ISO 9001 and the SE-CMM

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Abstract: This paper provides a top level summary of the comparison between the Systems Engineering Capability Maturity Model[sm] (SzE-CMM[sm]) and ISO 9001, the international standard on Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation, and Servicing. People from many organizations have asked us to characterize the overlap between the two documents. Questions such as "If we perform systems engineering according to the SE-CMM, or at an SE-CMM level 'x', are we ISO compliant?" are of interest to organizations that are trying to implement both concepts concurrently. The answer, of course, is "It depends." But the bottom line is that an organization can achieve a peaceful coexistence between the SE-CMM and ISO 9001 by planning ahead, looking at the requirements imposed by each document, and folding the results into the organization's way of doing business.

Basic Comparison Between ISO 9001 and the SE-CMM

Due to the inherent limitations of writing a technical paper such as this, it is not possible to "start at the beginning" with a full description of these two documents [see references]. However, there are some basic points of comparison which can be made to help set the stage.

A major difference between ISO 9001 and the SE-CMM is the stated intended use. ISO 9001 states that it is intended "for use when conformance to specified requirements is to be assured by the supplier during design, development, production, installation, and servicing." In other words, when an organization is intending to win business as a supplier of products to certain customers, it must look at ISO 9001 compliance or certification as a condition of being awarded future business. It is the intention of that customer to use ISO 9001 as part of its supplier selection criteria. SE-CMM states that it "is specifically developed to support an organization's need to assess and improve their systems engineering capability" and furthermore "use of the model for supplier selection is discouraged."

However, both documents claim that they should be used as guidance to the organization, to be used as a requirements document by the organization when developing its way of doing business. ISO 9001 describes it as "They [9001 - 9004] specify requirements which determine what elements quality systems have to encompass, but it is not the purpose of these ... Standards to enforce uniformity of quality systems. They are generic and independent of any specific industry or economic sector." SE-CMM similarly claims "The process areas are composed of base practices, which are mandatory characteristics that must exist within an organization's implemented systems engineering process for the organization to claim satisfaction of that PA."

[sm] Capability Maturity Model and CMM are service marks of Carnegie Mellon University

In general, both the SE-CMM and ISO 9001 expand on the notion that an organization should decide how they are going to do something, write that down, do it that way, and then check to see if they did what they said they were going to do. ISO 9001 is concerned with making sure that these documented processes are carried out by qualified personnel and will result in a product that meets quality requirements. The SE-CMM splits these concepts between capability levels; for example, doing a process is a capability level 1 concept, writing down a process is addressed in capability level 2, having an organizational level written process is a capability level 3 requirement, etc. The SE-CMM also addresses quantitatively measuring and managing processes in capability level 4 and continuously improving processes in capability level 5.

Another difference between the two documents concerns the scope of coverage. The scope of ISO 9001 is "the production, installation, and servicing processes which directly affect the quality" of the end product. The SE-CMM covers all processes and work products (including internal work products) which an organization must perform in order to achieve success in the systems engineering domain. Therefore the SE-CMM contains process areas, such as Manage Product Line Evolution and Manage Systems Engineering Support Environment, which are not addressed at all in ISO 9001.

Both documents discuss product development and the quality of the product, however the SE-CMM provides more detail on the design and development of the product and ISO 9001 goes into more detail on the quality aspects of the development process and the products themselves. The SE-CMM builds up to the concept of an organizational standard way of doing systems engineering at capability level 3, which is not addressed in ISO 9001. The SE-CMM does not address test equipment or product storage; both of which are contained in ISO 9001.

Comparison Between ISO 9001 Compliance and the SE-CMM Scoring Profile

First, remember that an SE-CMM assessment provides an organization with a profile of scores (a separate score for each process area examined), not an organizational level score. Second, the SE-CMM is evaluating whether a systems engineering activity is taking place within the organization regardless of the specific role of the person performing the job, the specific document capturing the results, etc. ISO 9001 provides more restrictions to the organization in terms of stating specific roles and documentation contents.

