughout the life cycle and there is no definitive order in their use. Any life cycle process may be executed concurrently with any other life cycle process. Any life cycle process may apply at any level in the hierarchical representation of a system's structure. Therefore, in the following description of the system life cycle processes, the order that the processes are presented and the process groups used do not imply any precedence in, or sequence of application of, processes during the life cycle of a system. The process groups, however, do reflect underlying concepts used in this International Standard and these are described in Annex D.

5.2 Agreement Processes

5.2.1 Introduction

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.

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 an operational system, 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.

5.2.2 Acquisition Process

5.2.2.1 Purpose of the Acquisition Process

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

5.2.2.2 Acquisition Process Outcomes

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

a) A strategy for the acquisition is established.

b) A supplier is selected.

c) Communication with the supplier is maintained.

d) A justification for the selection is declared.

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

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

g) Payment or other consideration is rendered.

5.2.2.3 Acquisition Process Activities

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

a) Establish a plan for how the acquisition will be conducted.

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

b) Prepare a request for the supply of a product or service.

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.

c) 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.

d) Select a supplier.

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 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.

e) 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.

f) Assess the execution of the agreement.

NOTE This includes confirmation that both 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.

g) 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.

h) Make payment or provide other agreed consideration to the supplier for the product or service rendered.

NOTE When the supplied product or service has satisfied the conditions of the agreement, the acquirer concludes the agreement by rendering payment or other agreed consideration.

5.2.3 Supply Process

5.2.3.1 Purpose of the Supply Process

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

5.2.3.2 Supply Process 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.

5.2.3.3 Supply Process Activities

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

a) Determine the existence and identity of an acquirer who has, or who represents a party or parties 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) Evaluate a request for the supply of a product or service to determine feasibility and how to respond.

c) Prepare a response that satisfies the solicitation.

d) 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.

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

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

f) 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.

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

h) Accept and acknowledge payment or other agreed consideration.

i) Transfer the responsibility for the product or service to the acquirer, or other party, as directed by the agreement.

5.3 Enterprise Processes

5.3.1 Introduction

The Enterprise Processes manage 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 Enterprise Processes consist of the following:

a) Enterprise Environment Management Process;

b) Investment Management Process;

c) System Life Cycle Processes Management Process;

d) Resource Management Process;

e) Quality Management Process.

5.3.2 Enterprise Environment Management Process

5.3.2.1 Purpose of the Enterprise Environment Management Process

The purpose of the Enterprise Environment Management Process is to define and maintain the policies and procedures needed for the organization's business with respect to the scope of this International Standard.

5.3.2.2 Enterprise Environment Management Process Outcomes

As a result of the successful implementation of the Enterprise Environment Management Process:

a) Policies and procedures for the strategic management of system life cycles are provided.

b) Accountability and authority for system life cycle management are defined.

c) A policy for the improvement of system life cycle processes is provided.

5.3.2.3 Enterprise Environment Management Process Activities

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

a) Establish plans for each business area.

NOTE Identify the short-term objectives that contribute to achieving strategic objectives and the projects that will be undertaken to accomplish the strategic objectives.

b) Prepare system life cycle policies and procedures that implement the requirements of this International Standard and are consistent with enterprise strategic and business area plans.

NOTE The actual range and detail of the system 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. Relevant policies and procedures include risk management, quality management and resource management.

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

d) Define business criteria that control progression through the system 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.

e) Conduct periodic reviews of the system 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.

f) Communicate to projects the policies and procedures adopted by the enterprise in order to implement the requirements of this standard.

5.3.3 Investment Management Process

5.3.3.1 Purpose of the Investment Management Process

The purpose of the Investment Management Process is to initiate and sustain sufficient and suitable projects in order to meet the 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.

5.3.3.2 Investment Management Process Outcomes

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

a) Investment opportunities or necessities are qualified and selected.

b) Resources and budgets are identified and allocated.

c) Project management accountability and authorities are defined.

d) Projects meeting agreement, stakeholder and organization requirements are sustained.

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

5.3.3.3 Investment Management Process Activities

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

a) 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.

b) Define projects, accountabilities and authorities.

c) Identify the expected outcomes of the projects.

d) Allocate resources for the achievement of project objectives.

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

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

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

h) Evaluate ongoing projects to confirm that:

1) projects are making progress towards achieving established goals;

2) projects are complying with project directives;

3) projects are being conducted according to system life cycle plans and procedures;

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

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

j) Act to cancel or suspend projects whose disadvantages or risks to the organization outweigh the benefits of continued investments, where agreements permit this.

5.3.4 System Life Cycle Processes Management Process

5.3.4.1 System Life Cycle Processes Management Process Purpose

The purpose of the System Life Cycle Processes Management Process is to assure that effective system life cycle processes are available for use by the organization.

This process provides system life cycle processes that are consistent with the organization's goals and policies, that are defined, adapted and maintained in a consistent way in order to meet the nature of individual projects, and that are capable of being applied using effective, proven methods and tools.

5.3.4.2 System Life Cycle Processes Management Process Outcomes

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

a) System life cycle processes for use by the organization are defined.

b) Policy to apply system life cycle processes is defined.

c) Policy to adapt system life cycle processes to meet the needs of individual projects is defined.

d) Measures are defined to evaluate the application of the system life cycle processes.

e) Improvements to the definition and application of system life cycle processes are undertaken.

5.3.4.3 System Life Cycle Processes Management Process Activities

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

a) Establish standard sets of system life cycle processes for applicable system life cycle stages.

b) Establish acceptable tailoring and application policies and procedures, with approval requirements.

c) Identify methods and tools that support system life cycle process execution.

d) Establish measures wherever possible that determine performance of the implemented standard processes.

e) Monitor process execution, store and analyze process measures, and identify trends with respect to enterprise criteria.

f) Identify opportunities for improvement of standard system life cycle process implementation.

g) Improve processes, methods and tools as determined.

5.3.5 Resource Management Process

5.3.5.1 Purpose of the Resource Management Process

The purpose of the Resource Management Process is to provide resources to projects.

This process provides resources, materials and services to projects to support organization and project objectives throughout the life cycle. This includes a supply of educated, skilled and experienced personnel qualified to perform life cycle processes. This process assures that there is effective co-ordination and sharing of resources, information and technologies.

5.3.5.2 Resource Management Process Outcomes

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

a) Necessary resources, materials and services are provided to projects.

b) Skills of personnel are maintained or enhanced.

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

5.3.5.3 Resource Management Process Activities

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

a) Determine and provide the resource infrastructure support needed to implement the requirements of this International Standard within the organization and provide project support.

NOTE 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.

b) Obtain resources other than personnel that are needed to implement and support projects.

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

NOTE This includes the recruitment, training and retention of personnel with experience levels and skills necessary to properly staff projects; managing the competency of personnel to perform life cycle processes; provision of training and education to improve their skill sets and support their career paths; 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.

d) Motivate staff, e.g. through career development and reward mechanisms.

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

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

   2) from project personnel being over-committed.

5.3.6 Quality Management Process

5.3.6.1 Quality Management Process Purpose

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

5.3.6.2 Quality Management Process 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 goals and 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 goals are not achieved.

5.3.6.3 Quality Management Process Activities

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

a) Establish quality management policies, standards and procedures.

NOTE A process model for quality management system requirements can be found in ISO 9001:2000 with further guidance in ISO 9004:2000.

b) Establish organization quality management goals and objectives based on business strategy for customer satisfaction.

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

d) Assess customer satisfaction and report.

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

e) Conduct periodic reviews of project quality plans.

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

f) Monitor the status of quality improvements on products and services.

5.4 Project Processes

5.4.1 Introduction

The Project Processes are used to establish and evolve 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 consist of the following processes:

a) Project Planning Process;

b) Project Assessment Process;

c) Project Control Process;

d) Decision-making Process;

e) Risk Management Process;

f) Configuration Management Process;

g) Information Management Process.

NOTE Planning, assessment and control are key to all management practices. They are evident in the management of any undertaking, ranging from a complete organization down to a single life cycle process and its activities. In this International Standard, the project has been chosen as the context for describing processes concerned with planning, assessment and control. The principles related to these processes can be applied in any area of an organization's management.

5.4.2 Project Planning Process

5.4.2.1 Purpose of the Project Planning Process

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.

5.4.2.2 Project Planning Process Outcomes

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

a) Project plans are available.

b) Roles, responsibilities and authorities are defined.

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

d) Project performance measures are defined.

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

5.4.2.3 Project Planning Process Activities

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

a) 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.

b) 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.

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

d) 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 necessary to achieve timely completion of the project.

e) 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.

f) 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.

g) 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. They include the effective use of human resources and draw 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.

h) 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.

i) 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.

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

k) Define the project measures to be generated and the associated data to be collected, validated and analyzed.

NOTE This includes identifying project data sources, recipients and timing.

l) Generate a project quality plan.

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

5.4.3 Project Assessment Process

5.4.3.1 Purpose of the Project Assessment Process

The purpose of the Project Assessment Process is to determine the status of the project.

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.

5.4.3.2 Project Assessment Process Outcomes

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

a) Project performance measures or assessment results are available.

b) Adequacy of roles, responsibilities and authorities is assessed.

c) Adequacy of resources and services necessary to achieve the project is assessed.

d) Deviations in project performance indicators are analyzed.

e) Concerned parties are informed of project status.

5.4.3.3 Project Assessment Process Activities

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

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

b) Perform quality assurance in accordance with project plans.

c) Assess the effectiveness of project team structure, roles and responsibilities.

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.

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

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

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

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.

f) 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.

g) Monitor critical processes and new technologies.

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

h) Analyze data and measures 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.

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

5.4.4 Project Control Process

5.4.4.1 Purpose of the Project Control Process

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

This process includes redirecting the project activities, as appropriate, to correct identified deviations and variations from other project management or technical processes. Redirection may include replanning as appropriate.

5.4.4.2 Project Control Process Outcomes

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

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

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

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

d) Project objectives are achieved.

5.4.4.3 Project Control Process Activities

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

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

b) 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-deployment and re-assignment of personnel, tools and project infrastructure assets when inadequacy or unavailability has been detected.

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

d) 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.

e) 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.

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

g) 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.

