



ISO/IEC JTC1/SC7
Software Engineering
Secretariat: CANADA (SCC)

ISO/IEC JTC1/SC7 N2021

1998-11-16

Doc. Type	Technical Contribution
Title	Technical Contribution - Demonstration Reference Model for SC 7 Processes.
Source	JTC1/SC7/WG7 OWG Convener
Project	
Status	Final
References	
Action ID	FYI
Due Date	
Mailing Date	1998-11-16
Distribution	SC7_AG
Medium	Encoded Acrobat
No. of Pages	23
Note	The document is offered as a starting point and it is expected that the document would be refined before adoption.

Demonstration Reference Model for SC 7 Processes

Contribution to SC 7

This document was drafted by an ad hoc group of interested individuals and made available for consideration by the WG 7/OWG. It is now offered, as a contribution to SC 7. The document is offered as a starting point and it is expected that the document would be refined before adoption.

Introduction

The purpose of the demonstration model is to indicate that it is possible to develop a single reference model for processes which accommodates the requirements of the current SC 7 standards, notably 12207 and 15504. The requirements of some other standards are considered: 14598, 15939. Furthermore, the anticipated requirements of 15288 are considered to the extent possible.

This is called a “demonstration model” because there is no claim that this is the best possible model. The only purpose of describing this model is to provide an existence proof that such a reference model is possible. It is not claimed that this demonstration model is a perfect fit to the current standards. (It is believed, though, that the changes needed for current standards to adopt such a model would be feasible.)

Furthermore, we are not making the claim that SC 7 should take any specific action with respect to the model. The demonstration model is merely a technical contribution; it is up to SC 7 to determine the appropriate use for it.

In the short term, one could use a model like the demonstration model as a reference for existing SC 7 standards. This could be accomplished with text explaining how the processes of the standard map to the processes described by the reference model. (An example is provided in an appendix.) In the longer term, one could hope that the standards would evolve so that they are phrased directly in terms of the processes described by the reference model.

It should be emphasized that this paper has the primary intent of describing the current standards in terms of a reference model. It is not intended to control the development of future standards or the future revisions of current standards. It is an exercise intended to demonstrate that the relationships of the processes described in the current standards can be explained with a single reference model.

Theoretical Underpinnings

It¹ is helpful to have an overall architecture for process abstraction. For this we use a framework developed by Basili for his *component factory* [Basili92] and applied by Heineman to general process modeling [Heineman94]. In this discussion [adapted from Moore97], their terminology will be modified slightly for the current context. The framework provides for three levels of abstraction in representing processes:

- The *reference* level, representing agents that carry out the processes. Decisions represented at this level are the selection of a coherent and cohesive set of activities that may be sensibly performed by a single agent. Such a set of activities is a process.
- The *conceptual* level, representing the flow of control and data among the agents. Decisions at this level include the logical relationships among the agents both for control and for the communication of data.
- The *implementation* level, representing the implementation, both technical and organizational, of the agents and their interfaces. Decisions at this level include mapping the agents to the management organization of the particular project or enterprise and the selection of policies, procedures, and tools to enable the agents to perform their tasks.

These levels are not to be regarded as successive functional decompositions. In fact, any one of them can be independently refined into greater details. The distinction between the former two levels permits discussion of the purposes and results of the processes independently of their fine-grained relationships. The distinction between the latter two levels permits discussion of specific processes independently of the structure of the organization that will implement them.

The goal of this demonstration model is to describe processes at the reference level. For this purpose, it characterizes processes in terms of their purpose and their outcomes without describing explicit connections to other processes. In his

¹ The material in this section is adapted from [Moore97].

paper, Basili makes the point that the generic nature of the processes is illustrated by the number of different ways in which they might be interconnected.

In addition, according to Basili, the "reference architecture contains a set of architectural rules that specify how the architectural agents can be configured and connected in the specific architectures derived from a reference architecture." Accordingly, this reference model provides a set of operations that may be performed upon reference processes to construct the processes of existing and future standards.

The reference model described in this paper is intended to be at the "reference" level described by Basili. This is not intended to preclude the possibility that various SC 7 standards may also describe processes at any of the levels described by Basili, including the reference level.

The Model

Characterization of Reference Processes

This model provides a number of "reference processes" (P) that may be manipulated in various ways to construct processes suitable for the use of various standards. The processes constructed by the standards differ from the reference processes because the standard processes are presumed to be adapted for application within the particular scope treated by the standard.

This model is a flat model. No substructure is assumed for the reference processes. In those cases where it might be thought that the P may overlap (for example, management and risk management), the apparently more general term may be presumed to exclude the more specific one. In any case where one P might seem to be a part of another, we simply separate them. Of course, this leads to a relatively fine-grained model.