The SE-CMM assigns a capability level score to a process area according to the following guidelines. If the organization is performing all of the base practices of the process area, the capability level is at least one. If the organization can also demonstrate all of the level two generic practices relative to the performance of that process level, the capability level is at least two. This continues for the generic practices of capability levels three through five. Figure 1 lists the level two generic practices in terms of questions which can be asked of the personnel performing a process area. For example, generic practice 2.1.1 asks if the management assigns adequate resources (including personnel) for the performance of the work associated with whatever process area is being examined. Note that all of the level two generic practices must be fulfilled to earn a score of two; the SE-CMM does not provide for partial level scoring.

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Figure 1 - SE-CMM Capability Level 2 Generic Practices

Do those responsible for managing the PA:	2.1.1	Allocate adequate resources?
	2.1.2	Assign responsibilities for developing the work products?
	2.1.3	Document the approach for performing the work?
	2.1.4	Provide appropriate tools?
	2.1.5	Ensure that people are appropriately trained?
	2.1.6	Plan the work?
	2.4.1	Track status against the plan using measurement?
	2.4.2	Take corrective action as appropriate?
Do those responsible for performing the work associated with the PA:	2.2.1	Use plans, standards or procedures?
	2.2.2	Place work products under configuration management?
	2.3.1	Verify compliance of processes with appropriate standards
	2.3.2	Verify compliance of work products with appropriate standards?

ISO 9001 requires (paragraph 4.1.2.1) that the responsibility and authority of all personnel working on the quality system be defined and documented. It also requires (paragraph 4.1.2.2) that adequate resources, including trained personnel, be provided. Each paragraph in section 4 requires that the supplier establishes and maintains documented procedures for the work being described. These all are directly traceable to SE-CMM capability level 2 generic practices. Therefore, when mapping from ISO 9001 paragraphs to the SE-CMM process areas, remember that the SE-CMM process areas must be performed to at least a capability level 2.

Mapping Between ISO 9001 and the SE-CMM

Figure 4 at the back of this paper contains a mapping from ISO 9001 paragraphs to process areas or capability level concepts within the SE-CMM. Following that is figure 5 containing the reverse mapping, from SE-CMM process areas to ISO 9001 paragraphs. The figures show an area is "not addressed" when the indicated document is silent on the corresponding topic.

Even with this mapping, it is still not possible for an organization to say that being a capability level 2 in a process area means it is compliant with the associated paragraphs in ISO 9001 or vice versa. A simple example of this is shown in figure 2, which maps the ISO 9001 paragraph "Training" to the SE-CMM process area "Provide Ongoing Skills & Knowledge." ISO 9001 paragraph 4.18 begins with requiring documented procedures, etc. which translates to at least a capability level 2 score in process area 17. But again, it is not possible for the organization to blindly claim that having earned a capability level 2 score in PA17 it is compliant with ISO 9001 paragraph 4.18. Conversely, it is not possible to say that because the organization has a capability level score of 0 or 1, it is not ISO 9001 compliant.

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Figure 2 - Comparison of ISO 9001 and SE-CMM Training Requirements

ISO 9001 Paragraph 4.18 - Training	SE-CMM PA17 - Provide Ongoing Skills & Knowledge
Identify training for activities affecting quality	Identify needed skills & knowledge throughout the organization
n/a	Evaluate & select mode of skill acquisition
Personnel can be qualified on the basis of education, training, and/or experience	Assure availability of skill and knowledge
n/a	Prepare training material
n/a	Train personnel
n/a	Assess training effectiveness
Maintain training records	Maintain training records
n/a	Maintain training material

Consider the following scenarios:

- The organization is compliant with paragraph 4.18, i.e. it has a written procedure for identifying quality training needs, assures that the quality people are qualified, and maintains records of the training received by its quality personnel. If this is the only training-related activity taking place in the organization, the organization will receive a capability level score of 0 in PA17 because the remaining parts of the process area are not being performed and because training for the organization as a whole is not being addressed.