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

5.4.5 Decision-making Process

5.4.5.1 Purpose of the Decision-making Process

The purpose of the Decision-making 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.

5.4.5.2 Decision-making Process Outcomes

As a result of the successful implementation of the Decision-making Process:

a) A decision-making 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.

5.4.5.3 Decision-making Process Activities

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

a) Define a decision-making strategy.

NOTE This includes identifying decision categories and a prioritization scheme, and identifying responsible parties. The decision makers are identified and given the responsibility and authority to make decisions. Decisions may arise as a result of an effectiveness assessment, a technical trade-off, problem needing to be solved, 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. A decision-making strategy includes the identification and allocation of responsibility for, and authority to make, decisions.

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

c) 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.

d) Select and declare the decision-making strategy for each decision situation. Identify desired outcomes and measurable success criteria.

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

f) 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.

g) 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.

5.4.6 Risk Management Process

5.4.6.1 Purpose of the Risk Management Process

The purpose of the Risk Management Process is to reduce the effects of uncertain events that may result in changes to quality, cost, schedule or technical characteristics.

This process identifies, assesses, treats and monitors risks during the entire life cycle, responding to each risk in terms of appropriate treatment or acceptance.

5.4.6.2 Risk Management Process Outcomes

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

a) Risks are identified and categorized.

b) The probabilities and consequence of risks are quantified.

c) A strategy to treat each risk is specified.

d) Risk status is available and communicated.

e) Risks that have become unacceptable are acted upon.

5.4.6.3 Risk Management Process Activities

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

a) Establish a systematic approach to risk identification, assessment and treatment.

NOTE This includes determining events that would adversely affect the system, project or the organization. It also may include establishing risk categories. Within the quality, cost, schedule or technical characteristics, define the method for expressing risks in suitable terms, including measures wherever possible.

b) Identify and define the risks.

NOTE This includes identifying the initiating events associated with each risk in each risk category, and defining the interrelationships between sources of risk. Within these dimensions, the method for expressing risks in suitable terms, including measures wherever possible, is defined.

c) Determine the probability associated with risk occurrence using the established risk criteria.

NOTE The criteria can include associated cost, legal and statutory requirements, socio-economic and environmental aspects, the concerns of stakeholders, priorities and other inputs to the assessment.

d) Evaluate the risks in terms of their possible consequences using the established criteria.

e) Prioritize the risks in terms of their probability and consequences.

f) Determine the risk treatment strategies.

NOTE This includes:

1) Risk avoidance by either a decision not to become involved in, or an action to withdraw from, a risk situation;

2) Risk optimization, including mitigation, to reduce the negative consequences and respective probabilities. Risk optimization depends upon risk criteria, including costs and legal requirements;

3) Transfer of risk by sharing the responsibility with another party for the burden of loss;

4) Risk retention, which is the acceptance of the burden of loss from a particular risk.

g) Define a threshold of acceptability for each identified risk.

h) Identify the risk treatment actions to follow if the threshold of acceptability is exceeded.

NOTE For risks that have high consequences, establish contingency plans that will be initiated if mitigation actions are unsuccessful.

i) Communicate the risk treatment actions and their status in accordance with the agreement, policies and procedures.

j) Maintain a register of risk throughout the life cycle.

NOTE The register includes a definition of the current perception of risks, and the relationship to risk treatment actions and budgets. This register maintains the history of the risks in order to assist decisions and may become a reference for an evolving design for future, related systems.

5.4.7 Configuration Management Process

5.4.7.1 Purpose of the Configuration Management Process

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.

5.4.7.2 Configuration Management Process 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.

5.4.7.3 Configuration Management Process Activities

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

a) Define a configuration management strategy.

NOTE This includes defining authorities for the deposition 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. The configuration management activities should be compatible with the guidance provided in ISO 10007.

b) 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.

c) 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.

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

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.

5.4.8 Information Management Process

5.4.8.1 Purpose of the Information Management Process

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, enterprise, agreement and user information.

5.4.8.2 Information Management Process 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.

5.4.8.3 Information Management Process Activities

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

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

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

c) 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.

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

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.

e) Obtain the identified items of information.

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

f) 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.

g) 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 new technology.

h) 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.

i) Provide official documentation as required.

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

j) Archive designated information, in accordance with the audit and knowledge retention 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.

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

5.5 Technical Processes

5.5.1 Introduction

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 enterprise and project functions to optimize the benefits and reduce the risks that arise from technical decisions and actions. These activities enable products 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.

5.5.2 Stakeholder Requirements Definition Process

5.5.2.1 Purpose of the Stakeholder Requirements Definition Process

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 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 in order to confirm that the system fulfils needs.

5.5.2.2 Stakeholder Requirements Definition Process Outcomes

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

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.

d) The basis for defining the system requirements is described.

e) The basis for validating the conformance of the services is defined.

f) A basis for negotiating and agreeing to supply a service or product is provided.

5.5.2.3 Stakeholder Requirements Definition Process Activities

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

a) 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, supporters, developers, producers, trainers, maintainers, disposers, acquirer and supplier organizations, regulatory bodies and members of society. Where direct communication is not practicable, e.g. consumer products and services, representatives or designated proxy stakeholders are selected, e.g. marketing.

b) Elicit stakeholder requirements.

NOTE Stakeholder requirements are expressed in terms of 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, such as found in ISO/IEC 9126, is 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 limiting characteristics of operator staff. Exclude unjustified constraints on a solution. 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.

c) 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.

d) 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 and 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.

e) 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. Where possible, applicable standards, e.g. ISO 9241, and accepted professional practices are used in order to define:

1) Physical, mental, and learned capabilities;

2) Work place, environment and facilities, including other equipment in the context of use;

3) Normal, unusual, and emergency conditions;

4) Operator and user recruitment, training and culture.

f) 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.

g) Analyze the complete set of elicited requirements.

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

h) Resolve requirements problems.

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

i) 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.

j) 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.

k) 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 systems.

l) 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.

5.5.3 Requirements Analysis Process

5.5.3.1 Purpose of the Requirements Analysis Process

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 developer's perspective, what characteristics it is to possess and with what magnitude in order to satisfy stakeholder requirements.

5.5.3.2 Requirements Analysis Process 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.

5.5.3.3 Requirements Analysis Process Activities

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

a) 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 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.

b) Define each function that the system is required to perform, 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 Conditions for the performance of functions may incorporate reference to states and required 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.

c) 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.

d) 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 with any non-compliance. ISO/IEC 15939 provides a process to identify, define and use appropriate measures. ISO/IEC 9126 may provide relevant quality measures.

e) 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.

f) 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. 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.

g) 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.

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

5.5.4 Architectural Design Process

5.5.4.1 Purpose of the Architectural Design Process

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 requirements resulting from this process are the basis for verifying the realized system and for devising an assembly and verification strategy.

5.5.4.2 Architectural Design Process Outcomes

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

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.

5.5.4.3 Architectural Design Process Activities

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

a) 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.

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

c) 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 12207:1995/AMD.1:2002 for software.

d) Determine which system requirements are allocated to operators.

NOTE 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.

1) Limitations of human capabilities;

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

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

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

e) 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.

f) 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:

1) assessing and communicating the emergence of adverse system properties resulting from the interaction of candidate system elements or from changes in a system element;
2) ensuring that the constraints of enabling system are taken account of in the design;
3) performing effectiveness assessments, trade-off analyses and risk analyses that lead toward realizing a feasible, effective, stable and optimized design.

g) 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 7498.

h) 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.

i) 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.

j) Maintain mutual traceability between architectural design and system requirements.

5.5.5 Implementation Process

5.5.5.1 Purpose of the Implementation Process

The purpose of the Implementation Process is to produce 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 specialisms or disciplines. This process results in a system element that satisfies architectural design requirements through verification and stakeholder requirements through validation.

5.5.5.2 Implementation Process Outcomes

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

a) An implementation strategy is defined.

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.

5.5.5.3 Implementation Process Activities

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

a) 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.

b) 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.

c) 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 element 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.

1) 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.

2) Software Creation

Code software elements and, as appropriate, compile, inspect and test to assure their conformance to the design criteria. ISO/IEC 12207:1995/AMD.1:2002 applies to system elements realized in software.

3) 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.

d) 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,

e) 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.

5.5.6 Integration Process

5.5.6.1 Purpose of the Integration Process

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.

5.5.6.2 Integration Process 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.

5.5.6.3 Integration Process Activities

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

a) Define an assembly sequence and strategy that minimizes system integration 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 include its human operators. Successive applications of the Integration Process and the Verification Process, and when required the Validation Process, are repeated for systems at successive levels until the system-of-interest has been realized.

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

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

c) 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.

d) 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.

e) Assure that the system elements have been verified 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.

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

g) Record integration information in an appropriate database.

NOTE This includes resolution of problems due to the integration strategy, the integration enabling systems or manual assembly errors. The data are analyzed to enable corrective or improvement actions to the integration strategy and its execution.

5.5.7 Verification Process

5.5.7.1 Purpose of the Verification Process

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.

5.5.7.2 Verification Process 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.

5.5.7.3 Verification Process Activities

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

a) Define the strategy for verifying the systems 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.

b) 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.

c) Identify and communicate potential constraints on design decisions.

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.

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

e) 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.

f) Make available verification data on the system.

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

g) 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.

5.5.8 Transition Process

5.5.8.1 Purpose of the Transition Process

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.

5.5.8.2 Transition Process 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 services.

d) The configuration as installed is recorded.

e) Corrective action reports are recorded.

f) A service is sustainable by enabling systems.

5.5.8.3 Transition Process Activities

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

a) 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.

b) 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.

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

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

d) 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.

e) 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.

f) Activate the system.

g) 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.

h) Record the installation data, including the operational configuration, anomalies detected, actions taken and lessons learned.

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.

5.5.9 Validation Process

5.5.9.1 Purpose of the Validation Process

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.

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.

5.5.9.2 Validation Process 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.

5.5.9.3 Validation Process Activities

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

a) 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 consumer. 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.

b) 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.

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

d) 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.

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

f) 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.

g) Analyze, record and report validation data according to criteria defined in the validation strategy.

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.

5.5.10 Operation Process

5.5.10.1 Purpose of the Operation Process

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.

