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BSI Standards Publication

Systems and software engineering — Life cycle management

Part 1: Guide for life cycle management

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National foreword

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Systems and software engineering — Life cycle management —

Part 1: Guide for life cycle management

*Ingénierie des systèmes et du logiciel — Gestion du cycle de vie —
Partie 1: Guide de gestion du cycle de vie*



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Contents

Page

Foreword	vi
Introduction.....	vii
1 Scope	1
2 Terms and definitions	1
3 Life cycle-related concepts	7
3.1 System concepts	7
3.1.1 Introduction.....	7
3.1.2 Systems	7
3.1.3 System structure	9
3.1.4 Structure in systems and projects	10
3.1.5 Enabling systems	11
3.2 Life cycle concepts	12
3.2.1 System life cycle model	12
3.2.2 System life cycle stages	14
3.2.3 Stages in a system-of-interest and its enabling systems	15
3.3 Process concepts	16
3.3.1 Life cycle processes	16
3.3.2 Process responsibility	19
3.4 Process application.....	20
3.5 Processes under key views.....	22
4 Life cycle stages.....	24
4.1 Introduction.....	24
4.2 Concept stage.....	25
4.2.1 Overview.....	25
4.2.2 Purpose	25
4.2.3 Outcomes	26
4.3 Development stage.....	26
4.3.1 Overview.....	26
4.3.2 Purpose	26
4.3.3 Outcomes	27
4.4 Production stage	27
4.4.1 Overview.....	27
4.4.2 Purpose	28
4.4.3 Outcomes	28
4.5 Utilization stage	28
4.5.1 Overview.....	28
4.5.2 Purpose	29
4.5.3 Outcomes	29
4.6 Support stage	29
4.6.1 Overview.....	29
4.6.2 Purpose	30
4.6.3 Outcomes	30
4.7 Retirement stage	30
4.7.1 Overview.....	30
4.7.2 Purpose	30
4.7.3 Outcomes	31
5 Life cycle model illustrations using ISO/IEC 15288 and ISO/IEC 12207	31
5.1 System life cycle model using ISO/IEC 15288.....	31
5.1.1 Example of ISO/IEC 15288 in a generic system life cycle model	31

5.2	Software life cycle model using ISO/IEC 12207	33
5.2.1	Example of ISO/IEC 12207 in a generic software life cycle model	33
5.3	Adapting ISO/IEC 15288 and ISO/IEC 12207 life cycle models	36
6	Life cycle adaptation	36
6.1	Introduction	36
6.2	Adaptation sequence	37
6.2.1	Identify the project environment and characteristics	38
6.2.2	Solicit inputs	38
6.2.3	Select the appropriate standards	39
6.2.4	Select life cycle model	39
6.2.5	Select stages and processes	39
6.2.6	Document the adaptation decisions and rationale	40
6.3	Adaptation guidance	40
6.4	Scope adaptation	42
6.5	Stage adaptation	42
6.6	Process adaptation	42
6.7	Adapting evaluation-related activities	42
7	Life cycle model use by domains, disciplines and specialties	43
7.1	Life cycle models for domains and disciplines	43
7.2	Adaptation for domains and disciplines	44
7.3	Adaptation for specialties	44
7.3.1	Human	45
7.3.2	Health	45
7.3.3	Safety	45
7.3.4	Security	45
7.3.5	Interoperability	45
7.3.6	Usability	46
7.3.7	Dependability	46
7.3.8	Environmental impacts	46
8	Relationship with detailed process standards	46
9	Guidance on transitioning from the previous versions	48
9.1	Comparisons between the versions	48
9.2	Relationship description for ISO/IEC 12207:2008 and ISO/IEC 15288:2008	61
9.3	General notes on transition	65
9.3.1	Joint usage of both ISO/IEC 15288 and ISO/IEC 12207	65
9.3.2	Independent usage	65
9.4	Notes for new versus existing users	66
9.4.1	Considerations for transition decisions	66
9.4.2	Timing and phasing of transition	66
9.4.3	Adaptation considerations	66
9.5	Notes on using application guides ISO/IEC TR 15271 and ISO/IEC TR 19760	66
9.6	Adjustments in relationships with other ISO and ISO/IEC documents	66
9.7	Developing a forward strategy	67
Annex A	(informative) Guidance on development strategies and build planning	68
A.1	Scope	68
A.2	Candidate development strategies	68
A.3	Selecting an appropriate development strategy	68
A.4	Relationship of systems and software to development strategies	70
A.5	Planning software builds	70
A.5.1	Identifying builds and their objectives	70
A.5.2	Identifying the activities to be performed in each build	70
A.5.3	Recording build planning decisions	70
A.5.4	Scheduling the selected activities in each build	70
Annex B	(informative) Candidate joint management reviews	71
B.1	Scope	71
B.2	Assumptions	71
B.3	Candidate reviews	71