The Ps are not characterized in any way, e.g. "supporting", "primary", "agreement", "customer" etc. Such characterizations are the responsibility of standards that might construct standard processes from the reference processes described in this model.

Each P is characterized by a purpose and a set of outcomes. Ideally, each outcome would have the following characteristics:

- capability-neutral ("capability" is used here in the sense of 15504)
- role-independent ("role" is explained later)
- succinct
- not a restatement or functional decomposition of the purpose
- phrased in terms of a continuing responsibility to: (1) produce and maintain an artifact; (2) achieve and maintain a state; or (3) meet a constraint.

To develop a list of processes, one needs a set of selection criteria or a set of desired characteristics. Desirable characteristics for processes include:

- Consistent with each other
- Autonomous
- Non-overlapping
- Cohesive
- Low coupling with other processes
- Cover the existing set of standards

The description of processes in this reference model specifically excludes some characteristics. The excluded characteristics are:

- Interfaces to other processes (both control and data interfaces)
- Normative requirements levied upon users
- Provisions for evaluation.

These characteristics would be provided by the SC 7 standards that use this reference model.

The initial set of reference processes (P) are listed in Appendix 1. The list has been derived from a survey of relevant standards, including 12207, 15504-2, a working draft of 15288, a working draft of 15939, and balloted drafts of 14598. In general, when two documents treated apparently similar processes at different levels of aggregation, the finer level of decomposition was chosen for the reference processes. The current list of P is thought to be at a fine enough level of decomposition to map to the processes of the existing standards without further decomposing the P. The list is not to be regarded as final. It may be appropriate to examine additional standards for candidate processes or to perform other sorts of empirical validation. Of course, one must also assess the “fit” of the various existing standards with this or any list of reference processes.

Format of Reference Process Descriptions

Given the characteristics listed in the previous section, a *format* or *data model* is needed for the description of processes. For our purposes a simple format suffices--a process is described by:

- The *name* of the process
- A statement of the *purpose* for executing the process
- A list of *outcomes* of executing the process

Definitions of Purpose and Outcome should be developed to ensure that those developed are consistent in terms of the level of detail.

Operations on Reference Processes

The basic concept of the demonstration reference model is that any of the SC 7 standards could, with modest accommodation, describe their own standard processes in terms of the Ps provided by a reference model. In describing standard processes, the following operations may be performed upon the Ps provided by the reference model:

- A P may be composed with a “role” (such as developer, customer, assessor or user). In such a case, the purpose and outcome may be specialized to meet the specific needs of the role. For example, product evaluation as described in 14598 has different provisions depending upon the role of the applier as developer, acquirer or independent evaluator. The specialized purpose and set of outcomes must be consistent with those of the reference model. (The current list of known roles appears in an appendix.)
- A P may be specialized for implementation by an individual, by a project, by an enterprise or by some other collective body. In such a case, the purpose and outcome may be specialized, consistent with those of the reference model, to meet the specific context of the intended implementation.
- The Ps may be aggregated. The purpose and outcomes of the aggregate are the union of those of the constituent Ps.
- Additional structure may be superimposed upon the Ps. For example, they may be hierarchically grouped. Additional purpose and outcomes, consistent with those of the P, may be attributed to the resulting structure.
- Additional structure may be subordinated to a P. For example, they may be functionally decomposed. More detailed purposes and outcomes, derived from the overall purpose and outcomes, may be attributed to the resulting substructure.
- Additional processes may be defined for needs that fall beyond the scope of the existing P. A purpose and a set of outcomes must be provided for the new processes; they should make it clear that the new process does not overlap the existing P.

The construction operations listed above may be performed in any combination to show the relationship between standard processes and reference processes. After standard processes are defined, one additional operation may be applied:

- The standard processes may be categorized and the categories may be characterized. The characterizations of the categories must be consistent with the purposes and outcomes of the processes assigned to the categories.

After developing a (possibly categorized) set of “processes” (or similarly termed items), a standard is permitted to supplement them with additional normative or informative provisions. These provisions may take the form of objectives, requirements, or other forms of provisions. The provisions must be consistent with the purpose and outcomes and must not exceed the scope described by the purpose and outcomes. Those provisions might prescribe activities, work products, tasks, capabilities, or other things compatible with the purpose and outcomes provided by the reference model.

Possible Uses of a Reference Model

A reference model such as the one described in this paper could be applied in several possible ways. It could be used to:

- Explain the relationships among existing standards.
- Clarify issues regarding relationships among future standards.
- Serve as a target for evolution of standards.