5.5.10.2 Operation Process 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.

5.5.10.3 Operation Process Activities

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

a) 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.

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

c) 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.

d) 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.

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

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

f) 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.

g) 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).

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

i) 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.

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

k) 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.

5.5.11 Maintenance Process

5.5.11.1 Purpose of the Maintenance Process

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.

5.5.11.2 Maintenance Process 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.

e) The need for corrective design changes is reported.

f) Failure and lifetime data is recorded.

5.5.11.3 Maintenance Process Activities

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

a) 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:

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

2) 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;

3) 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;

4) 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.

b) 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.

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

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

e) 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.

f) 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. software defect, and/or to production actions. This can have consequences on relevant enabling systems.

g) 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.

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

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

j) 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 elements.

5.5.12 Disposal Process

5.5.12.1 Purpose of the Disposal Process

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 elements 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.

5.5.12.2 Disposal Process 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 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.

5.5.12.3 Disposal Process Activities

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

a) 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.

b) Communicate unavoidable constraints on the system design arising from the disposal strategy.

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

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

d) 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.

e) 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.

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

g) 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.

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

i) 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.

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

k) 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.

6 System Life Cycle Stages

6.1 Introduction

This clause describes the requirements for stages in the system life cycle. The life cycle stages provide a framework for the detailed modelling of system life cycles using the system life cycle processes described in Clause 5.

6.2 Life Cycle Models

A life cycle model that is comprised of stages shall be established.

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 this International Standard using a commonly encountered example of life cycle stages and this is described in Annex B.

6.3 Life Cycle Stages

The purpose and outcomes shall be defined for each stage of the life cycle.

NOTE 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. Different organizations may undertake different stages in the life cycle. However, each stage is conducted by the organization responsible for that stage with due consideration of the available information on life cycle plans and decisions made in preceding stages. Similarly, the organization responsible for that stage records the decisions made and records the assumptions regarding subsequent stages in the life cycle.

Annex A
(normative)

Tailoring Process

A.1 Introduction

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

A.2 Tailoring Process

A.2.1 Purpose of the Tailoring Process

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 Tailoring Process Outcomes

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

a) A life cycle model is defined in terms of stages and the contributions they make to the system.

b) Individual life cycle stages that influence the fulfilment of an agreement to supply a product or service are described.

c) Modified or new system life cycle processes are defined.

A.2.3 Tailoring Process Activities

If this International Standard is tailored, then the organization or project shall implement the following activities 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;

   6) emerging technology opportunities;

7) profile of budget and organizational resources available;

8) availability of the services of enabling systems.

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-making Process.

e) Define a suitable system life cycle model that permits the system-of-interest to be created and utilized in a manner that conforms to the services needed or the product specified.

f) Identify a life cycle model in terms of stages, their identities, their purposes and the outcomes they accomplish as a result of the application of the life cycle processes within each stage.

1) The exemplary stages described in this International Standard may be individually selected and used to define the identity, purposes, and outcomes of stages that form part of a selected life cycle model.

2) Alternatively, life cycle stages described in this International Standard may be individually selected, identified and modified or not applied, as necessary, to achieve changed purpose and outcomes. Document the changes made.

3) Alternatively, define and document any new stage in terms of its identity, purpose and outcomes. Each new stage is assessed to confirm its contribution to a complete and consistent life cycle.

g) Select the life cycle processes that require tailoring in order to satisfy the life cycle stage outcomes.

1) The life cycle processes described in this International Standard may be individually selected, identified and modified, as necessary, to achieve changed purpose and outcomes. Document the changes made.

2) Alternatively, define and document any new Life Cycle Process in terms of its identity, purpose and outcomes. The contribution of each new Life Cycle Process is evaluated for its contribution to the system.

Annex B
(informative)

Life Cycle Stages

B.1 Introduction

Stages may be used to construct frameworks within which system life cycle processes are used to model life cycles. The scale and rigour of process application in the listed stages and the duration of these stages will be determined by the varying technical and business needs of the projects defining and using the life cycle.

This Annex describes six example stages as follows:

a) Concept Stage;

b) Development Stage;

c) Production Stage;

d) Utilization Stage;

e) Support Stage;

f) Retirement Stage.

Following a description of each Stage, the Purpose and Outcomes of these example stages are defined.

B.2 Concept Stage

B.2.1 Overview

The Concept Stage begins with initial recognition of a need or a concept for a new system-of-interest or for the modification to an existing system-of-interest. This is an initial exploration, fact finding, and planning period, when economic, technical, strategic, and market bases are assessed through acquirer/market survey, feasibility analysis and trade-off studies. Acquirer/user feedback to the concept is obtained.

One or more alternative solutions to meet the identified need or concept are developed through analysis, feasibility evaluations, estimations (such as cost, schedule, market intelligence and logistics), trade-off studies, and experimental or prototype development and demonstration. The need for one or more enabling systems for development, production, utilization, support and retirement of the system-of-interest is identified and candidate solutions included in the evaluation of alternatives in order to arrive at a balanced, life cycle solution. Typical outputs are stakeholder requirements, concepts of operation, assessment of feasibility, preliminary system requirements, outline design solutions in the form of drawings, models, prototypes, etc., and concept plans for enabling systems, including whole life cost and human resource requirements estimates and preliminary project schedules. Decisions are made whether to continue with the implementation of a solution in the Development Stage or to cancel further work.

It is presumed that the organization has available the methods, techniques, tools and competent human resources to undertake market/economic analysis and forecasting, feasibility analysis, trade-off analysis, technical analysis, whole life cost estimation, modelling, simulation, and prototyping.

B.2.2 Purpose of the Concept Stage

The Concept Stage is executed to assess new business opportunities and to develop preliminary system requirements and a feasible design solution.

B.2.3 Concept Stage Outcomes

The outcomes of the Concept Stage are listed below:

a) The identification of new concepts that offer new capabilities, enhanced overall performance or reduced stakeholders' total ownership costs over the system life cycle.

b) An assessment of feasible system-of-interest concepts and solutions, including enabling systems throughout the life cycle, for closure against both technical and business stakeholder objectives.

c) The preparation and baselining of stakeholder requirements and preliminary system requirements (technical specifications for the selected system-of-interest and usability specifications for the envisaged human-system interaction).

d) Refinement of the outcomes for stages of the system life cycle model.

e) Risk identification, assessment and mitigation plans for stages of system life cycle model.

f) Identification and initial specification of the services needed from enabling systems throughout the life of the system.

g) Concepts for execution of all succeeding stages.

h) Plans and exit criteria for the Development Stage.

i) Risk identification, assessment and mitigation plans for this and subsequent stages of system life cycle model.

j) Satisfaction of stage exit criteria.

k) Approval to proceed to the Development Stage.

B.3 Development Stage

B.3.1 Overview

The Development Stage begins with sufficiently detailed technical refinement of the system requirements and the design solution and transforms these into one or more feasible products that enable a service during the Utilization Stage. The system-of-interest may be a prototype in this stage. The hardware, software and operator interfaces are specified, analyzed, designed, fabricated, integrated, tested and evaluated, as applicable, and the requirements for production, training, and support facilities are defined. This stage also ensures that the aspects of future stages (production, utilization, support, and retirement) and their enabling systems' requirements and capabilities are considered and incorporated into the design through the involvement of all interested parties. Feedback is obtained from stakeholders and those who will produce, operate, use, support, and retire the system-of-interest. Outputs are a system-of-interest or a prototype of the final system-of-interest, refined enabling systems or the enabling systems themselves and all documentation and cost estimates of future stages.

Planning for this stage begins in the preceding stage to ensure the organization has available, or can establish, an infrastructure of development enabling systems, consisting of methods, techniques, tools and competent human resources to undertake analysis, modelling and simulation, prototyping, design, integration, test and documentation. These items are developed or acquired to be available when needed to support development.

B.3.2 Purpose of the Development Stage

The Development Stage is executed to develop a system-of-interest that meets acquirer requirements and can be produced, tested, evaluated, operated, supported and retired.

B.3.3 Development Stage Outcomes

The outcomes of the Development Stage are listed below:

a) Evaluated and refined system requirements, project budget and schedule baselines and life cycle ownership cost estimates.

b) A system-of-interest architecture comprised of hardware elements, software elements and humans and their interfaces (internal and external).

c) Verification and validation documentation.

d) Confirmation that the system-of-interest meets all stakeholder and system requirements and is producible, operable, supportable and capable of retirement and is cost effective for stakeholders.

e) Refined and baselined requirements for the enabling systems.

f) Technical information, including as appropriate:

   1) hardware diagrams, drawings and models;

   2) software design documentation;

   3) interface specifications;

   4) production plans;

   5) operating instructions;

   6) training manuals for operators;

   7) maintenance procedures;

   8) retirement considerations.

g) A prototype or final system-of-interest is built.

h) Refined outcomes and cost estimates for the Production, Utilization, Support and Retirement Stages.

i) Definition of the enabling system services required in subsequent life cycle stages.

j) Plans and exit criteria for the Production Stage.

k) Current risks identified and mitigating actions determined.

l) Satisfaction of stage exit criteria.

m) Approval to proceed to the Production Stage.

B.4 Production Stage

B.4.1 Overview

The Production Stage begins with the approval to produce the system-of-interest. The system-of-interest may be individually produced, assembled, integrated, and tested, as appropriate, or may be mass-produced. Planning for this stage begins in the preceding Stage. Production may continue throughout the remainder of the system life cycle. During this stage, the product may undergo enhancements or redesigns, the enabling systems may need to be reconfigured and production staff re-trained in order to continue evolving a cost effective service from the stakeholder viewpoint.

It is presumed that the organization has available the production infrastructure, consisting of budget, production equipment, tools, procedures and competent human resources. These items are developed or acquired in order to be available when needed to enable production.

This stage may overlap with a Development Stage, with the Utilization Stage and with a Support Stage.

B.4.2 Purpose of the Production Stage

The Production Stage is executed to produce or manufacture the product, to test the product and to produce related supporting and enabling systems as needed.