B.3.1	Plan reviews	71
B.3.2	Operational concept reviews	71
B.3.3	System requirements reviews.....	71
B.3.4	System design reviews	72
B.3.5	Software requirements reviews	72
B.3.6	Software design reviews.....	72
B.3.7	Test readiness reviews	72
B.3.8	Test results reviews	72
B.3.9	Usability reviews	72
B.3.10	Maintenance reviews.....	72
B.3.11	Critical requirement reviews	73
B.4	Other resources	73
Annex C	(informative) Problem reporting capability	74
C.1	Unified problem reporting	74
C.2	Problem classification	74
Bibliography		76

Foreword

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

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

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

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

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

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

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

ISO/IEC TR 24748-1, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 7, *Software and systems engineering*.

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

Part 1: Guide for life cycle management

Guides for the application of ISO/IEC 15288 (systems life cycle processes) and ISO/IEC 12207 (software life cycle processes) will form the subjects of future parts 2 and 3, respectively.

Introduction

ISO/IEC 15288, *Systems and software engineering — System life cycle processes*, and ISO/IEC 12207, *Systems and software engineering — Software life cycle processes*, each have published guides (ISO/IEC TR 19760 and ISO/IEC TR 15271, respectively) for the use of each International Standard individually. The purpose of this Technical Report is to facilitate the joint usage of the process content of the latest revisions of ISO/IEC 15288 and ISO/IEC 12207 by providing unified and consolidated guidance on life cycle management of systems and software. This is to help ensure consistency in system concepts and life cycle concepts, models, stages, processes, process application, key points of view, adaptation and use in various domains as the two International Standards are used in combination. That will in turn help a project team design a life cycle model for managing the progress of their project.

This Technical Report will also aid in identifying and planning use of life cycle processes described in ISO/IEC 15288 and ISO/IEC 12207 that will enable the project to be completed successfully, meeting its objectives/requirements for each stage and for the overall project. ISO/IEC TR 19760 and ISO/IEC TR 15271 will be replaced by ISO/IEC TR 24748-2 and ISO/IEC TR 24748-3, respectively, to support use of the two revised International Standards individually.

Besides the above, there is also increasing recognition of the importance of ensuring that all life cycle stages, and all aspects within each stage, are supported with thorough guidance to enable alignment with any process documents that might subsequently be created that focus on areas besides systems and software, including hardware, humans, processes (e.g. review process), procedures (e.g. operator instructions), facilities and naturally occurring entities (e.g. water, organisms, minerals).

By addressing these needs specifically in this Technical Report, the users of the process-focused ISO/IEC 12207 and ISO/IEC 15288 will not only benefit from having one document complementarily addressing the aspect of product or service life cycle: they will also benefit from a framework that links life cycle management aspects to more than just the systems or software aspects of products or services.

Systems and software engineering — Life cycle management —

Part 1: Guide for life cycle management

1 Scope

This Technical Report is a guide for the life cycle management of systems and software based on ISO/IEC 15288 and ISO/IEC 12207. This Technical Report:

- addresses systems concepts and life cycle concepts, models, stages, processes, process application, key points of view, adaptation and use in various domains;
- establishes a common framework for describing life cycles, including their individual stages, for the management of projects to provide or acquire either products or services;
- defines the concept and terminology of a life cycle;
- supports the use of the life cycle processes within an organization or a project. Organizations and projects can use these life cycle concepts when acquiring and supplying either products or services;
- provides guidance on adapting a life cycle model and the content associated with a life cycle or a part of a life cycle;
- describes the relationship between life cycles and their use in ISO/IEC 15288 (systems aspects) and ISO/IEC 12207 (software aspects);
- shows the relationships of life cycle concepts to the hardware, human, services, process, procedure, facility and naturally occurring entity aspects of projects;
- describes how its concepts relate to detailed process standards, for example, in the areas of measurement, project management and risk management;
- complements domain-specific application guidance in ISO/IEC TR 19760 and ISO/IEC TR 15271.

NOTE When published, ISO/IEC TR 24748-2 and ISO/IEC 24748-3 will cancel and replace ISO/IEC TR 19760 and ISO/IEC TR 15271, respectively.

2 Terms and definitions

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

2.1

acquirer

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

NOTE The acquirer could be one of the following: buyer, customer, owner, or purchaser.

2.2

acquisition

process of obtaining a product or service

[ISO/IEC 15288:2008]

2.3

activity

set of cohesive tasks of a process

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

2.4

agreement

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

2.5

architecture

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

[ISO/IEC 42010:2007]

NOTE ISO/IEC 12207 and ISO/IEC 15288 use the word “elements” instead of “components” and this Technical Report follows that usage.