- The organization is compliant with paragraph 4.18 and performs all of the elements of PA17. However, assume that the training associated with quality is covered by a written procedure and the training associated with other engineering skills (e.g. configuration management) is ad hoc and has no written records. In this case the organization will receive a capability level score of 1 in PA17 because the level 2 generic practices are not being performed for all training within the organization.

- It is conceivable that an organization could be assessed at a capability level 1 or 2 in PA17 and not even address training for quality activities. This is likely to happen in an organization in which the quality work is performed by a separate or independent group. The organization is evaluated on its performance of training as it relates to the performance of systems engineering activities throughout the organization. If the organization considers quality as something performed "outside" of the organization, then it is likely that quality training will be overlooked in the scoring of this process area.

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For an organization to make a comparison of its work processes to the SE-CMM and ISO 9001, it must look at the specifics associated each of these: its work processes, the appropriate SE-CMM process areas, and the associated ISO 9001 paragraphs. Expect to find the most detail in the organization's work processes. After all, a process should contain start and stop criteria, sequencing information, role assignments, etc. In general, ISO 9001 is more prescriptive than the SE-CMM in terms of stating who should perform an activity ("the supplier's management") or where the results of an activity should be captured ("the quality manual.")

For an organization just developing its work processes, using the SE-CMM and ISO 9001 simultaneously as reference material, along with the organization and project specific requirements, will facilitate the creation of work processes that can be both ISO 9001 compliant and SE-CMM capability level 2.

Figure 3 shows all the SE-CMM process areas which map, at least partially, to ISO 9001 paragraphs. The figure shows that all process areas must receive at lease a capability level 2 rating; this is to meet the ISO 9001 requirements of written procedures, adequate resources, trained personnel, etc. As illustrated in the training example above, care must be taken in mapping the requirements to the organization's processes. But the bottom line is that an organization can achieve a peaceful coexistence between the SE-CMM and ISO 9001 by planning ahead, looking at the requirements imposed by each document, and folding the results into the organization's way of doing business.

Figure 3 - Minimum SE-CMM Rating Profile for Organization with ISO 9001 Compliance