B.4.3 Production Stage Outcomes

The outcomes of the Production Stage are listed below:

a) Qualification of the production capability.

b) Acquisition of resources, material, services and system elements to support the target production quantity goals.

c) The product produced according to approved and qualified production information.

d) Packaged product transfer to distribution channels or acquirer.

e) Plans and exit criteria for the Utilization Stage and the Support Stage.

f) Updated concepts for execution of all succeeding stages.

g) Current risks and mitigating actions identified.

h) Quality assured systems-of-interest accepted by the acquirer

i) Satisfaction of stage exit criteria.

j) Approval to proceed to the Utilization Stage.

B.5 Utilization Stage

B.5.1 Overview

The Utilization Stage begins after installation and transition to use of the system. The Utilization Stage is executed to operate the product at the intended operational sites to deliver the required services with continued operational and cost effectiveness. This stage ends when the system-of-interest is taken out of service.

Planning for this stage begins in the preceding stages. This stage includes those processes related to use of the product to provide services, as well as monitoring performance and identifying, classifying and reporting of anomalies, deficiencies, and failures. The response to identified problems includes taking no action; maintenance and minor (low cost/temporary) modification (reference Support Stage); major (permanent) modification and system-of-interest life extensions (reference Development and Production Stages), and end-of-life retirement (reference Retirement Stage).

During this stage the product or services can evolve giving rise to different configurations. The user operates the different configurations and the responsible product supplier manages the status and descriptions of the various versions and configurations of the product or services in use.

It is presumed that the organization has available the operational infrastructure which includes facilities, equipment, trained personnel, and instruction manuals and procedures. These items are developed or acquired in order to be available when needed to support utilization.

B.5.2 Purpose of the Utilization Stage

The Utilization Stage is executed to operate the product, to deliver services within intended environments and to ensure continued operational effectiveness.

B.5.3 Utilization Stage Outcomes

The outcomes of the Utilization Stage are listed below:

a) Experienced personnel with the competence to be operators in the system-of-interest and provide operational services.

b) An installed system-of-interest that is capable of being operated and of providing sustainable operational services.

c) Performance and cost monitoring and assessment to confirm conformance to service objectives.

d) Identification of problems or deficiencies, informing appropriate organizations (user, development, production, or support) of the need for corrective action.

e) New opportunities for system-of-interest enhancement through stakeholder feedback.

f) Plans and exit criteria for exiting the Retirement stage.

g) Satisfaction of stage exit criteria.

h) Approval to proceed to the Retirement Stage.

B.6 Support Stage

B.6.1 Overview

The Support Stage begins with the provision of maintenance, logistics and other support for the system-of-interest's operation and use. Planning for this stage begins in the preceding stages. The Support Stage is completed with the retirement of the system-of-interest and termination of support services.

This stage includes those processes related to operating the support system and providing support services to users of the system-of-interest. This stage also includes monitoring performance of the support system and services and the identification, classification, and reporting of anomalies, deficiencies, and failures of the support system and services. Actions to be taken as a result of identified problems include maintenance and minor modification of the support system and services, major modification of the support system or services (reference

Development and Production Stages), and end-of-life retirement of the support system and services (reference Retirement Stage).

During this stage the support system and services can evolve under different versions or configurations. The support organization operates the different versions or configurations and the responsible product organization manages the status and descriptions of the various versions and configurations of the support system and services in use.

It is presumed that the organization has available the support which includes the support sites, facilities, equipment and tools, trained support personnel, and maintenance manuals and procedures. The items making up the support infrastructure are developed and acquired in order to be ready when needed to support the system-of-interest.

B.6.2 Purpose of the Support Stage

The Support Stage is executed to provide logistics, maintenance, and support services that enable continued system-of-interest operation and a sustainable service.

B.6.3 Support Stage Outcomes

The outcomes of the Support Stage are listed below:

a) Trained personnel who will maintain and provide the support services.

b) Organizational interfaces with the operating and production organizations that ensure problem resolution and corrective actions.

c) Maintained product and services and the provision of all related support services, including logistics, to the operational sites.

d) Product and service maintenance and corrected design deficiencies.

e) All required logistics support, including a spare parts inventory sufficient to satisfy operational availability goals.

f) Current risks and mitigating actions identified.

g) Agreement to terminate support services.

h) Satisfaction of stage exit criteria.

B.7 Retirement Stage

B.7.1 Overview

The Retirement Stage provides for the removal of a system-of-interest and related operational and support services. Planning for the Retirement Stage begins in the preceding stages. This stage begins when a system-of-interest is taken out of service.

This stage includes those processes related to operating the retirement system and also includes monitoring performance of the retirement system and the identification, classification, and reporting of anomalies, deficiencies, and failures of the retirement system. Actions to be taken as a result of identified problems include maintenance and minor modification of the retirement system (reference Support Stage), major modification of the retirement system (reference Development and Production stages), and end-of-life retirement of the retirement system itself (reference Retirement Stage).

It is presumed that the organization has access to an infrastructure to support retirement, including retirement facilities, tools and equipment, personnel trained in retirement actions, retirement procedures and, as appropriate,

access to recycling, disposal or containment facilities. The items making up the retirement infrastructure are developed and acquired in order to be ready when needed to perform retirement functions.

This stage is applicable whenever a system-of-interest reaches its end-of-service life. Such end-of-service life can be the result of replacement by a new system, irreparable wear, catastrophic failure, no further use to the user, or not cost effective to continue operating and supporting the system-of-interest.

B.7.2 Purpose of the Retirement Stage

The Retirement Stage is executed to provide for the removal of a system-of-interest and related operational and support services, and to operate and support the retirement system itself.

B.7.3 Retirement Stage Outcomes

The outcomes of the Retirement Stage are listed below:

a) Experienced personnel who can provide retirement services.

b) Required system-of-interest decommissioning, including disposal, refurbishing, or recycling, in accordance with applicable health, safety, security, privacy and environmental laws and regulations.

c) Plans and procedures for transferring the provision of services to the new system-of-interest if applicable.

d) Removal of waste.

e) Environment returned to original or agreed state.

f) Archived elements.

g) Operational staff are reallocated, redeployed or retired.

h) Satisfaction of stage exit criteria.

Annex C
(informative)

Relationship between ISO/IEC 15288 and ISO/IEC 12207:1995/AMD.1:2002

C.1 Diagrammatic representation

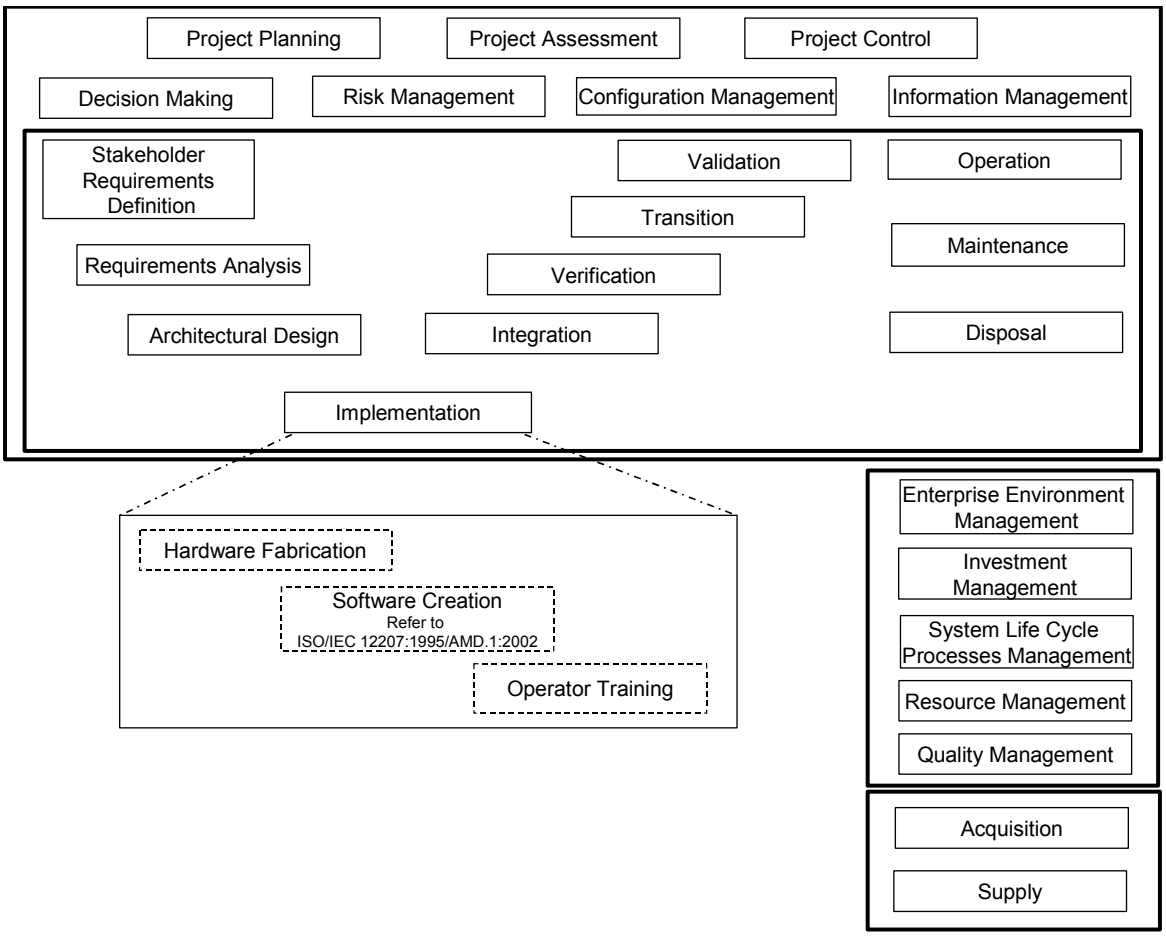

Figure C.1 — Relationship between ISO/IEC 15288 and ISO/IEC 12207:1995/AMD.1:2002

Figure C.1 illustrates processes in ISO/IEC 15288 from which system life cycles are built. When a system element is developed, an appropriate standard is applied corresponding to the nature of the system element. For system elements that are implemented in software, the processes of ISO/IEC 12207:1995/AMD.1:2002 are applied.

C.2 Tabular representation

Table C.1 provides a broad mapping between the processes in ISO/IEC 15288 and those in ISO/IEC 12207:1995/AMD.1:2002 to show the relationship between the standards. The scope, emphasis, structure and detail varies between the standards but the system principles are applied similarly and their descriptions, in terms of processes used to build life cycle models, are also similar.