2.6

audit

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

[ISO 9000:2005]

2.7

baseline

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

[ISO/IEC 15288:2008]

2.8

contract

binding agreement between two parties, especially enforceable by law, or a similar internal agreement wholly within an organization

[ISO/IEC 12207:2008]

2.9

customer

organization or person that receives a product or service

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

NOTE 2 Adapted from ISO 9000:2005.

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

2.10

developer

organization that performs development activities (including requirements analysis, design, testing through acceptance) during the life cycle process

NOTE Adapted from ISO/IEC 12207:2008.

2.11

enabling system

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

NOTE 1 Adapted from ISO/IEC 15288:2008.

NOTE 2 For example, when a system-of-interest enters the production stage, a production enabling system is required.

NOTE 3 Each enabling system has a life cycle of its own. This Technical Report is applicable to each enabling system when, in its own right, it is treated as a system-of-interest.

2.12

evaluation

systematic determination of the extent to which an entity meets its specified criteria

[ISO/IEC 12207:2008]

2.13

facility

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

[ISO/IEC 15288:2008]

2.14

life cycle

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

2.15

life cycle model

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

2.16

maintainer

individual who, or organization that, performs maintenance activities

NOTE Adapted from ISO/IEC 12207:2008.

2.17

monitoring

examination of the status of the activities of a supplier and of their results by the acquirer or a third party

[ISO/IEC 12207:2008]

2.18

operator

entity that performs the operation of a system

[ISO/IEC 15288:2008]

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

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

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

2.19 **organization**

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

NOTE 1 Adapted from ISO 9000:2005.

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

NOTE 3 An identified part of an organization (even as small as a single individual) or an identified group of organizations can be regarded as an organization if it has responsibilities, authorities and relationships.

2.20 **party** organization entering into an agreement

NOTE In this Technical Report, the agreeing parties are called the acquirer and the supplier.

[ISO/IEC 15288:2008]

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

[ISO 9000:2005]

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

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

[ISO/IEC 12207:2008]

2.23 **process outcome** observable result of the successful achievement of the process purpose

[ISO/IEC 12207:2008]

2.24 **product** result of a process

[ISO 9000:2005]

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

NOTE 1 Adapted from ISO 9000:2005.

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

NOTE 3 A process can also be viewed as a specific instantiation of life cycle processes, adapted within a life cycle model, to create the service or product for the specific requirements and context of the project.

2.26

qualification

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

[ISO/IEC 12207:2008]

2.27

quality assurance

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

[ISO 9000:2005]

2.28

resource

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

[ISO/IEC 15288:2008]

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

NOTE 2 Resources may be reusable, renewable or consumable.

2.29

retirement

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

[ISO/IEC 12207:2008]

2.30

security

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

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

2.31

service

performance of activities, work, or duties associated with a product

[ISO/IEC 12207:2008]

2.32

software product

set of computer programs, procedures, and possibly associated documentation and data

[ISO/IEC 12207:2008]

2.33

stage

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

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

NOTE 2 Stages may be overlapping.

2.34
stakeholder

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

2.35
supplier

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

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

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

2.36
system

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

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.

2.37
system element

member of a set of elements that constitutes a system

[ISO/IEC 15288:2008]

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

2.38
system-of-interest

system whose life cycle is under consideration in the context of this Technical Report

[ISO/IEC 15288:2008]

2.39
task

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

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

2.40
trade-off

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

[ISO/IEC 15288:2008]

2.41

user

individual or group that benefits from a system during its utilization

[ISO/IEC 12207:2008 and ISO/IEC 15288:2008]

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

2.42

validation

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

[ISO 9000:2005]

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

2.43

verification

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

[ISO 9000:2005]

NOTE Verification is a set of activities that compares a product of the 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.

2.44

version

identified instance of an item

[ISO/IEC 12207:2008]

NOTE Modification to a version of a product, resulting in a new version, requires configuration management action.

3 Life cycle-related concepts

3.1 System concepts

3.1.1 Introduction

This section is included to highlight and to help explain essential concepts on which this Technical Report is based. These concepts are directly applicable to software, as addressed in ISO/IEC 12207, systems, as addressed in ISO/IEC 15288, and to hardware, facilities, services, humans, processes and procedures and naturally occurring entities.

3.1.2 Systems

The systems considered in this Technical Report are man-made 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, services, humans, processes (e.g. review process), procedures (e.g. operator instructions), facilities and naturally occurring entities (e.g. water, organisms, minerals).

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 yet another person's system-of-interest.

