TECHNICAL SPECIFICATION

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Software and Systems Engineering — Lifecycle Processes — Framework for Product Quality Achievement

Ingénierie du logiciel et des systèmes — Processus du cycle de vie — Cadre pour la réalisation de la qualité du produit

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 7, *Software and Systems Engineering*.

Introduction

This Technical Specification provides guidance on the application of ISO/IEC/IEEE 15288:2008[1] life cycle processes with specific reference to addressing quality in projects that deliver systems and software products and services. It focuses on a systematic approach to achieving quality, involving the development of certain information items, the inter-relationships between these information items and the maintenance and mutual consistency management of these information items. In particular, it describes how to develop detailed specifications of the collection of process instances needed to produce a specific product or system and achieve its quality goals. It describes how the guidance in life cycle process standards may be applied in conjunction with other standards (such as the ISO/IEC 25000[12] SQuaRE series of standards that address the specification, measurement and evaluation of product quality) to achieve quality during the development of a specific system.

Application of life cycle processes to develop a system involves the production of, among others, a collection of information items such as stakeholder requirements, system requirements, designs, plans, and technical strategies, as well as a collection of artefacts including the various system elements and enabling systems. The guidance in this Technical Specification is based on the following principles:

— **Localization of quality responsibility**: Requirements should be established for each system element and enabling system, derived from the overall system requirements; the set of process instances needed to develop each system element or enabling system should be identified; their responsibilities towards quality are demarcated by the outcomes defined for the corresponding life cycle process in ISO/IEC/IEEE 15288;

— **Creation of process instance descriptions**: For each process instance, success criteria should be established based on the outcomes defined for the corresponding life cycle process, the characteristics and requirements of the particular system element, and requirements and constraints arising from product decisions made in other process instances; the set of specific tasks and associated competencies needed to achieve these success criteria should be identified, particularly for system elements with significant quality risk;

— **Consistency with institutional knowledge:** Achievement of quality ultimately depends on correct technical decisions. Relevant institutional knowledge should be systematically identified and deployed for making product and process decisions, and the resulting information items and artefacts should be checked for consistency with the applicable bodies of institutional knowledge;

— **Maintenance of content consistency**: All the information items, including the process instance specifications themselves, may evolve concurrently throughout the development life cycle. Content consistency relationships among the various information items and artefacts should be tracked and managed as these information items and artefacts evolve concurrently.

The Technical Specification is applicable to any project involving the development, enhancement or re-engineering of systems with hardware, software and human elements. It is particularly useful to project organizations that operate in multiple application domains where the set of critical quality characteristics varies widely across projects, requiring a more systematic and detailed approach to planning the achievement of quality during the development stage of the system life cycle.

This Technical Specification is intended to provide guidance for two-party situations and may be equally applied where the two parties are from the same organization. This Technical Specification can also be used by a single party as self-imposed tasks. This Technical Specification can also serve as guidance in multi-party situations, where high risks are inherent in the supply and integration of complex systems, and procurement can involve several suppliers, organizations or contracting parties.

Software and Systems Engineering — Lifecycle Processes — Framework for Product Quality Achievement

1 Scope

1.1 Application

This Technical Specification provides guidance on

— applying processes from ISO/IEC/IEEE 15288:2008[1] in conjunction with other standards to contribute to achieving quality of systems and software products and services during the development stage of the life cycle (6.4),

— the information items that should be produced through the implementation of the relevant processes (6.5), and

— the new information items (Clauses 9 and 10).

The scope of this Technical Specification is to indicate how to apply the life cycle processes in ISO/IEC/IEEE 15288:2008 to achieve quality in the context of a specific product. It is independent of any tailoring that may be made to modify the generic process descriptions to suit the needs of a particular context. Even after any applicable tailoring, there is a need to apply the resulting process guidance and determine the specific detailed activities, tasks and associated success criteria for each of the process instances needed to deliver the target system. That is the focus of the framework described in this Technical Specification.