The three centre columns indicate which standard has greater emphasis:

a) A tick in the left column indicates that ISO/IEC 15288 has more emphasis

b) A tick in the centre column indicates that the processes have similar levels of treatment in both International Standards.

c) A tick in the right column indicates that ISO/IEC 12207:1995/AMD.1:2002 has greater emphasis.

There is also variation in the way the two International Standards treat some processes:

a) In ISO/IEC 15288 the improvement activities are distributed into a number of processes while ISO/IEC 12207:1995/AMD.1:2002 contains these in an Improvement Process

b) In ISO/IEC 12207:1995/AMD.1:2002 risk management activities are distributed into a number of processes while ISO/IEC 15288 contains these in a Risk Management Process.

Table C.1 — Relationship between ISO/IEC 15288 and ISO/IEC 12207:1995/AMD.1:2002

ISO/IEC 15288	⇑	∝	⇓	ISO/IEC 12207:1995/AMD.1:2002
Enterprise Environment Management Process		✓#		Management process, Improvement process
Investment Management Process	✓			Infrastructure process
System Life Cycle Processes Management Process	✓			Supply Process
System Life Cycle Processes Management Process, Enterprise Environment Process			✓	Management process, Improvement process
Acquisition Process		✓		Acquisition process
Stakeholder Requirements Definition Process	✓			Development process, Usability process
Supply Process		✓		Supply process
Risk Management Process	✓			Acquisition process, Supply process, Management process
Information Management Process		✓		Documentation process, Asset management process
Requirements Analysis Process		✓		Development process
Architectural Design Process		✓		Development process, Usability process
Implementation Process		✓		Development process
Integration Process		✓		Development process
Transition Process	✓			Development process
Transition Process		✓		Training process
Operation Process		✓		Operation process
Maintenance Process		✓		Maintenance process
Disposal Process	✓			Maintenance process
Configuration Management Process		✓		Configuration management process
Project Assessment Process		✓		Quality assurance process
Quality Management Process		✓		Management process

Verification Process		✓		Verification process
Validation Process		✓		Validation process, Usability process
Project Assessment Process			✓	Joint review process
Enterprise Environment Management Process			✓	Audit process
Project Assessment Process			✓	Audit process
Decision Making Process		✓		Problem resolution process, Development process, Reuse program management process
Project Assessment Process			✓	Product evaluation process
Project Planning Process		✓		Management process, Supply process, Development process
Project Assessment Process		✓		Management process
Project Control Process		✓		Management process, Problem resolution process
Resource Management Process		✓		Infrastructure process
Resource Management Process		✓		Human resource management process
Implementation			✓	Domain engineering
Tailoring Process		✓		Tailoring process

Annex D
(informative)

Concepts

D.1 System Concepts

D.1.1 Introduction

This Annex is included to highlight and to help explain essential concepts on which this International Standard is based.

D.1.2 Systems

The systems considered in this International Standard are man-made, created and utilized to provide services in defined environments for the benefit of users and other stakeholders. These systems may be configured with one or more of the following: hardware, software, humans, processes (e.g. review process), procedures (e.g. operator instructions), facilities and naturally occurring entities (e.g. water, organisms, minerals). 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 another person's system-of-interest. Conversely, it can be viewed as being part of the environment of operation for another person's system-of-interest.

Figure D.1 exemplifies the multitude of perceivable systems-of-interest in an aircraft and its environment of operation. It illustrates:

a) the importance of defined boundaries that encapsulate meaningful needs and practical solutions;

b) the hierarchical perception of system physical structure;

c) that an entity at any level in a hierarchical structure can be viewed as a system;

d) that a system comprises a fully integrated, defined set of subordinate systems;

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

f) that humans can be viewed as users external to a system (e.g. air crew and navigation system) and as system elements within a system (e.g. air crew and aircraft);

g) that a system can be viewed in isolation as an entity, i.e. a product, or as an ordered 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, a user and an element of a system.

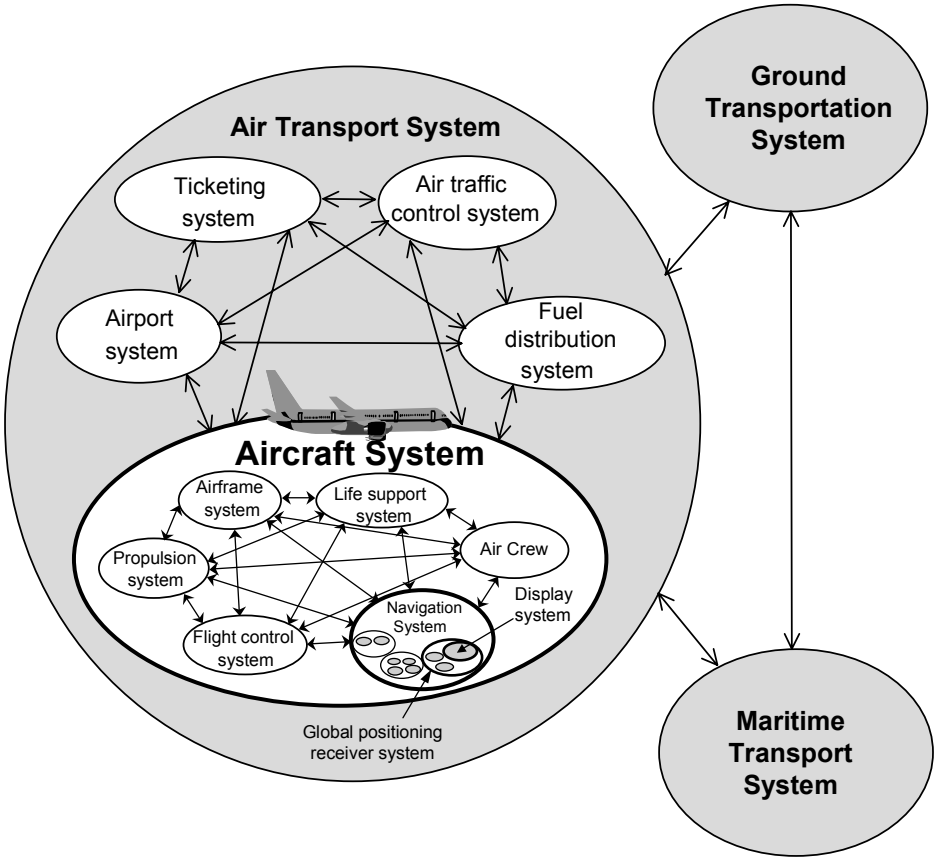

Figure D.1 —Typical system view of an aircraft in its environment of use

Humans contribute to the performance and characteristics of many systems for numerous reasons, e.g. their special skills, the need for flexibility, for legal reasons. Whether they are users or operators, humans are highly complex, with behaviour that is frequently difficult to predict, and they need protection from harm. This requires the system life cycle processes to address human element factors in the areas of: human factors engineering, system safety, health hazard assessment, manpower, personnel and training. These issues are addressed by particular activities and iteration in the life cycle, and are described in more detail in ISO 13407 and ISO/TR 18529.

D.1.3 System Structure

The system life cycle processes in this International Standard are described in relation to a system, see Figure D.2, 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.

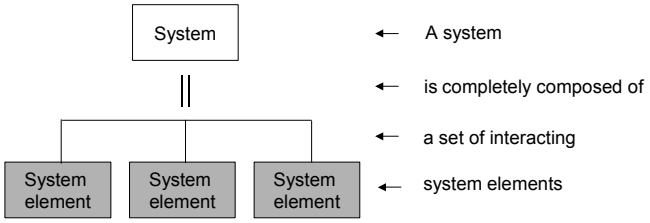

Figure D.2 — System and system element relationship

The relationship between the system and its complete set of system elements can typically only be resolved in a single step 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 D.3. In this manner, the 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 or reused, or acquired from another party.

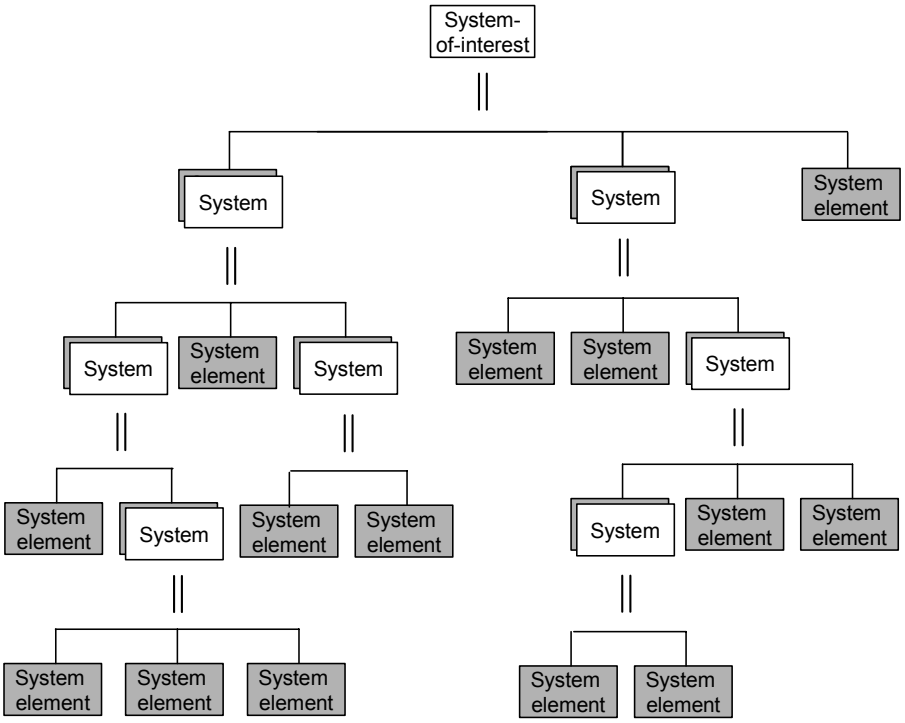

Figure D.3 — System-of-interest structure

D.1.4 Hierarchy in Systems and Projects

Each system in the hierarchy illustrated in Figure D.1 could be the responsibility of a separate project. Thus there can be (and typically is) a strong correlation between levels of detail in the architectural structure and levels of responsibility in a hierarchy of projects. Each project has responsibility for acquiring and using levels of system composition beneath it and creating and supplying to the level above it.