Figure 1 exemplifies the multitude of perceivable systems-of-interest in an aircraft and its environment of operation. First, the figure in its entirety comprises a transportation system with air, ground and water elements, which can be a system-of-interest. Next, any one element of the transportation system can be viewed as a system-of-interest, such as the Air Transport System. The example can be continued through the levels so that, for example, the display can be an element of the navigation system, which is in turn an element of the aircraft system within the air transport system. However, from an equally valid perspective, such as that of display

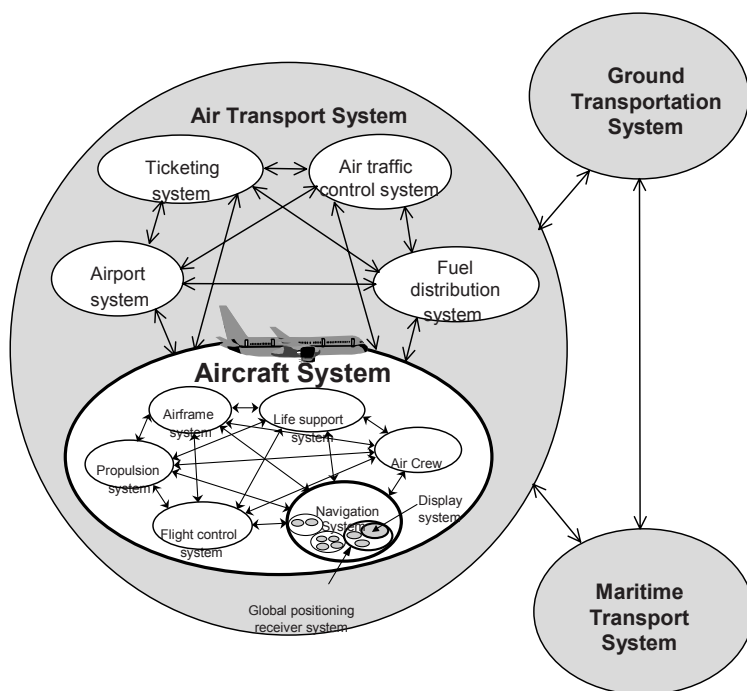


Figure 1 — Typical system view of an aircraft in its environment of use

manufacturers, the display will be their system-of-interest and they will then determine the elements within their display system. On a deeper level, Figure 1 also illustrates:

- the importance of defined boundaries that encapsulate meaningful needs and practical solutions;
- the perception of system structure (in this case, the physical structure, hierarchical in this instance);
- that an entity at any level in a system structure can be viewed as a system;
- that a system is comprised of a fully integrated, defined set of subordinate systems;
- that characteristic properties at a system's boundary arise from the interactions between subordinate systems;
- 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);
- that a system can be viewed as an isolated entity (that is, a product), or as an ordered collection of functions capable of interacting with its surrounding environment, (i.e. a set of services);
- that a system can be viewed as part of a larger system of systems and that a system of systems can be viewed as a system.

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

In this Technical Report, humans are considered both 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, such as those involved in providing a service. An individual can be, simultaneously or sequentially, a user and an element of a system, for example, the pilot of a private aircraft in the civil aviation system.

Humans contribute to the performance and characteristics of many systems for numerous reasons, e.g. their special skills, the need for flexibility and 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 that the system life cycle processes 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 iterations in the life cycle, and are described in more detail in ISO 13407:1999, *Human-centred design processes for interactive systems*, and ISO/TR 18529:2000, *Ergonomics — Ergonomics of human-system interaction — Human-centered lifecycle process descriptions*.

3.1.3 System structure

The system life cycle processes in this Technical Report are described in relation to a system that is composed of a set of interacting physical, logical and/or other system elements, depicted in Figure 2, 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.

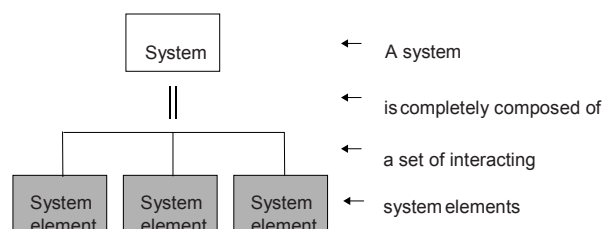


Figure 2 — System and system element relationship

The relationship between the system and its complete set of system elements can typically be resolved in a single step only 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, as indicated by Figure 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. While Figures 2 and 3 imply a hierarchical relationship, in reality there are an increasing number of systems that, from one or more aspects are not hierarchical, such as networks and other distributed systems. So, recursion is not necessarily linearly downward in all cases.