It should be emphasized that this document does not envision any changes in the roles of the current standards. In particular, it is not envisioned that this document would become a standard. Instead, it is anticipated that the document would be used internally to SC 7 as a guide to standards-writers. In some sense, it would serve a role similar to that of ISO/IEC Guide 2, which provides guidance to standards-writers regarding vocabulary, or that of ISO/IEC Guide 25, which provides guidance to standards-writers regarding calibration and testing.

The anticipated relationships are that:

- users would apply SC 7 standards
- SC 7 standards-writers would apply the reference model

The drafters of this document have tried to develop a model that explains the relationships among the current SC 7 standards as they are at present.

Appendix 1: Reference processes

This is the current list of candidate processes. In each case, the table lists a standard providing a process with a close fit to the listed process.

Reference Process	An existing document with a process that is a close fit with the intent of the reference process
Acquisition preparation	15504
Supplier selection	15504
Supplier monitoring	15504
Customer acceptance	15504
Supply	12207, 15504, 15288
Negotiation	15288
Requirements elicitation	15504, (15288 Stakeholder Requirements?)
Operational use	15504
Customer support	15504
System analysis	15288
System architectural design	15288
SW requirements analysis and design	15504
SW design	15504
SW construction	15504
SW integration	15504
SW testing	15504
System integration and testing	15504, 15288
System and SW maintenance	12207, 15504
Documentation	15504
Configuration Management	12207
Quality Assurance	12207
Verification	12207
Validation	12207
Joint review	12207
Audit	12207
Problem resolution	12207
Management	12207 or 15504 with QM and RM removed
Quality management	15504, 15288
Risk management	15504, 15288
Organizational alignment	15504
Process establishment	15504
Process assessment	15504
Process improvement	15504
Investment management	15288
Human resource management	15504 or 15288 with training removed
Training	12207
Infrastructure	12207, 15288
Measurement	15939
Product Evaluation	14598
Product Transition	15288

In addition, there are candidate P that remain under consideration:

- Reuse - this is a process of 15504, but some feel that reuse is actually several processes (IEEE is working on a standard in this area; it might be useful to examine it.)
- Usability Engineering - perhaps from ISO 9241 and the other work of ISO TC159

Appendix 2: Known roles for software processes

In developing a standard process, it is permitted to compose one or more reference processes with a designated *role*. The list of roles should be regarded as open-ended. Known candidates include the following:

- Developer
- Acquirer
- 3rd party Evaluator
- Assessor
- Supplier
- Maintainer
- Operator
- User
- Any of the above at a systems level

Appendix 3: Mappings to existing standards

Appendix 3a: Mapping to 12207

This is an example of mapping a set of standard processes to the current set of reference processes. The "+" sign represents process aggregation. The "x" sign represents composition with a role. The "/" sign represents specialization to an individual, project or organizational level.

12207 Process	How 12207 Process is Constructed from Reference Processes
Acquisition	Acquirer role x (Acquisition preparation + Requirements elicitation + Supplier selection + Supplier monitoring + Customer acceptance + Product evaluation)
Supply	Supply
Development	Developer role x (System requirements, analysis and design + SW requirements analysis and design + SW design + SW construction + SW integration + SW testing + System integration and testing + Product evaluation)
Operation	Operational use + Customer Support
Maintenance	System and software maintenance
Documentation	Documentation
CM	CM
QA	QA
Verification	Verification
Validation	Validation
Joint Review	Joint Review
Audit	Audit
Problem Resolution	Problem Resolution
Management	(Management + Risk management + Quality management) / project-level implementation
Training	Training / project-level implementation
Infrastructure	Infrastructure / project-level implementation
Improvement	(Process establishment + Process assessment + Process improvement) / project-level implementation

Appendix 3b: Mapping to 15504 [TBD]

This is an example of mapping a set of standard processes to the current set of reference processes. The "+" sign represents process aggregation. The "x" sign represents composition with a role. The "/" sign represents specialization to an individual, project or organizational level.

15504 Process	How 15504 Process is Constructed from Reference Processes

Appendix 3c: Mapping to 15939

This is an example of mapping a set of standard processes to the current set of reference processes. The "+" sign represents process aggregation. The "x" sign represents composition with a role. The "/" sign represents specialization to an individual, project or organizational level.

15939 Process	How 15939 Process is Constructed from Reference Processes
Measurement	Measurement / project-level or organization-level implementation

Appendix 3d: Mapping to 14598

This is an example of mapping a set of standard processes to the current set of reference processes. The "+" sign represents process aggregation. The "x" sign represents composition with a role. The "/" sign represents specialization to an individual, project or organizational level.