This Technical Specification is applicable to

— those who use or plan to use ISO/IEC/IEEE 15288:2008 on projects dealing with man-made systems, software-intensive systems, software products, and services related to those systems and products, regardless of project scope, product(s), service(s), methodology, size or complexity,

— those who use or plan to use ISO/IEC/IEEE 15289[5] on projects dealing with man-made systems, software-intensive systems, software products, and services related to those systems and products, regardless of project scope, product(s), methodology, size or complexity,

— anyone performing technical processes and tasks,

— those who are responsible for the technical management of projects concerned with the development of systems,

— those responsible for performing ISO/IEC/IEEE 15288:2008 life cycle processes at a project level,

— organizations and individuals subcontracting a project management effort,

— anyone developing systems engineering management documentation to complete technical planning aspects of their project processes,

— anyone performing systems engineering activities,

— project managers responsible for staffing projects and identifying competency development needs,

— anyone developing information items during the application of project and technical processes, and

— anyone performing project and technical processes to aid in ensuring that the information items developed during these processes conform to ISO/IEC/IEEE 15289.

1.2 Audience

The guidance in this Technical Specification is intended to be used in the development and maintenance stages of the life cycle by all organizations and projects that develop or maintain systems and software products and services. It is of particular value to organizations that work in a variety of application domains, where the set of critical quality characteristics and approaches to achieve them vary widely across projects.

1.3 Limitations

The achievement of quality ultimately depends on the competent performance of technical and management tasks. While this Technical Specification provides guidance on a systematic approach to quality achievement, including identification of needed competencies, the use of the approach alone is not sufficient to guarantee achievement of quality.

This Technical Specification provides guidance on developing detailed specifications of the collection of process instances needed to develop the product or service including the artefact-specific tasks within each process instance, but it does not address sequencing and information flow issues among these tasks and processes. The area of situational method engineering[8] addresses the problem of organizing the collection of tasks into a network with defined information flow patterns.

Tradeoffs among quality attributes are intentionally not addressed. Tradeoffs are part of the enactment of requirements, design, planning and other processes. Any iteration needed to address tradeoffs is part of concurrent elaboration. Consistency relationships must hold among information items and artefacts after tradeoffs have been made. Guidance on tradeoffs is not provided to avoid over-prescription.

The approach described herein is applicable to design and realization of services and service delivery systems. However, the achievement of service quality also depends on management of quality during interactive service delivery, and this approach does not address that aspect of service quality.

2 Motivation

ISO/IEC/IEEE 15288:2008 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 a project level and guidance is provided on the outcomes, activities and tasks needed to achieve quality.

These processes are intentionally defined to be product-agnostic so that they can be widely applicable to all projects involving systems and software products and services. ISO/IEC TR 24748-1[2], ISO/IEC TR 24748-2[3] and ISO/IEC/IEEE 29148[11] provide guidance on the application of these life cycle processes to a specific system, indicating that multiple recursive instances of each life cycle process may be needed corresponding to system elements at each hierarchical level of the system, and that multiple iterative instances may be needed to deal with dependencies and changes.

When applying the guidance from these standards to develop a specific system, there are challenges that can potentially lead to gaps in quality achievement which may not be detected until late in the life cycle.

— All the specific tasks needed to develop each artefact associated with each system element and enabling system must be identified. While the list of activities and tasks in each life cycle process provides a starting point, the specific tasks to be performed depend on the requirements and characteristics of the target system element. Any omissions in identifying the right set of specific tasks will lead to defects that may not be detected until late in the life cycle.

— The product decisions made in various process instances need to be mutually consistent. The decisions in some information items and artefacts impose requirements and constraints on others. Mutual consistency relationships among deliverables must be maintained as they evolve during the concurrent enactment of the various process instances. Gaps arise if changes are not propagated consistently among artefacts.

— Quality achievement depends on the right technical decisions being taken. There is considerable institutional knowledge from standards and other sources that can guide these technical decisions, but there are often gaps in identification and application of the relevant technical knowledge.

This Technical Specification closes these potential gaps, describing in detail how the life cycle processes may be used to achieve quality for a specific system.

3 Terms, definitions and abbreviated terms

3.1
concurrent elaboration
life cycle process instances are enacted concurrently during the project, and the information items and artefacts produced by these process instances evolve concurrently

Note 1 to entry: This is referred to as concurrent elaboration of information items.