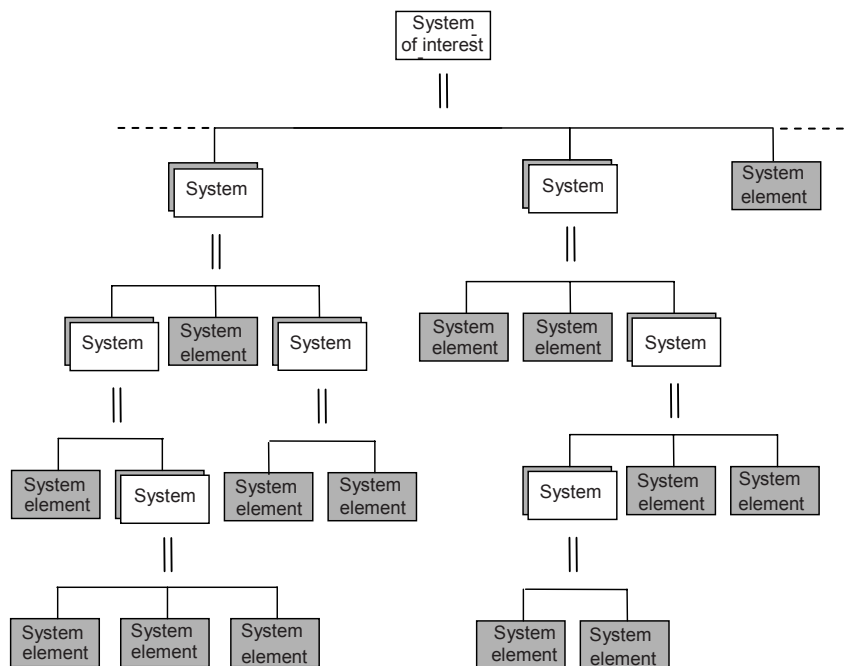


Figure 3 — System-of-interest structure

3.1.4 Structure in systems and projects

Each system in the structure illustrated in Figure 2 (or Figure 3) could be the responsibility of a separate project. This can be true whether the system is hierarchical, as used for the illustration, or other system structure, such as a network, or a mix of structures. The point is that there can be (and typically is) a strong correlation between levels of detail in the system structure and levels of responsibility in a set of projects. Each project characteristically has responsibility for acquiring and using system elements subordinate to it and creating and supplying to the level superior to it, as would be the case for hierarchical, non-hierarchical, or mixed, system structures.

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, even though it may not have responsibility for each system element considered by itself, it does have responsibility for all system elements that constitute its system-of-interest and consequently for the output of projects at all levels subordinate to it, as shown in Figure 4.

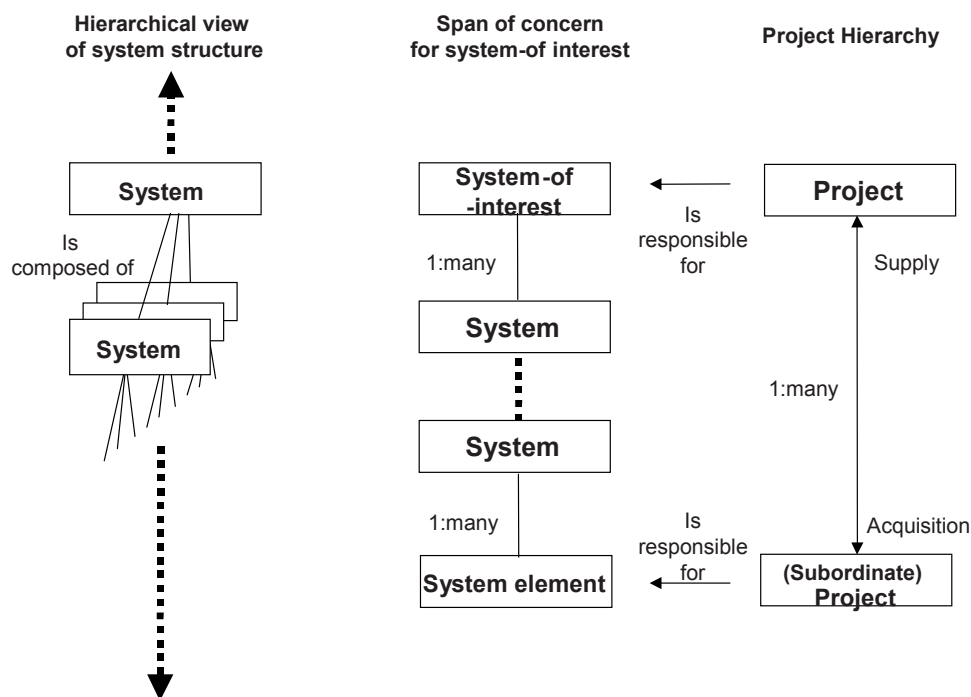


Figure 4 — System and project hierarchies

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 direct attention or 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 below some level. For example, if the system-of-interest for the project were a radar, in normal practice, the formulation and cure of the slurry mix for the resistive part of a composition resistor on a printed circuit board in a subassembly in a system element of the system-of-interest would not be addressed directly. Rather, the requirements at the system-of-interest and possibly the system element level would drive choices that would force a particular selection of this material in order to meet all the requirements for the higher level elements. From the system-of-interest view, the system elements may appear to be where specialist disciplines or particular implementation technology practices are present.