14598 Process	How 14598 Process is Constructed from Reference Processes
14598-3	Product Evaluation x Developer role
14598-4	Product Evaluation x Acquirer role
14598-5	Product Evaluation x Third Party Evaluator role

Appendix 4: Definitions of Reference Processes

Acquisition preparation

Purpose:

The purpose of the *Acquisition preparation process* is to establish the needs and goals of the acquisition and to communicate these with the potential suppliers.

Outcomes:

As a result of successful implementation of the process:

- the concept or the need to acquire, develop, or enhance a system, software product, or software process will be established;
- the needed acquisition requirements (e.g. request for proposal) defining the project needs will be produced;
- the customer's software and/or system requirements will be defined and validated;
- an acquisition strategy/plan will be developed;
- acceptance criteria will be defined.

Supplier selection

Purpose:

The purpose of the *Supplier selection process* is to choose the organization that will be responsible for the implementation of the project's requirements.

Outcomes:

As a result of successful implementation of the process:

- the supplier selection criteria will be used to evaluate potential suppliers;
- the supplier will be selected based upon the evaluation of the supplier's proposals, capabilities, and other factors;
- a contract will be established and negotiated between the customer and the supplier.

Supplier monitoring

Purpose:

The purpose of the *Supplier monitoring process* is to monitor the supplier's activities during the development of the software product and/or service.

Outcomes:

As a result of successful implementation of the process:

- joint activities between the customer and the supplier will be performed as needed;
- information on technical progress will be exchanged regularly with the supplier;
- performance of the supplier will be monitored against the agreed requirements.

Customer acceptance

Purpose

The purpose of the *Customer acceptance process* is to approve the supplier's deliverable when all acceptance conditions are satisfied.

Outcomes:

As a result of successful implementation of the process:

- acceptance will be based on the acquisition strategy and conducted according to the agreed acceptance criteria; [Note: This is questionable as an outcome.]
- the delivered software product and/or service will be evaluated with regard to the agreed requirements.

Supply

Purpose

The purpose of the *Supply process* is to provide software to the customer that meets the agreed requirements.

Outcomes:

As a result of successful implementation of the process:

- a response to customer's request will be produced;
- a contract will be established between the customer and the supplier for developing, packaging, delivering, and installing the software product and/or service;
- a software product and/or service that meets the agreed requirements will be developed by the supplier;
- the software product and/or service will be delivered to the customer and installed in accordance with the agreed requirements.

Negotiation

Purpose:

The purpose of the *Negotiation process* is to provide an approach to establish a satisfactory agreement between the Acquirer and the Supplier.

Outcomes:

As a result of successful implementation of the process:

- a negotiated agreement between the Acquirer and the Supplier is established
- the agreement satisfies the respective Acquirer/Supplier business objectives
- the agreement is mutually implemented by the Acquirer and the Supplier
- an environment of mutual cooperation will exist throughout the project life cycle
[Note: This is questionable as a measurable outcome.]

Requirements elicitation

Purpose:

The purpose of the *Requirements elicitation process* is to gather, process, and track evolving customer needs and requirements throughout the life of the software product and/or service so as to establish a requirements baseline that serves as the basis for defining the needed software work products.

Outcomes:

As a result of successful implementation of the process:

- continuing communication with the customer will be established;
- agreed customer requirements will be defined;
- a mechanism will be established to incorporate new customer requirements into the established requirements baseline;
- a mechanism will be established for continuous monitoring of customer needs;
- a mechanism will be established for ensuring that customers can easily determine the status and disposition of their requests;
- enhancements arising from changing technology and customer needs will be identified and their impact managed.

Operational use

Purpose:

The purpose of the *Operational use process* is to ensure the correct and efficient operation of the software product for the duration of its intended usage and in its installed environment.

Outcomes:

As a result of successful implementation of the process:

- operational risks for the software introduction and operation will be identified and monitored;
[Note: This is really a Risk Management outcome]
- the software will be operated in its intended environment according to requirements;
- assurance will be provided that software capacities are adequate to meet customer needs.

Customer support

Purpose:

The purpose of the *Customer support process* is to establish and maintain an acceptable level of service to the customer to support effective use of the software product. Assistance and consultation to the customer is provided as requested to support the operation of the software product.

Outcomes:

As a result of successful implementation of the process:

- customer support service needs will be identified and monitored on an ongoing basis;
- customer satisfaction with both the support services being provided and the product itself will be evaluated on an ongoing basis;
[Note: Also that improvement targets are met.]
- operational support will be provided by resolving operational problems and handling customer inquiries and requests;
- customer needs will be met through delivery of appropriate services.
- [Note: Consider also "Pro-active improvements" as an outcome.]