3.2
content consistency
semantic consistency among the contents of information items

3.3
information item
separately identifiable body of information that is produced, stored, and delivered for human use

[SOURCE: ISO/IEC/IEEE 15289]

3.4
institutional knowledge
knowledge from accepted sources, including standards, academic sources, domain and industry bodies of knowledge and organizational knowledge

3.5
instantiation
identification, for each instance of a life cycle process, of the success criteria, artefact-specific activities and tasks needed to achieve the process outcomes, and the competencies needed to perform these tasks, based on the characteristics and requirements of the target system element

Note 1 to entry: This is referred to as instantiation of the life cycle processes for a specific system, product or service.

3.6
locality of quality responsibility
assignment of responsibility for specific quality-related requirements or decompositions thereof to a particular process instance

3.7
process instance
single specific and identifiable execution of a process

[SOURCE: ISO/IEC 33001:2015, 3.2.17]

Note 1 to entry: It is the result of instantiation of life cycle processes for a specific system, product or service.

3.8
quality responsibility
responsibility for achievement of a quality requirement or decomposition thereof

3.9
success criteria
set of conditions to be satisfied by a process instance at completion

Note 1 to entry: Information items and artefacts produced by the process instance must meet the success criteria. Success criteria are established based on the outcomes of the corresponding life cycle process, requirements of the system element to which the process instance contributes, and requirements and constraints arising from decisions in other process instances.

4 Quality achievement concepts

4.1 Overview of quality achievement

Figure 1 shows an overview of the relationships between the process and product decisions related to quality achievement in a project. Product decisions for a project include, among others, the system requirements, design, realization technologies, as well as verification, integration, validation, transition and measurement strategies. Process decisions include identification of the specific tasks needed to achieve quality for the specific system, as well as the practices, tools and technical management approach. The process decisions are influenced by previous product decisions, and in turn generate further product decisions.

The figure indicates the life cycle process standards that provide guidance on process decisions, and some of the standards that provide guidance on product decisions. There are also other standards that provide guidance on product and process decisions related to particular quality characteristics or application domains, such as security, safety and automotive standards.