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

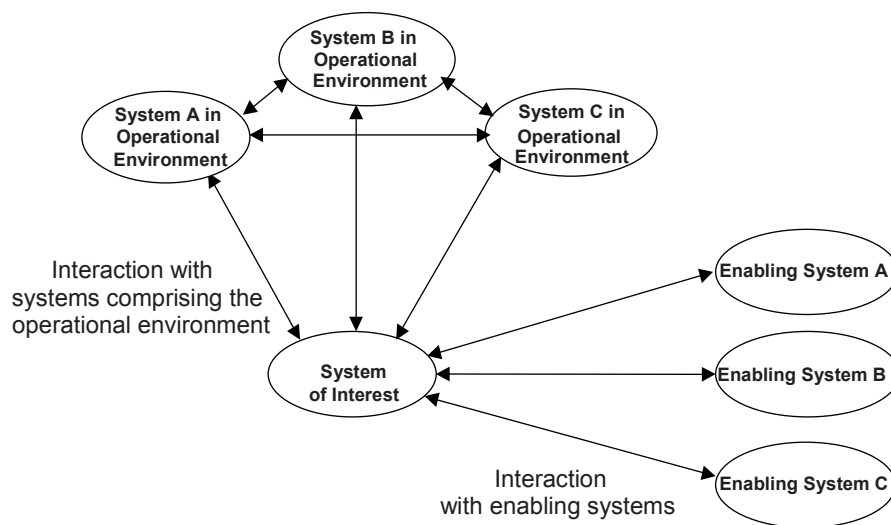


Figure 5 — System-of-interest, its operational environment and enabling systems

During any particular 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 systems. 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.

3.2 Life cycle concepts

3.2.1 System life cycle model

Every system, whatever the kind or size, inherently follows some life cycle, evolving from its initial conceptualization through its eventual retirement, as defined in Clause 2.14. It is generally useful to build a model of this progression to help manage the evolution of the system because movement from one stage to another represents a decision point with specific criteria to be satisfied before movement to the next stage is allowed. A life cycle model, then, is a decision-linked conceptual segmentation of the definition of the need for the system, its realization as a product or service, and its utilization, evolution and disposal. Note that the actual progression of a system through the parts of the model, however done, is the system's life cycle.

A system life cycle model is typically segmented by stages to facilitate planning, provisioning, operating and supporting the system-of-interest. These segments provide an orderly progression of a system through established decision-making gates to reduce risk and to ensure satisfactory progress. As stated before, it is the need to make a decision to specific criteria before a system can progress to the next stage that is the most important reason for using a life cycle model. A secondary aspect is that using a life cycle model can help an organization ensure that it thinks of its work and its processes within a larger framework, which may have useful business overtones. See, for example, the discussion of a services life cycle model in Clause 7.1.

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

A typical system, however, progresses through a common series of stages where it is conceptualized, developed, produced as a product or service, utilized, supported and retired. The life cycle model is the framework that helps ensure that the system is able to meet its required functionality throughout its life. Thus, to define system requirements and developing system solutions during the concept and development stages, experts from other stages (for example production, utilization, support, retirement) are needed to perform trade-off analyses and to help make design decisions and arrive at a balanced solution. This helps ensure that a system has the necessary attributes designed in as early as possible. Also, it is essential to have the necessary enabling systems available to perform required stage functions.

A representative system life cycle model, shown in Figure 6, illustrates this progression.



Figure 6 — Representative life cycle model

The stages in Figure 6, although drawn as discrete, are in practice interdependent and overlapping. Further, the figure implicitly conveys a uniformity and single linearity of time progression that is not inherently part of a life cycle model: stages do not necessarily occur one after another in time sequence. So, one actuality of the “progression” of a system through its life cycle could be as represented in Figure 7. When, in this Technical Report, reference is made to the next, subsequent, or later stage, this type of model must be kept in mind to avoid confusion by inferring linear time sequencing.