System analysis

Purpose:

The purpose of the *Systems analysis process* is to transform the defined stakeholder requirements into a set of desired system technical requirements that will guide the design of the system.

Outcomes:

As a result of successful implementation of the process:

- a defined set of system requirements stated in acceptable technical terms describing the problem to be solved
- a basis for establishing the design solution of the system architecture

System architectural design

Purpose:

The purpose of the *System architectural design process* is to identify which system requirements should be allocated to which elements of the system and to which releases.

Outcomes:

As a result of successful implementation of the process:

- a solution will be proposed that identifies the main elements of the system;
[Note: The "solution" is really a "system architectural design"]
- the requirements will be allocated to each of the main elements of the system;
- a release strategy will be developed that defines the priority for implementing system requirements;
[Note: Is this really needed?]
- the system requirements will be approved and updated as needed;
- the requirements, proposed solution, and their relationships will be communicated to all affected parties.

Software requirements analysis

Purpose:

The purpose of the *Software requirements analysis process* is to establish the requirements of the software components of the system.

Outcomes:

As a result of successful implementation of the process:

- the requirements allocated to software components of the system and their interfaces will be defined to match the customer's stated needs;
[Note: A "stated need" can be considered to be the same as a "software requirement". This view would thus consider this and the next outcome as identical.]
- analyzed, correct, and testable software requirements will be developed;
- the impact of software requirements on the operating environment will be understood;
- a software release strategy will be developed that defines the priority for implementing software requirements;
[Note: Not considered to be an outcome for this process.]
- the software requirements will be approved and updated as needed;
[Note: Not considered to be an outcome for this process.]
- consistency will be established between system requirements and design and software requirements;
[Note: Not considered to be an outcome for this process.]

- the software requirements will be communicated to all affected parties.
[Note: Can this be strengthened?]

Software design

Purpose:

The purpose of the *Software design process* is to define a design for the software that implements the requirements and can be tested against them.

Outcomes:

As a result of successful implementation of the process:

- an architectural design will be developed that describes the major software components that will implement the software requirements;
- internal and external interfaces of each software component will be defined;
- a detailed design will be developed that describes software units that can be built and tested;
[Note: What about a verified design?]
- consistency will be established between software requirements and software designs.

Software construction

Purpose:

The purpose of *Software construction* is to code and test each software unit developed in the software design process. Each unit of code is reviewed for compliance with the corresponding requirements, design, and the software coding standards prior to establishing control over the unit and making it available for integration.

Outcomes:

As a result of successful implementation of the process:

- Verification criteria will be defined for all software units against their requirements;
- Software units defined by the design will be produced;
- Consistency will be established between software requirements and design and software components;
- Verification of the software units against the design will be accomplished.

Software integration

Purpose:

The purpose of *Software integration* is to ensure the performance and functionality of the software on an equivalent or complete operational platform. Software integration combines the software units into software aggregates in accordance with the software integration plan. The execution of this process results in producing integrated software items and to verify that the integrated software item satisfies the software design and the software requirements.

Outcomes:

As a result of successful implementation of the process:

- An integration strategy will be developed for software units consistent with the release strategy;
- Verification criteria for software items will be developed that ensure compliance with the software requirements allocated to the items;
- Software items defined by the integration strategy will be produced;
- Software items will be verified using the defined acceptance criteria;
- Results of integration testing will be recorded;

- Consistency will be established between software requirements and software items;
- A regression strategy will be developed for reverifying software items should a change in software units occur;
- Regression testing will be carried out as necessary.

Software testing

Purpose:

The purpose of *Software testing* is to test the integrated software item to the software requirements and ensuring that each software requirement is tested for compliance.

Outcomes:

As a result of successful implementation of the process:

- Acceptance criteria for integrated software will be developed that verify compliance with the software requirements;
- Integrated software will be verified using the defined acceptance criteria;
- Test results will be recorded;
- A regression strategy will be developed for retesting the integrated software should a change in software items be made;
- Regression testing will be carried out as necessary.

System integration and testing

Purpose:

The purpose of the *System integration and testing* is to integrate the software item with other software items, and to integrate the software with hardware items, manual operations, and other systems, as necessary, to produce a complete system that will satisfy the customers' expectations expressed in the system requirements.

Outcomes:

As a result of successful implementation of the process:

- An integration strategy will be developed to build system unit aggregates according to the release strategy;
- Acceptance criteria for each aggregate will be developed to verify compliance with the system requirements allocated to the units;
- System aggregates will be verified using the defined acceptance criteria;
- An integrated system demonstrating compliance with the system requirements (functional, non-functional, operations and maintenance) and validation that a complete set of useable deliverable components exists, will be constructed;
- Test results will be recorded;
- A regression strategy will be developed for retesting aggregates or the integrated system should a change be made to existing components;
- Regression testing will be carried out as necessary.