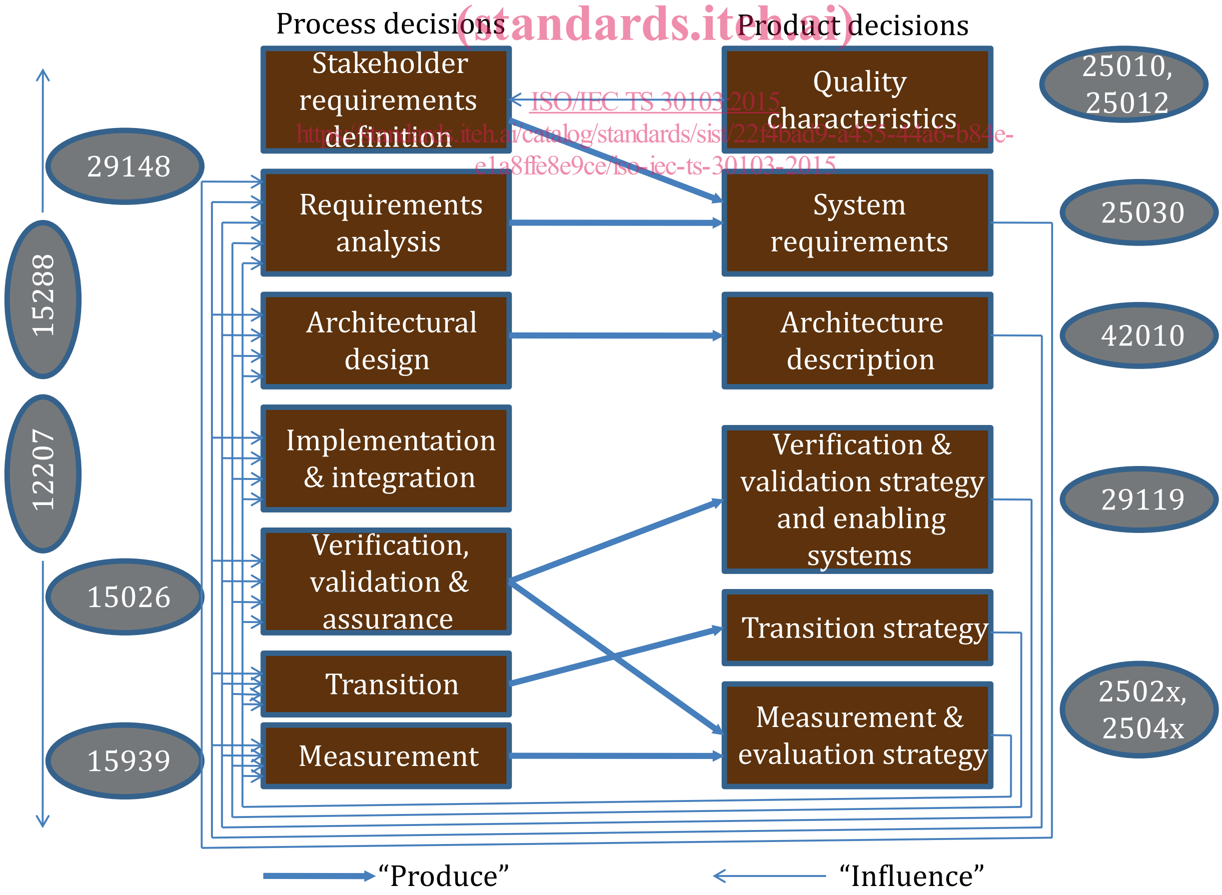

Figure 1 — Overview of quality achievement

It should be noted that the lines in the above diagram represent informational and generative relationships, not control flows. Life cycle processes are typically enacted concurrently and iteratively, so that the various product-related decisions and the related process decisions evolve continuously throughout the project. In general, it cannot be assumed either that the process decisions are all frozen prior to enactment of that process, or that information items and artefacts are produced sequentially. In complex projects, all of these evolve continuously and concurrently, and the consistency relationships among them must be managed.

4.2 Guiding principles and approach

The approach to quality achievement described herein incorporates four principles.

— **Localization of quality responsibility**: Quality requirements should be established for each system element and enabling system (herein referred to generically as artefacts), based on the overall system requirements and the architectural design; the responsibility for meeting these requirements should be further distributed among the collection of process instances that together produce the system element, in accordance with the outcomes defined for the corresponding life cycle processes.

— **Creation of process instance descriptions**: For each process instance, its responsibilities towards meeting the requirements of the system element should be captured in the form of success criteria. The detailed activities and tasks needed to achieve the success criteria, and the competencies to perform them should be identified, especially for system elements with significant quality risk.

— **Consistency with institutional knowledge**: Achievement of quality ultimately depends on correct technical decisions. Relevant institutional knowledge should be systematically identified and deployed for making product and process decisions, and the resulting information items and artefacts should be checked for consistency with the applicable bodies of institutional knowledge.

— **Maintenance of content consistency**: Content consistency relationships among the information items and artefacts (i.e. mutual consistency of product decisions) should be tracked and managed as they are concurrently elaborated during project enactment.

The principles establish each process instance as a locality of quality responsibility with defined success criteria that reflect quality requirements, along with the complementary concepts of ensuring consistency of decisions across localities and systematic application of institutional knowledge to process and product decisions. The creation of detailed descriptions of process instances is referred to as *instantiation* of the life cycle processes to the particular system element.

The resulting approach is shown in Figure 2.