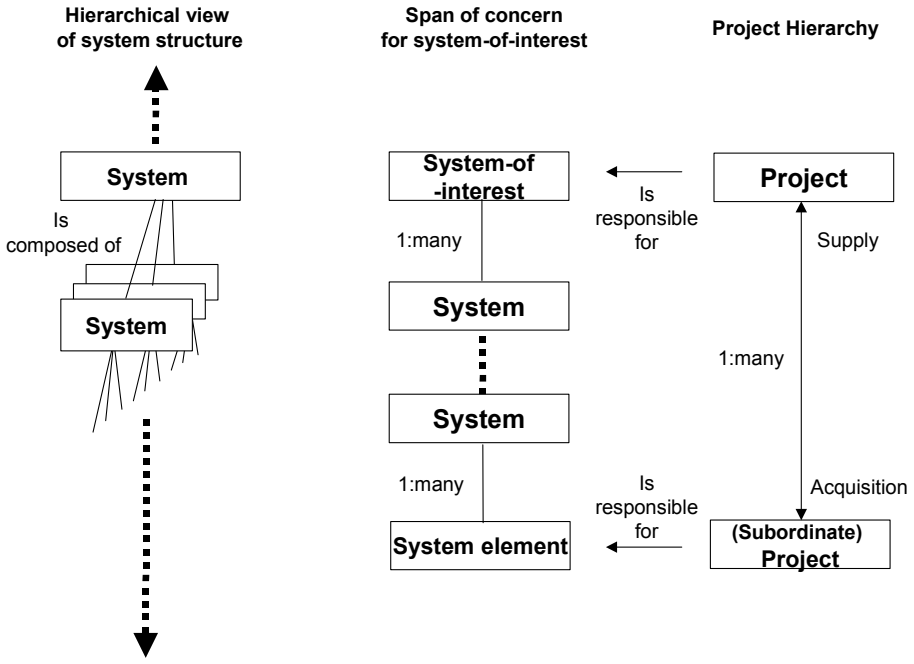

Figure D.4 — System and Project Hierarchies

Any particular project normally views its system as the system-of-interest, and whilst it can influence higher system levels it does not have responsibility for them. However, it does have responsibility for the system elements that constitute its system-of-interest, and consequently for the output of projects at all levels beneath, see Figure D.4.

In practice, the risks associated with implementing systems that fulfil specified requirements typically diminish with descending level of detail in the system-of-interest's structure and eventually are no longer of undue concern to the particular project. At this level (not necessarily the same level down different paths of system-of-interest decomposition) a system element can be acquired with acceptable risk and the detail of its composition can remain hidden. From the system-of-interest viewpoint, the system elements may appear to be where specialist disciplines or particular implementation technology practices are present.

D.1.5 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 D.5. Enabling systems can be seen to contribute indirectly to the services provided by the system-of-interest.

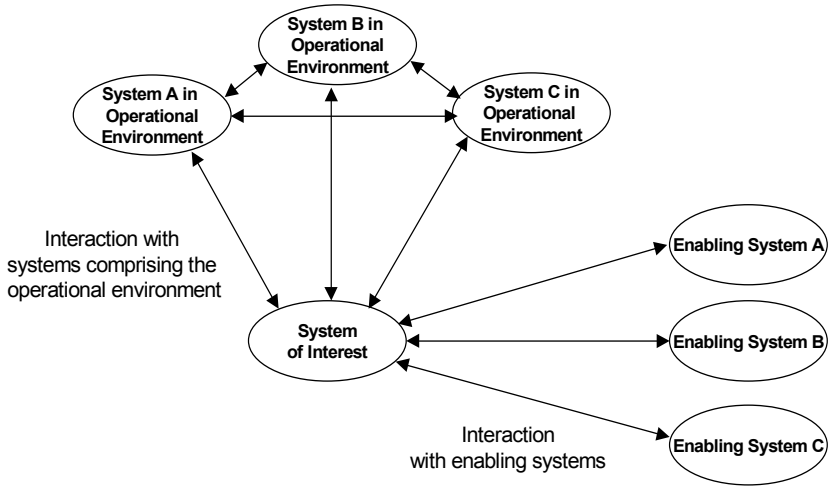

Figure D.5 — System-of-interest, its operational environment and enabling systems

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.

D.2 Life Cycle Concepts

D.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 their performance. The detail in the life cycle model is expressed in terms of these processes, their outcomes, relationships and occurrence. This International Standard defines a set of processes, termed life cycle processes, by which a system's life cycle may be modelled.

D.2.2 System Life Cycle Stages

Life cycles vary according to the nature, purpose, use and prevailing circumstances of the system. Nevertheless, despite an apparently limitless variety in system life cycles, there is an underlying, essential set of characteristic life cycle stages that exists in the complete life cycle of any 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 contain the inherent uncertainties and risks associated with costs, schedule and functionality when creating or utilizing a system. The stages thus provide organizations with a framework within which enterprise management has high-level visibility and control of project and technical processes.

Table D.1 shows a commonly encountered example of life cycle stages. Also shown are the principal purposes of each of these stages and the possible decision options used to manage the achievement and risk associated with progression through the life cycle.

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. Sequential, incremental or evolutionary life cycle forms are frequently used, alternatively, a suitable hybrid of these can be developed. The selection and development of such life cycle forms by an organization depend on several factors, including the business context, the nature and complexity of the system, the stability of requirements, the technology opportunities, the need for different system capabilities at different times and the availability of budget and resources.

Table D.1 — An example of stages, their purposes and major decisions gates

LIFE CYCLE STAGES	PURPOSE	DECISION GATES
CONCEPT	Identify stakeholders' needs Explore concepts Propose viable solutions	Decision Options: - Execute next stage - Continue this stage - Go to a preceding stage - Hold project activity - Terminate project
DEVELOPMENT	Refine system requirements Create solution description Build system Verify and validate system	
PRODUCTION	Produce systems Inspect and test	
UTILIZATION	Operate system to satisfy users' needs	
SUPPORT	Provide sustained system capability	
RETIREMENT	Store, archive or dispose of the system	

Just as all the system elements of a system contribute to the system as a whole, so each stage of the life cycle needs to be considered during any other stage of the life cycle. As a consequence, the contributing parties need to co-ordinate and co-operate with each other throughout the life cycle. This synergism of the life cycle stages and the functional contributors is necessary for successful project actions. Close communication with, and where appropriate project team members from, the different functions and organizations responsible for other life cycle stages leads to consistency in the life cycle.

D.2.3 Stages in a system-of-interest and its enabling systems

As with any system, each enabling system also has its own life cycle. Each life cycle is linked and synchronized to that of the system-of-interest, e.g. when (in the case that it does not already exist) the enabling system requirement is defined during the Concept Stage of the system-of-interest (or later if lead times permit), when the enabling system is utilized to provide its particular service to the system-of-interest (see Figure D.6).

An enabling system can pre-exist the system-of-interest, i.e. be an existing part of the infrastructure of the organization responsible for the system-of-interest or be in a service supplier's organization. Pre-existing enabling systems can introduce additional constraints on the system-of-interest.

Each enabling system can itself be considered as a system-of-interest, having in turn its own enabling systems. Therefore this International Standard can also be applied to enabling systems.

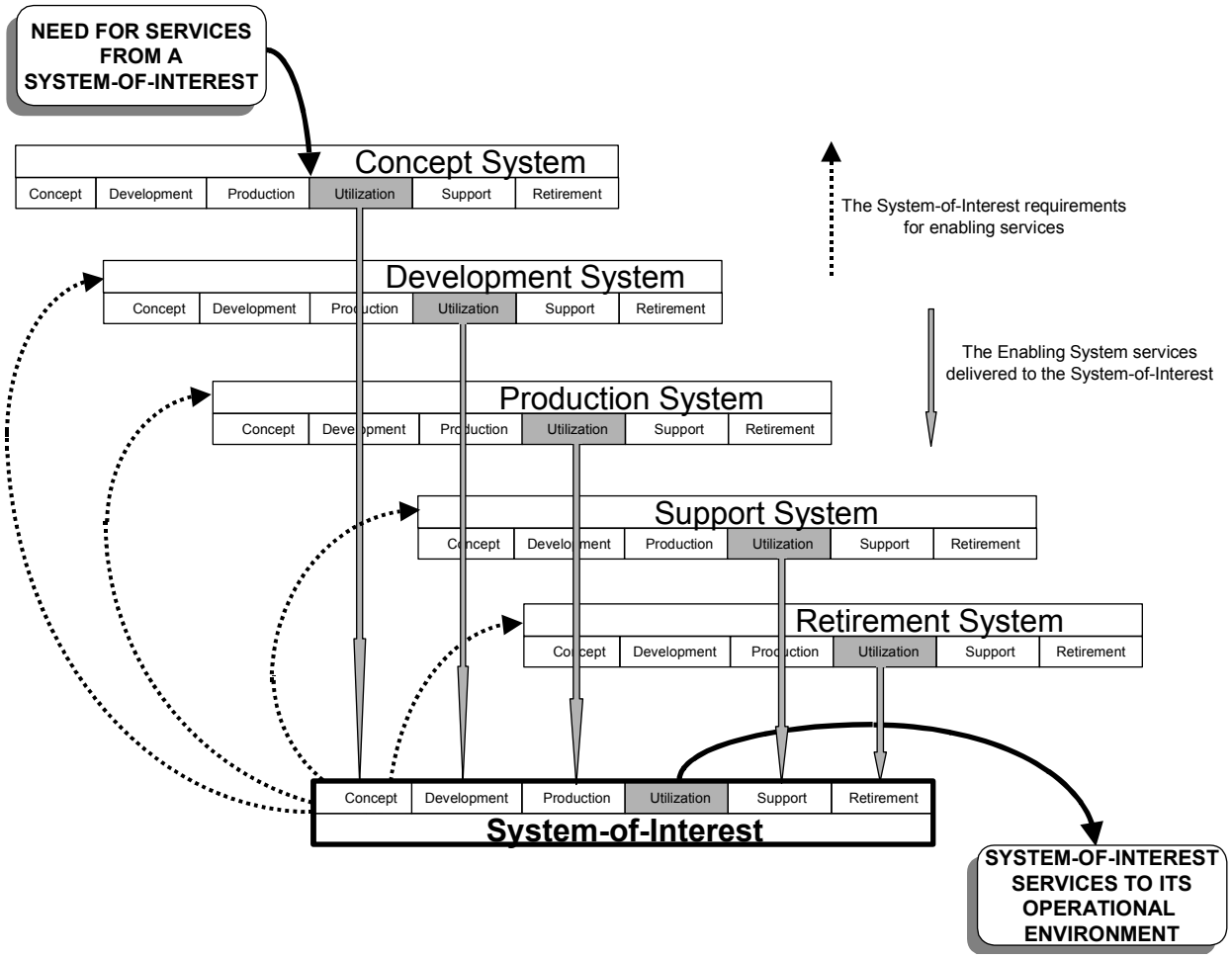

Figure D.6 — System interaction with Typical Enabling Systems

D.3 Process Concepts

D.3.1 Life Cycle Processes

The life cycle processes defined in this International Standard can be used by any organization when acquiring and using and when creating and 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 that constitute the process.