System and SW maintenance

Purpose:

The purpose of the *System and software maintenance process* is to manage modification, migration and retirement of system components (such as hardware, software, manual operations and network if any) in response to customer requests. The origin of requests might be a discovered problem or the need for improvement or adaptation. The objective is to modify and/or retire existing systems and/or software while preserving the integrity of organizational operations.

Outcomes:

As a result of successful implementation of the process:

- a maintenance strategy will be developed to manage modification, migration and retirement of system components according to the release strategy;
- the impact of organization, operations and interfaces on the existing system in operation will be defined;
- specifications, design documents and test strategies will be updated;
- modified system components will be developed with associated tests that demonstrate that the system requirements will not be compromised;
- system and software upgrades will be migrated to the customer's environment;
- on request, software and systems will be retired from use in a controlled manner that minimizes disturbance to the customers.

Documentation

Purpose:

The purpose of the *Documentation process* is to develop and maintain the recorded software information produced by a process or activity.

Outcomes:

As a result of successful implementation of the process:

- a strategy identifying the documentation to be produced during the life cycle of the software product will be developed;
- the standards to be applied for the development of the software documentation will be identified;
- all documentation to be produced by the process or project will be identified;
- the content and purpose of all documentation will be specified, reviewed and approved;
- all documentation will be developed and made available for viewing in accordance with identified standards;
- all documentation will be maintained in accordance with specified criteria.

Configuration Management

Purpose:

The purpose of the *Configuration management process* is to establish and maintain the integrity of all the work products of a process or project.

Outcomes:

As a result of successful implementation of the process:

- a configuration management strategy will be developed;
- all items generated by the process or project will be identified, defined and baselined;
- modifications and releases of the items will be controlled;
- the status of the items and modification requests will be recorded and reported;
- the completeness and consistency of the items will be ensured;
- storage, handling and delivery of the items will be controlled.

Quality Assurance

Purpose:

The purpose of the *Quality assurance process* is to provide assurance that work products and processes of a process or project comply with their specified requirements and adhere to their established plans.

Outcomes:

As a result of successful implementation of the process:

- a strategy for conducting the quality assurance process activities and tasks will be developed, implemented and maintained;
- evidence of quality assurance activities and tasks will be produced and maintained;
- problems or non-conformances with contract requirements will be identified;
- adherence of software products, processes and activities to the applicable standards, procedures and requirements will be verified objectively.

Verification

Purpose:

The purpose of the *Verification process* is to confirm that each software work product and/or service of a process or project properly reflects the specified requirements.

Outcomes:

As a result of successful implementation of the process:

- a verification strategy will be developed and implemented;
- criteria for verification of all required software work products will be identified;
- required verification activities will be performed;
- identified defects will be found and removed from software work products;
- results of the verification activities will be made available to the customer and other involved organizations.

Validation

Purpose:

The purpose of the *Validation process* is to confirm that the requirements for a specific intended use of the software work product are fulfilled.

Outcomes:

- As a result of successful implementation of the process:
- a validation strategy will be developed and implemented;
- criteria for validation of all required work products will be identified;
- required validation activities will be performed;
- all identified problems will be resolved;
- evidence will be provided that the software work products as developed are suitable for their intended use;
- results of the validation activities will be made available to the customer and other involved organizations.

Joint review

Purpose:

The purpose of the *Joint review process* is to maintain a common understanding with the customer of the progress against the objectives of the contract and what should be done to help ensure development of a product that satisfies the customer. Joint reviews are at both project management and technical levels and are held throughout the life of the project.

Outcomes:

As a result of successful implementation of the process:

- periodic reviews will be held at predetermined milestones;
- the status and products of an activity of a process will be evaluated through joint review activities between the customers, suppliers and other stakeholders (or interested parties);
- review results will be made known to all affected parties;
- action items resulting from reviews will be tracked to closure.

Audit

Purpose:

The purpose of the *Audit process* is to independently determine compliance of selected products and processes with the requirements, plans and contract, as appropriate.

Outcomes:

As a result of successful implementation of the process:

- an audit strategy will be developed and implemented;
- audits will be held at predetermined milestones;
- compliance of selected software work products and/or services or processes with requirements, plans and contract will be determined according to the audit strategy;
- the conduct of audits by an appropriate independent party will be arranged;
- problems detected during an audit will be identified, communicated to those responsible for corrective action, and resolved.