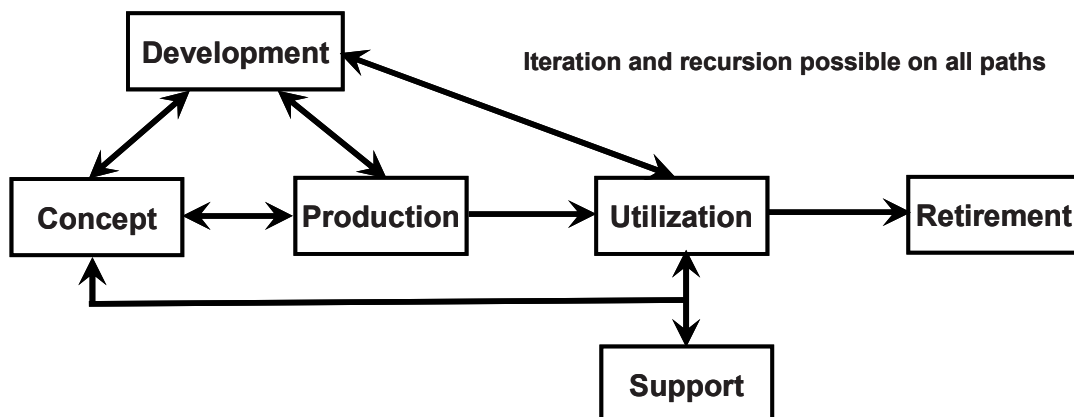


Figure 7 — Life cycle model with some of the possible progressions

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. A key aspect of life cycle management is that each stage requires exit criteria that must be met before progress from that stage is allowed. Since stages can have complex relationships as illustrated in Figure 7, definition of both exit and entry criteria for a specific stage progression may be needed. Thus, the use of stages corresponds to satisfying decision criteria before allowing further progress, providing a strong project control feature, whatever the sequence of stages within a given project's life cycle model.

Four common principles associated with a life cycle model are:

- A system progresses through specific stages during its life;
- Enabling systems should be available for each stage in order to achieve the outcomes of the stage;

- c) At specific life cycle stages, attributes such as producibility, usability, supportability and disposability should be specified and designed into a system;
- d) Progression to another stage requires satisfaction of exit criteria of the current stage.

The system life cycle model that is presented in Figure 6 is discussed in Clause 7 of ISO/IEC TR 19760:2003 from an organizational view and an engineering view. The organizational view illustrates sequential, incremental, and evolutionary approaches. Another discussion of life cycle models is in Annex C of ISO/IEC TR 15271:1998, where software is treated as a system-of-interest having its own life cycle, with three illustrative models being used for the discussion of the features, risks and opportunities of each model. Indeed, the Annex actually focuses on software development, thereby considering software development as a system-of-interest with its own life cycle.

3.2.2 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 realization of the system's set of products or services. 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 management has high-level visibility and control of project and technical processes.

Table 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.

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 system	

Table 1 — An example of stages, their purposes and major decision gates

Organizations employ stages differently to satisfy contrasting business and risk mitigation strategies. Using stages concurrently and, in a few cases, even 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. In addition, major decision gates, often called milestones, and reviews to focus on making the decisions, may be incorporated by an organization on an incremental basis within a stage, as well as at the end of a stage, to further manage risks.

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 project team members from the different functions and organizations responsible for other life cycle stages leads to consistency in the life cycle.

3.2.3 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. For example, if an enabling system does not already exist, its requirement is defined during the Concept Stage of the system-of-interest (or later if lead times permit), before the enabling system is utilized as shown in Figure 8 to provide its particular service to the system-of-interest.

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, the concepts in this Technical Report can also be applied to enabling systems.