The processes described in this International Standard are not intended to preclude or discourage the use of additional processes that organizations find useful.

D.3.2 Responsibilities and Agreements within and between Organizations

D.3.2.1 Process Responsibility

Typically, organizations distinguish different areas of managerial responsibility and action (see Figure D.7); together, these areas contribute to the organization's overall capability to trade. This International Standard employs a process model based on three primary organizational areas (or levels) of responsibility: enterprise, project and technical. Within each organization, a co-ordinated set of enterprise, project and technical processes contribute to the effective creation and use of systems, and therefore to achieving the organization's goals.

Different organizations and different areas of responsibility within an organization mutually establish their working relationships and acknowledge their respective responsibilities by making agreements. These agreements unify and co-ordinate the contributions made by different areas of responsibility in order that they can meet a common business purpose.

D.3.2.2 Agreement Processes

Organizations are producers and consumers of systems, i.e. they trade products and services. One organization can, acting as an acquirer, 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, for example in Figure D.7 the vertical relationship of Organizations A and B can be considered to represent organizations in a supply chain, trading during a stage in a life cycle. Similarly, the horizontal relationship of Organizations A and C can be considered to represent organizations with successive responsibility for stages in a life cycle.

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 enterprise, project and technical functions.

D.3.2.3 Enterprise Processes

The Enterprise Processes are concerned with ensuring that the needs and expectations of the organization's interested parties are met. The Enterprise 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. Responsibility for these processes is typically at the highest level in the organization.

The Enterprise Processes create a strong enterprise image for many organizations and imply commercial and profit-making motives. Nevertheless, the Enterprise Processes are equally relevant to non-profit organizations, since they are also accountable to interested parties, are responsible for resources and encounter risk in their undertakings. This International Standard can thus be applied to non-profit organizations as well as to profit-making organizations.

D.3.2.4 Project Processes

The Project Processes are concerned with managing the resources and assets allocated by enterprise management and with applying them to fulfil the agreements into which that organization enters. They relate to the management of projects, in particular to planning in terms of cost, time scales 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 can co-exist in any one organization. The Project Processes can be employed to provide, at a corporate level, an organization's infrastructure, e.g. facilities, enabling services, technology base.

D.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.

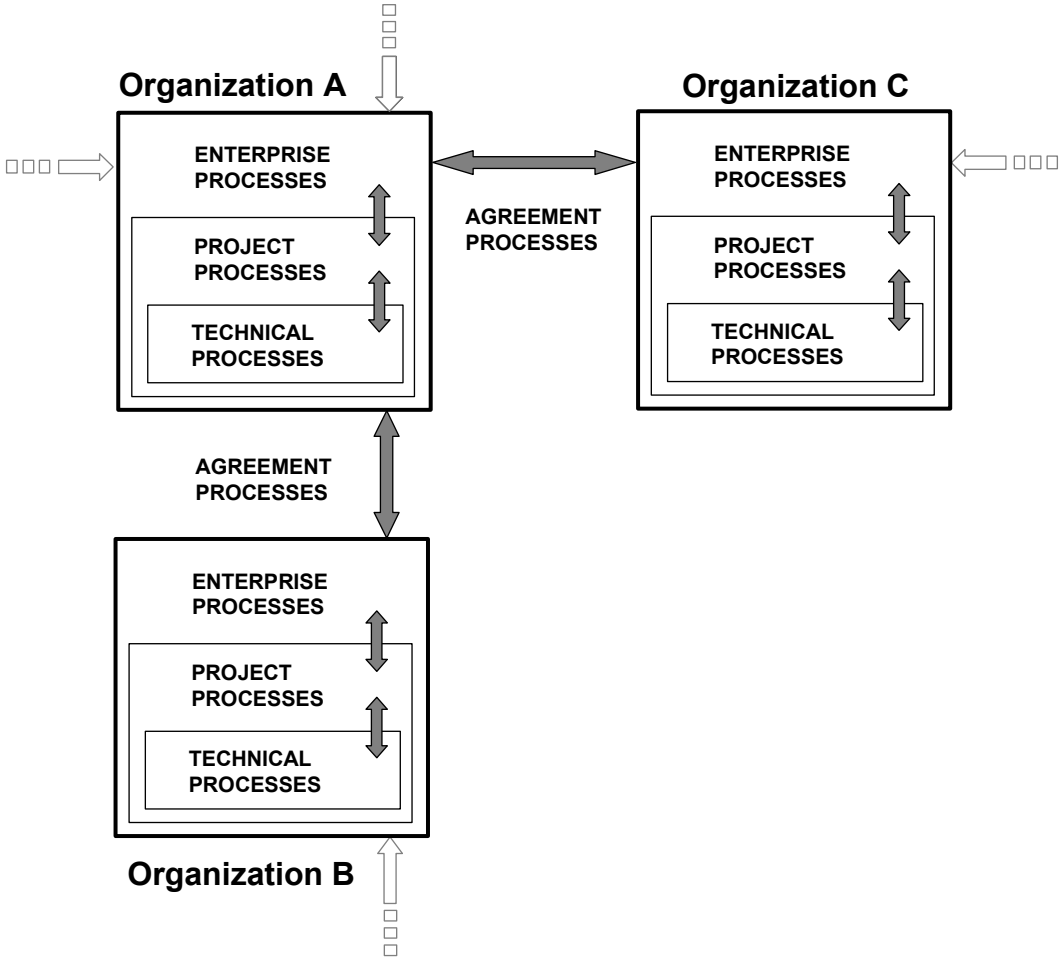

Figure D.7 — Agreement, enterprise, project and technical processes in co-operating organizations

D.3.3 Process application

Each life cycle process in Figure D.8 can be invoked, as required, at any time throughout the life cycle and there is no definitive order in their use. 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.

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.

The iterative use of processes, i.e. the repeated application of a process or set of processes at the same hierarchical level of structural detail, 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.

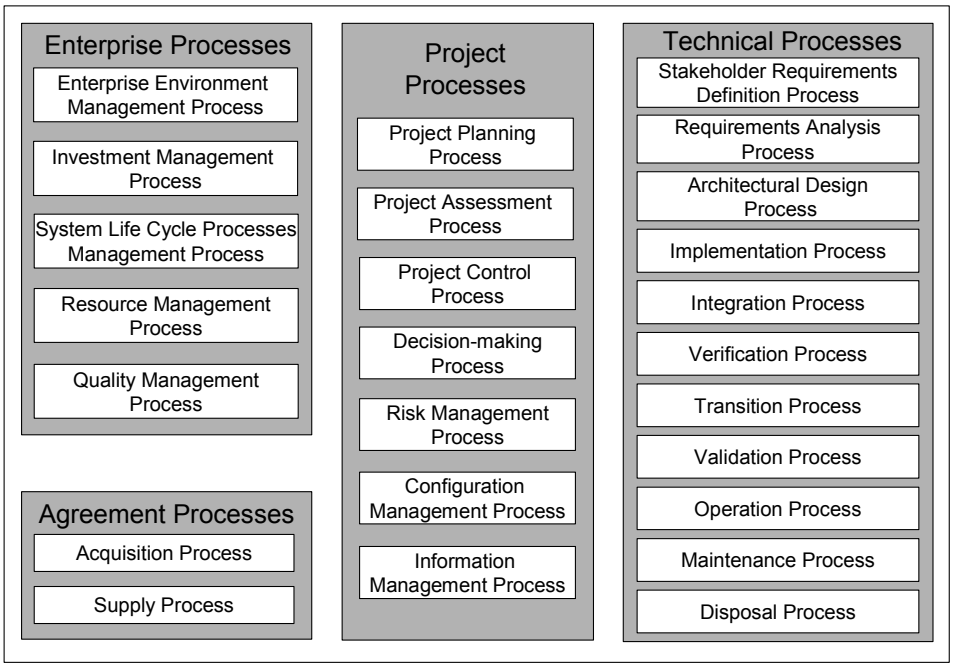

Figure D.8 — The system life cycle processes

The recursive use of processes, i.e. the repeated application of the same process or set of processes applied to successive levels of detail in a system's hierarchical 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 above or level below. This results in a response, information, artefacts or service, which can then modify the original output. In this way, the outputs across all levels of the system architecture can be resolved and consistency achieved, e.g. system element descriptions that form a consistent architecture.

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 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. Precedence, particularly in similar market and product sectors, can assist the selection of stages and the application of life cycle processes to build an appropriate and effective life cycle model for any system.

Annex E

(informative)

Relationship to other IEEE standards

E.1 Introduction

The IEEE has previously adopted ISO/IEC 12207:1995 as a three part standard, IEEE/EIA 12207™, Software Life Cycle Processes. The writers of ISO/IEC 12207 worked from the premise that all software products are embedded in some sort of system—if nothing else, the computer on which the software is executed. Therefore, the development, maintenance, or operation of software inherently implies a system context. To this end, the 12207 standard defined the minimum set of system development activities necessary to develop software. IEEE standards-writers have shared this view, so it is not surprising that the IEEE would write standards related to systems life cycle processes to complement their standards on software life cycle processes. These standards are listed below. This annex explains their relationships to IEEE Std 15288™.