Problem resolution

Purpose:

The purpose of the *Problem resolution process* is to ensure that all discovered problems are analyzed and resolved and that trends are recognized.

Outcomes:

As a result of successful implementation of the process:

- the problem resolution activities will be identified to ensure that all discovered problems are analyzed and resolved;
- problem reports will be prepared upon detection of problems (including non-conformances) in a software product or activity;
- a mechanism will be provided for recognizing and acting on trends in problems identified.

Management

Purpose:

The purpose of the *Management process* is to organize, monitor, and control the initiation and performance of any processes or functions within the organization to achieve their goals and the business goals of the organization in an effective manner.

Outcomes:

As a result of successful implementation of the process:

- the activities and tasks that must be performed to achieve the purpose of the process or function will be identified;
- the feasibility of achieving process goals with available resources and constraints will be evaluated;
- the resources and infrastructure required to perform the identified activities and tasks will be established;
- activities will be identified and tasks will be implemented;
- performance of the defined activities and tasks will be monitored;
- work products resulting from the process activities will be reviewed and results analyzed and evaluated;
- action will be taken to modify the performance of the process or function when performance deviates from the identified activities and tasks or fails to achieve their goals;
- successful achievement of the purpose of the process or function will be demonstrated.

Quality management

Purpose:

The purpose of the *Quality management process* is to monitor the quality of the project's products and/or services and to ensure that they satisfy the customer. The process involves establishing a focus on monitoring the quality of product and process at both the project and organizational level.

[Note: Quality Management should be much more than monitoring "the quality of the project's products and/or services". Suggest a strong linkage to ISO 9001.]

Outcomes:

As a result of successful implementation of the process:

- quality goals based on the customer's stated and implicit quality requirements will be established for various checkpoints within the project's software life cycle;
- an overall strategy will be developed to achieve the defined goals;
- identified quality control and assurance activities will be performed and their performance confirmed;
- actual performance against the quality goals will be monitored;
- appropriate action will be taken when quality goals are not achieved.

Risk management

Purpose:

The purpose of the *Risk management process* is to identify and mitigate the project risks continuously throughout the life-cycle of a project. The process involves establishing a focus on monitoring of risks at both the project and organizational levels.

Outcomes:

As a result of successful implementation of the process:

- the scope of the risk management to be performed for the project will be determined;
- appropriate risk management strategies will be defined and implemented;
- risks to the project will be identified in the project strategy, and as they develop during the conduct of the project;
- the risks will be analyzed and the priority in which to apply resources to monitor these risks will be determined;
- risk metrics will be defined, applied, and assessed to determine the change in the risk state and the progress of the monitoring activities;
- appropriate action will be taken to correct or avoid the impact of risk.

Organizational alignment

Purpose:

The purpose of the *Organizational alignment process* is to ensure that the individuals in the organization share a common vision and culture and understanding of the business goals to empower them to function effectively. Although business re-engineering and Total Quality Management have a much broader scope than that of software process, software process improvement occurs in a business context and, to be successful, must address business goals.

[Note: The reference to TQM is of questionable value as significant variation exists in terms of what this means.]]

Outcomes:

As a result of successful implementation of the process:

[Note: These outcomes are highly questionable and ignore the Organizational Change Management which is needed to achieve Organizational alignment.]

- a vision, mission, goals and objectives for the business will be made known to all employees;
- everyone in the organization understands their role in achieving the goals of the business and is able to perform that role.

Process establishment

Purpose:

The purpose of the *Process establishment process* is to establish a suite of organizational processes for all software life cycle processes as they apply to its business activities.

Outcomes:

As a result of successful implementation of the process:

- a defined and maintained standard set of processes will be established, along with an indication of each process's applicability;
- the detailed tasks, activities and associated work products of the standard process will be identified, together with expected performance characteristics;
- a strategy for tailoring the standard process for the product or service will be developed in accordance with the needs of the project;
- information and data related to the use of the standard process for specific projects will exist and be maintained.

Process assessment

Purpose:

The purpose of the *Process assessment process* is to determine the extent to which the organization's standard software processes contribute to the achievement of its business goals and to help the organization focus on the need for continuous process improvement.

Outcomes:

As a result of successful implementation of the process:

- an efficient and effective process assessment method will exist to determine the current capability of the organization and its processes to produce products and services consistent with its business goals;
- the relative strengths and weaknesses of the organization's standard software processes will be understood;
- accurate and accessible assessment records will be kept and maintained;
- reviews of the organization's standard processes will be carried out at appropriate intervals to ensure their continuing suitability and effectiveness in light of assessment results.