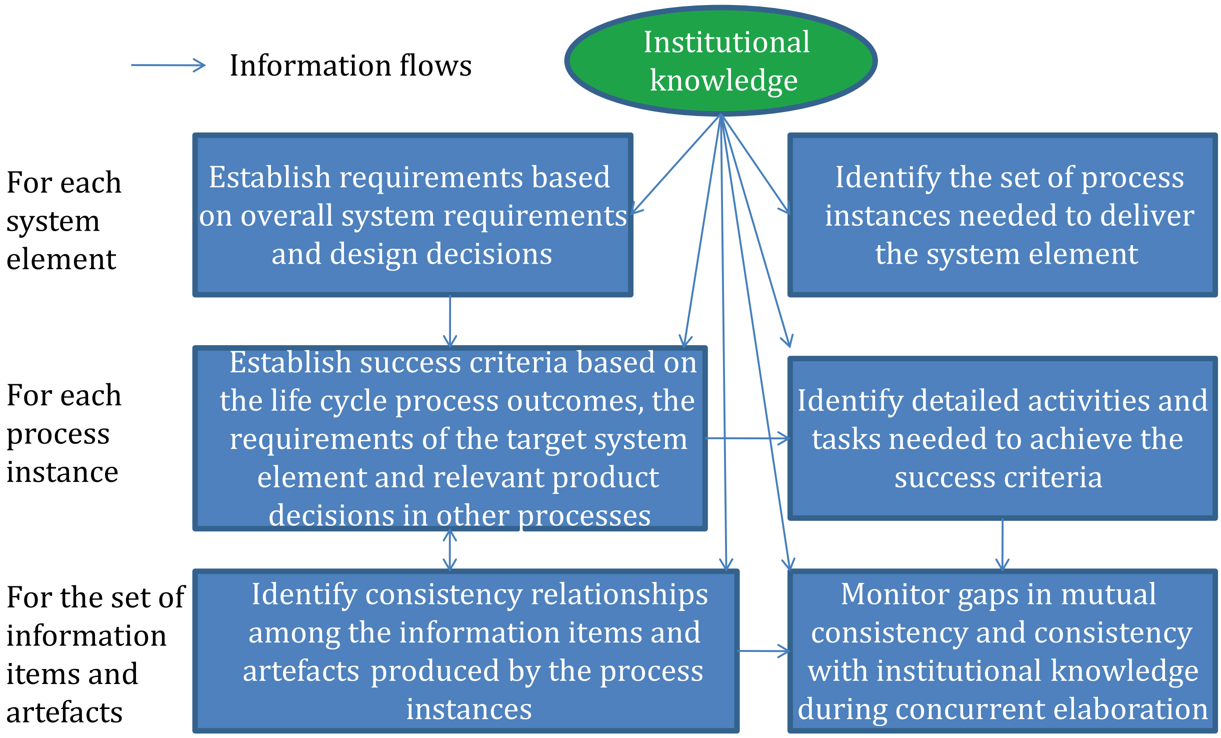

Figure 2 — Approach to quality achievement

The application of these principles should be tuned to the complexity of the system, development context, criticality of quality characteristics and identified technical risks to achieve the best balance between the benefits conferred by the systematic approach and the effort required to implement the approach. There are several dimensions of flexibility in the application of the approach, for each of which choices need to be made based on identified risks and other contextual factors:

— the granularity of system elements to which the approach is applied;

— whether to drill all system requirements down to the lowest level of the system hierarchy, or only those requirements that are critical to the particular system element;

— the set of process instances selected for detailed instantiation, and the level of detail needed in the description, based on identified risks;

— the set of content consistency relationships to be tracked and managed.

The theoretical foundations underlying these principles are discussed in the informational Annex E. This approach is similar to the concepts of Quality by Design[9] and aligned with the “Right First Time” concept[28].

4.3 Localization of quality responsibility

4.3.1 Establishing system element requirements

The system requirements and architecture description identify the collection of system elements that need to be developed, typically by decomposing the system-of-interest hierarchically into lower level system elements.

NOTE 1 These system elements may be modules, components, services, features or updates and changes to existing system elements (in the case of incremental development or re-engineering).

Recursive instances of the Requirements Analysis and Architectural Design processes decompose the overall system requirements to establish the requirements for each lower level system element. Requirements relating to quality characteristics should be hierarchically decomposed and allocated. Depending on the nature of the quality characteristic and the decomposition, a requirement may be directly assigned to a single system element, assigned to each of several system elements, or decomposed and distributed among multiple system elements.

NOTE 2 In incremental development, the allocated requirements may reflect the changes in characteristics needed for each system element, rather than the overall characteristics of the element.