— IEEE Std 1220™-1998, IEEE Standard for Application and Management of the Systems Engineering Process.[1]

— 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.

— IEEE/EIA 12207™ [3 parts], Software Life Cycle Processes.

E.2 Overview of relationships

The software life cycle processes of IEEE/EIA 12207 must fit with the system life cycle processes of the IEEE Std 15288 in order to implement the software items of the system. IEEE/EIA 12207 is an adoption of ISO/IEC 12207:1995. The IEEE adoption replaced some of the annexes of ISO/IEC 12207, and provided an errata sheet. In terms of its normative provisions, IEEE/EIA 12207.0 is substantively similar to ISO/IEC 12207:1995. Since that time, the responsible international committee has adopted an Amendment to ISO/IEC 12207 as a step toward both the harmonization of system and software processes and the harmonization of process definition and process assessment. The primary content of the Amendment is an Annex providing a more granular set of processes than those contained in the 1995 standard and defining them through statements of purpose and outcomes. IEEE has not adopted this Amendment because it is only a partial step toward the eventual complete harmonization. Annex C of this standard provides a thorough discussion of the relationship of ISO/IEC 15288 and ISO/IEC 12207:1995, as amended. The discussion in Annex C is largely true for ISO/IEC 12207:1995 also, and for IEEE/EIA 12207.0 as well (since it incorporates the full normative content of ISO/IEC 12207:1995), but there are some exceptions. For example, neither ISO/IEC 12207:1995 nor IEEE/EIA 12207 contains a Usability process or a Product Evaluation process. The Human Resource Management process mentioned in Annex C is a generalization of the Training process of IEEE/EIA 12207. Finally, the Asset Management, Domain Engineering, and Reuse Program Management pro-

[1]The IEEE standards or products referred to in this annex are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

cesses shown in the table cannot be found in IEEE/EIA 12207, but very similar processes can be found in IEEE Std 1517™, Software Reuse Processes.

One of the problems in reconciling the 15288 processes with the 12207 processes is that the Development process of 12207 includes systems engineering activities that are also covered by the Technical processes of 15288. So it is not enough to simply "plug" 12207 into the Implementation process of 15288.

Table E.1[2] illustrates the relationship between the Technical processes of IEEE Std 15288 and selected activities of the Development process of IEEE/EIA 12207.[3] The first column lists each Technical process of IEEE Std 15288. The second column lists selected activities of the Development process of 12207 and places them next to a roughly corresponding process of 15288. The final column lists IEEE systems engineering standards that are helpful in implementing the Technical processes of IEEE Std 15288. One important standard, IEEE Std 1220, Application and Management of the Systems Engineering Process, is omitted from this chart. It is handled in E.8.

E.3 Relationship of IEEE/EIA 12207

Table E.1—Relationship between the Technical processes of IEEE Std 15288 and selected activities of the Development process of IEEE/EIA 12207

15288 Technical Process	Activity of the 12207 Development Process	Helpful IEEE Systems Engineering Standards
Stakeholder Requirements Definition	System Requirements Analysis (unless already performed by Acquisition	IEEE Std 1362, Concept of Operations Document
Requirements Analysis	System Requirements Analysis	IEEE Std 1233, System Requirements Specification
Architectural Design	System Architectural Design	IEEE Std 1471, Description
Implementation	Development process activities not listed elsewhere	IEEE Std 1228, Safety Plans
Integration	System Integration	—
Verification	System Qualification Test	—
Transition	Software Installation	—
Validation	Software Acceptance Support	—
Operation	(12207 Operation process)	—
Maintenance	(12207 Maintenance process)	—
Disposal	(12207 Maintenance process)	—

The purpose of this subclause is to provide a concise description of the relationship of IEEE Std 15288 with IEEE/EIA 12207.0. As Annex C explains, even when there is a similar process in IEEE Std 15288 and IEEE/EIA 12207.0 (for example the Supply process), the emphasis that one standard places on the process

[2]The table is adapted from James W. Moore, Roadmap to Software Engineering—A Standards-Based Guide, John Wiley & Sons, forthcoming, by permission.

[3] A more detailed mapping is provided in Annex C.

may be greater or less than the emphasis that the other standard places on the process. Also, in some cases, activities that are distributed across several processes in one standard may be collected into a single process in the other standard.

Four of the five primary processes of IEEE/EIA 12207 line up with the processes of IEEE Std 15288 in a straightforward manner. The business processes of Acquisition and Supply line up directly with their counterparts in IEEE Std 15288, as do two other primary processes, Operation and Maintenance. The alignment of Development is more complicated. Basically, the process aligns with the 15288 Implementation process, but the fit is not perfect. Because the writers of 12207 wanted to provide the context of software development, they included activities providing minimal requirements for system activities. Those activities map to other processes of IEEE Std 15288 as shown in Table E.1.

The alignment of the 15288 Verification and Validation processes shown in the table is notable. One objective of the 15288 Verification process is to verify that integration was successful; one objective of the 15288 Validation process is to demonstrate that the system, as delivered, accomplishes its goals. With this interpretation the 15288 Verification and Validation processes align with the System Qualification Test and the Software Acceptance Support activities of the 12207 Development Process. If, however, one construes 15288 Verification and Validation processes as providing continuous or stepwise activities throughout development, then they could be aligned with the Verification and Validation processes of 12207.

The four organizational processes provided by 12207 align with 15288 in a complicated manner as explained in C.2.

One could take the view that all of the supporting processes of 12207 are subsumed by the alignment of the Development process to the 15288 Implementation process. If one wishes to integrate the supporting processes with the processes of 15288, then the correspondence shown in Table C.1 is somewhat complicated. However, two clear correspondences are apparent. The 12207 Documentation and Configuration Management processes could be aligned with the Information Management and Configuration Management processes of 15288 while noting that the 12207 processes are specialized to the needs of software.

The IEEE/EIA 12207.1 and IEEE/EIA 12207.2 parts of IEEE/EIA 12207 have no parallels in the 15288 standard. For example, IEEE/EIA 12207.1 provides recommended content for the information items mentioned in IEEE/EIA 12207.0. The content of information items mentioned in the 15288 standard is left mostly undefined by that standard. If conformance with IEEE/EIA 12207.1 is required, according to subclause 4.4, the recommendations in 12207.1 become requirements, and the level of control exerted on the content of a supplier’s data items goes far beyond the guidance in IEEE Std 15288.

IEEE/EIA 12207.2 contains guidance for the engineering tasks involved in the implementation of many processes in IEEE/EIA 12207.0.

Neither IEEE/EIA 12207.1 nor IEEE/EIA 12207.2 conflict with IEEE Std 15288. Their relationship to the 15288 standard is best described as supplementary guidance (on software life cycle data and on implementing software life cycle processes).

E.4 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. IEEE has a relevant standard: IEEE Std 1362-1998, IEEE Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document. According to its abstract:

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.

E.5 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, the process for creating the document, and guidance in performing it well.

E.6 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 IEEE Std 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 for 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 viewpoints that 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 seems to anticipate multiple viewpoints when it mentions multiple “logical architectures.”

E.7 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 applies all of the processes of 12207 and may involve interaction with systems engineers: IEEE Std 1228-1994, IEEE Standard for Software Safety Plans. Its abstract is as follows:

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.

IEEE Std 1228 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.

E.8 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 IEEE Std 15288. IEEE Std 1220-1998, IEEE Standard for 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 IEEE Std 15288 and IEEE Std 1220 requires considering both the life cycle processes and life cycle stages provided by IEEE Std 15288. In short, IEEE Std 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.

IEEE Std 1220 provides requirements for an integrated technical approach to defining and developing system products. The SEP defined by the standard 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 IEEE Std 1220 and IEEE Std 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 IEEE Std 1220 defines a “building block.” Recursive application of IEEE Std 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.

Clause 5 of IEEE Std 1220 describes the application of the SEP to the life cycle of the system. The life cycle stages identified in IEEE Std 1220 are as follows:

— *System Definition:* Establish the definition of the system with a focus on system products required to satisfy operational requirements.

— *Subsystem Definition—Preliminary Design:* Initiate subsystem design and create subsystem-level specifications and design-to baselines to guide component development.

— *Subsystem Definition—Detailed Design:* Complete subsystem design down to the lowest component level, and create a component specification and build-to component baseline for each component.

— *Subsystem Definition—Fabrication, Assembly, Integration and Test:* Resolve product deficiencies when specifications for the system, product, subsystem, assembly, or component are not met.

— *Operation—Production:* Correct deficiencies discovered during production, assembly, integration, and acceptance testing of products and/or life cycle process products.

— *Operation—Customer Support:* Evolve the product to implement an incremental change, resolve product or service deficiencies, or to implement planned evolutionary growth.

Although the SEP is focused on development, it treats four of the six exemplar life cycle stages of IEEE Std 15288—development, production, utilization, and support—and largely omits the two at each end—concept and retirement.

Clause 6 of IEEE Std 1220 describes the SEP. The process consists of eight sub-processes:

— *Requirements Analysis:* Establish what the system should do by refining the requirements of the next system up in the hierarchy.

— *Requirements Validation:* Validate the requirements against customer expectations, project constraints, and life cycle operation and support needs.

— *Functional Analysis:* Decompose the system functions to lower level ones to be accomplished by parts of the system.

— *Functional Verification:* Assess the functional architecture to verify that all requirements are met.

— *Synthesis:* Develop a design architecture that provides an arrangement of system elements, their interfaces, and their relationships.

— *Design Verification:* Verify that the requirements of the lowest level of the design architecture are traceable to the functional architecture and satisfy the requirements baseline.

— *Systems Analysis:* Perform quantitative analysis in support of the other sub-processes.

— *Control:* Manage and document the sub-processes of the SEP.

The SEP maps to two technical processes of 15288—Requirements Analysis and Architectural Design. The two verification sub-processes of the SEP are different from the Verification process of 15288. The intent of 15288 verification seems largely confined to verifying a system after it is assembled, rather than verifying preliminary architectures of the system.