Process improvement

Purpose:

The purpose of the *Process improvement process* is to continually improve the effectiveness and efficiency of the processes used by the organization in line with the business need.

Outcomes:

As a result of successful implementation of the process:

- changes to standard and defined processes will be made in a controlled way, with predictable results;
- the organization will effect improvements to its processes through activities such as process assessment and review;
- monitored software process improvement activities will be implemented in a coordinated manner across the organization;
- historical, technical and evaluation data will be analyzed and used to improve these processes, to recommend changes in projects, and to determine technology advancement needs;
- quality cost data will be collected, maintained, and used to improve the organization's processes as a monitoring activity, and to serve to establish the cost of prevention and resolution of problems and non-conformity in software products and services.

Investment management

Purpose

The purpose of the *Investment management process* is to provide an assessment of the benefits and risks to the enterprise stakeholders, of initiating or continuing individual projects, in accordance with supply and acquisition agreements and enterprise policies and resources, and of investing in corporate facilities and technology to the benefit of all projects.

Outcomes:

As a result of successful implementation of the process:

- confirmed enterprise investment plan (schedule, budget, resources) is available
- return on investment (expected and achieved) is available
- resources are committed
- results of the investment decisions are evaluated

Human resource management

Purpose:

The purpose of the *Human resource management process* is to provide the organization and projects with individuals who possess skills and knowledge to perform their roles effectively and to work together as a cohesive group.

Outcomes:

As a result of successful implementation of the process:

- the roles and skills required for the operations of the organization and the project will be identified through timely review of the organizational and project requirements;
- training will be identified and conducted to ensure that all individuals have the skills required to perform their assignments, using mechanisms such as training strategies and materials;
- individuals with the required skills and competencies will be identified and recruited using mechanisms such as procedures, or they will be trained as appropriate to perform the organizational and project roles;
- effective interaction between individuals and groups will be supported;
- the work force will have the skills to share information and coordinate their activities efficiently;
- objective criteria will be defined against which group and individual performance can be monitored to provide performance feedback and to enhance performance.

Training

Purpose:

The purpose of the *Training process* is to provide the organization and projects with individuals who possess the needed skills and knowledge to perform their roles effectively.

Outcomes:

As a result of successful implementation of the process:

- a set of common training needs across the organization based on organizational and project inputs will be identified;
- training will be developed or acquired to address the set of common training needs;
- training will be conducted to ensure that all individuals have the skills required to perform their assignments, using mechanisms such as training strategies and materials.

Infrastructure

Purpose:

The purpose of the *Infrastructure process* is to maintain a stable and reliable infrastructure that is needed to support the performance of any other process. The infrastructure may include hardware, software, methods, tools, techniques, standards, and facilities for development, operation, or maintenance.

Outcomes:

As a result of successful implementation of the process:

- an infrastructure will be established that is consistent with and supportive of the applicable process procedures, standards, tools and techniques;
- the infrastructure will meet all requirements for functionality, performance, safety, security, availability, space, equipment, cost, time and data integrity.

Measurement

Purpose:

The purpose of the *Measurement process* is to collect and analyze data relating to the products developed and processes implemented within the organizational unit, to support effective management of the processes, and to objectively demonstrate the quality of the products.

Outcomes:

As a result of successful implementation of the process:

- an appropriate set of measurements driven by the project and organizational goals will be identified;
- data required will be collected and analyzed;
- a collection of historical data relating to process implementation will be established and maintained;
- measurements will be used to support decisions and provide an objective basis for communication between the interested parties.

Product Evaluation

Purpose:

Ensure that a product meets the stated and implied needs of the users of that product. It may be applied to intermediate or final products.

Outcomes:

As a result of successful implementation of the process:

- A suitable quality model will be selected and applied.
- A list of products that evaluate satisfactorily will be maintained.

Product Transition

Purpose:

The purpose of the *Product transition process* is to move the verified system product from its development/production environment to its operational environment for sustained operational use.

Outcomes:

As a result of successful implementation of the process:

- the system is in its intended operational environment
- the system is ready for operation
- operational support is available

Appendix 5: References

[Basili92] Victor R. Basili et al, "A Reference Architecture for the Component Factory," ACM Trans. Software Eng. And Methodology, Vol. 1, No. 1, Jan. 1992, pp. 53-80.

[Heineman94] G. T. Heineman et al, "Emerging Technologies that Support a Software Process Life Cycle," IBM Systems J., Vol. 33, No. 3, 1994, pp. 501-529.

[Moore97] James W. Moore, Software Engineering Standards: A User's Road Map, IEEE Computer Society, Los Alamitos, CA, 1998.