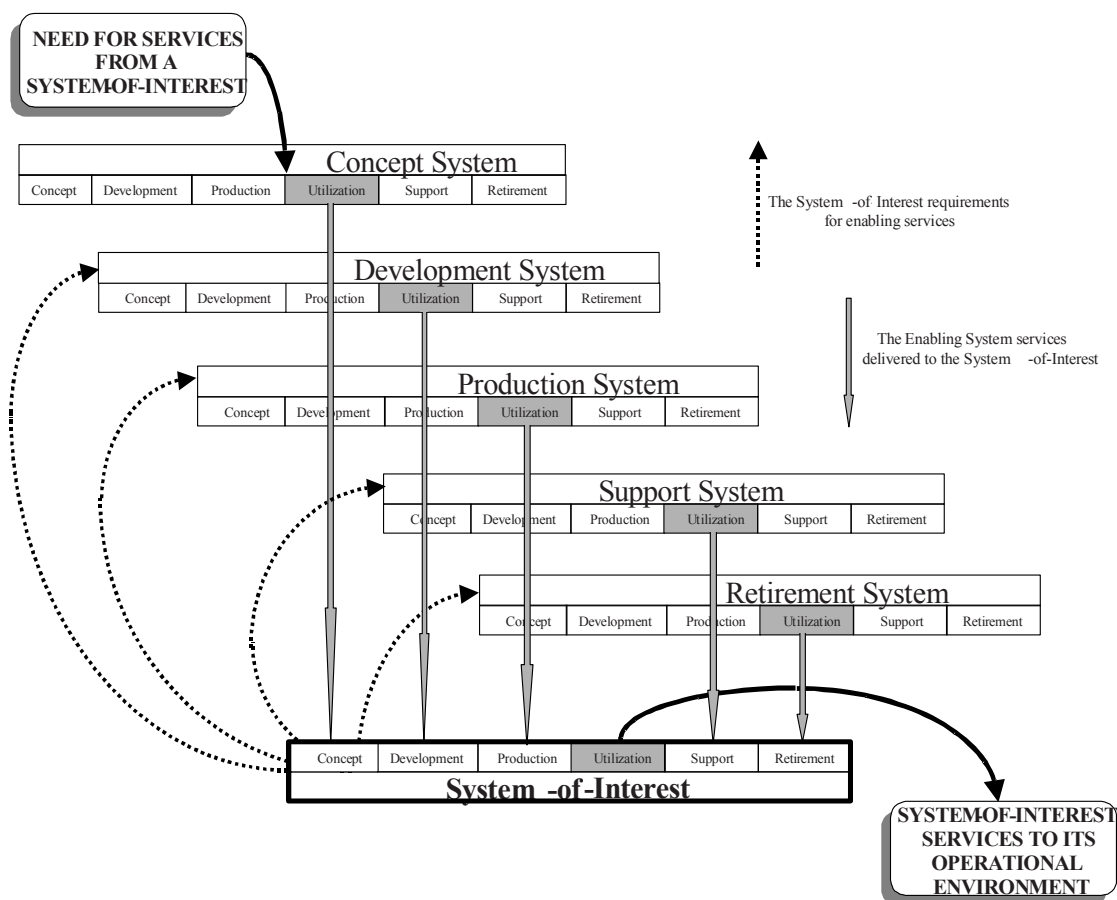


Figure 8 — System interaction with typical enabling systems

3.3 Process concepts

3.3.1 Life cycle processes

The life cycle processes defined in this Technical Report can be used by any organization when acquiring and using, as well as when creating and supplying, a system. They can be applied at any level in a system's structure and at any stage in the life cycle.

The life cycle processes are based on principles of ownership (a process is associated with a responsibility, discussed further in Clause 3.3.2) and modularity. That is, the processes are:

- Strongly cohesive, meaning that all the parts of a process are strongly related;
- Loosely coupled, meaning that the number of interfaces among the processes is kept to a minimum.

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

3.3.1.1 General

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

ISO/IEC 15288 is used to provide a specific example of four groups of system life cycle processes – agreement, organizational project-enabling, project and technical. Each process has a specific purpose, a set of expected outcomes and a set of activities. Each group of processes is described in Clause 5.3.2 of ISO/IEC 15288:2008 and summarized in the following clauses of this Technical Report:

Guidance for the application of ISO/IEC 15288 life cycle processes is provided in Clauses 6, 7 and 8 of ISO/IEC TR 19760:2003. Similarly, guidance for ISO/IEC 12207 life cycle processes is provided in Clauses 6, 7 and 8 of ISO/IEC TR 15271:1998.

Organizations, when considering a new project, should select a life cycle model, such as shown in Figure 6, and the necessary life cycle processes to satisfy applicable life cycle stage entry or exit criteria. Decisions as to which processes to select should be based on cost-benefit or risk reduction. The example process groups are described below.

3.3.1.2 Agreement processes

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

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

- a) Form and ensure completion of an agreement between an acquirer and a supplier for work on a system at any level of the system structure;
- b) Establish and carry out agreements to acquire a system or related enabling system services;
- c) Obtain work efforts by consultants, subcontractors, organizations, projects or individuals or teams within a project.
- d) Provide the basis for closing an agreement after the system has been delivered or work has completed and payment made.

3.3.1.3 Organizational project-enabling processes

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

The organizational project-enabling processes included in International Standards such as ISO/IEC 12207 and ISO/IEC 15288 are not necessarily the only processes used by an organization for governance of its business. For example organizations also have processes for managing accounts receivable, accounts payable, payroll processing and marketing. These business-related processes are not directly within the scope of the mentioned standards and thus are not discussed further in this Technical Report. The Organizational project-enabling processes of ISO/IEC 15288 and ISO/IEC 12207 are constrained in their scope to the aspects of those processes that are required to bound and guide the project, even though there are implicit relationships that the organization must address elsewhere, for example, in the Human Resources Management Process.

For multiple projects involved in or interfacing with an organization, or for a teaming arrangement among external organizations, other organizational project-enabling processes can be appropriately tailored.