The granularity to which requirements are drilled down depends on the tradeoffs between the cost of establishing requirements for lower level elements and the benefits of more granular quality management. This tradeoff may be managed at the level of individual requirements, so that more critical requirements are drilled down deeper in the system hierarchy.

In this Technical Specification, the approach to quality achievement is illustrated with the example of adding barcode scanning capabilities to a hospital Blood Bag Inventory System. Figure 3 shows an example hierarchical decomposition and some requirements for each system element.

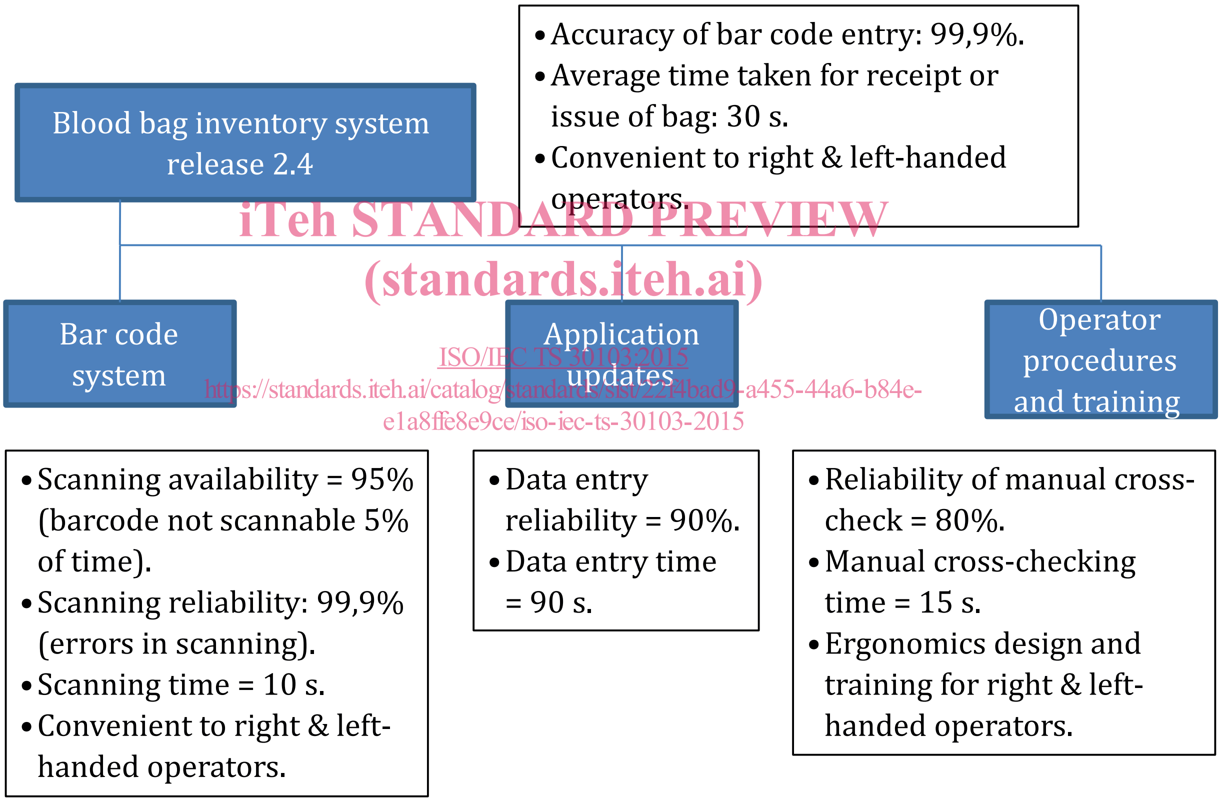

Figure 3 — Example (partial) system element requirements

Annex A describes the example problem in more detail, and indicates the approach for determining the requirements for each system element from the overall system requirements.

In addition to system elements, the development of the system-of-interest may also need enabling systems e.g. testbeds, deployment setup, swing hardware for transition etc. Requirements must also be established for each enabling system by application of the Architectural Design and Requirements processes in conjunction with the relevant Technical Process, i.e. Integration, Verification, Validation or Transition process.