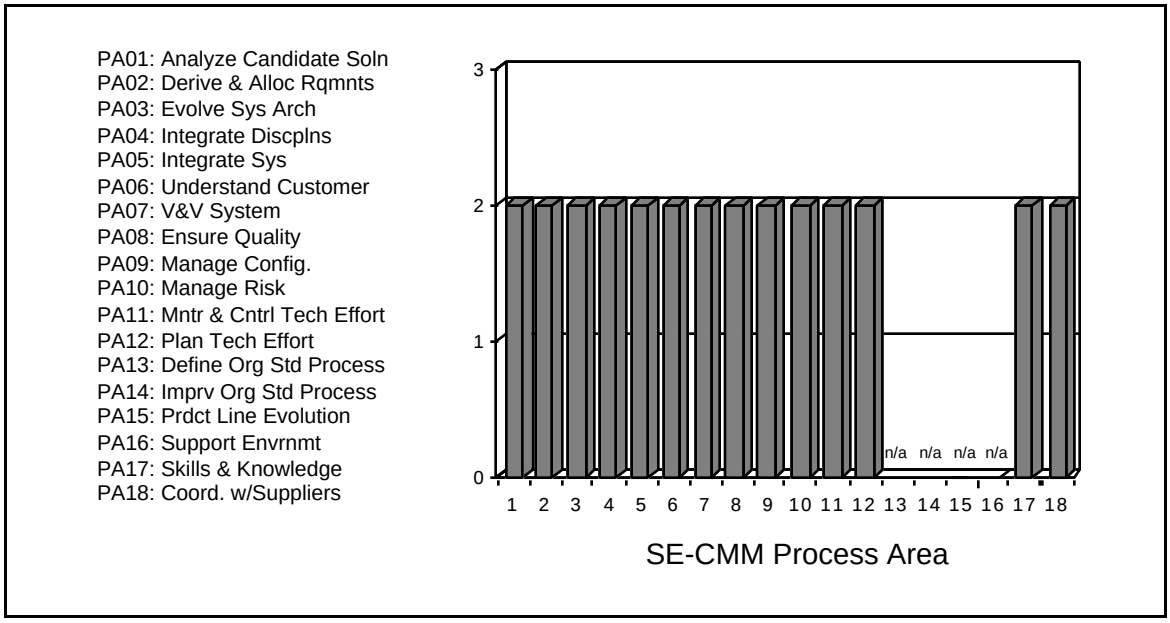

Figure 4 - Mapping from ISO 9001 Paragraph Number to SE-CMM Process Areas

ISO 9001 Paragraph Number	SE-CMM Process Areas
4.1 - Management Responsibility	PA 08 - Ensure Quality Partially Not Addressed
4.2 - Quality System	PA07 - Verify & Validate System PA08 - Ensure Quality PA12 - Plan Technical Effort
4.3 - Contract Review	PA06 - Understand Customer Needs & Expectations PA18 - Coordinate with Suppliers
4.4 - Design Control	PA01 - Analyze Candidate Solutions PA02 - Derive & Allocate Requirements PA03 - Evolve System Architecture PA04 - Integrate Disciplines PA06 - Understand Customer Needs & Expectations PA07 - Verify & Validate System PA09 - Manage Configurations PA12 - Plan Technical Effort
4.5 - Document and Data Control	PA09 - Manage Configurations
4.6 - Purchasing	PA05 - Integrate System PA18 - Coordinate with Suppliers
4.7 - Control of Customer-Supplied Product	PA09 - Manage Configurations
4.8 - Product Identification & Traceability	PA09 - Manage Configurations
4.9 - Process Control	PA08 - Ensure Quality PA11 - Monitor & Control Technical Effort PA12 - Plan Technical Effort
4.10 - Inspection & Testing	PA05 - Integrate System PA07 - Verify & Validate System
4.11 - Control of Inspecting, Measuring, and Test Equipment	Not Addressed
4.12 - Inspection & Test Status	PA05 - Integrate System PA07 - Verify & Validate System
4.13 - Control of Non-Conforming Product	PA05 - Integrate System PA07 - Verify & Validate System PA08 - Ensure Quality Capability Level 3 - Defect Reviews
4.14 - Corrective and Preventive Action	PA08 - Ensure Quality PA10 - Manage Risk
4.15 - Handling, Storage, Packaging, Preservation, & Delivery	Not Addressed
4.16 - Control of Quality Records	PA08 - Ensure Quality
4.17 - Internal Quality Audits	PA08 - Ensure Quality PA10 - Manage Risk PA11 - Monitor & Control Technical Effort PA12 - Plan Technical Effort
4.18 - Training	PA17 - Provide Ongoing Skills & Knowledge
4.19 - Servicing	Not Addressed (Service is part of product definition)
4.20 - Statistical Techniques	PA08 - Ensure Quality PA12 - Plan Technical Effort Capability Levels 2 through 5

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Figure 5 - Mapping from SE-CMM Process Area to ISO 9001 Paragraph Numbers

SE-CMM Process Area	ISO 9001 Paragraph Numbers
PA01 - Analyze Candidate Solutions	4.4 - Design Control
PA02 - Derive & Allocate Requirements	4.4 - Design Control
PA03 - Evolve System Architecture	4.4 - Design Control
PA04 - Integrate Disciplines	4.4 - Design Control
PA05 - Integrate System	4.6 - Purchasing 4.10 - Inspection & Testing 4.12 - Inspection & Test Status 4.13 - Control of Nonconforming Product
PA06 - Understand Customer Needs & Expectations	4.3 - Contract Review 4.4 - Design Control
PA07 - Verify & Validate System	4.2 - Quality System 4.4 - Design Control 4.10 - Inspection & Testing 4.12 - Inspection & Test Status 4.13 - Control of Nonconforming Product
PA08 - Ensure Quality	4.1 - Management Responsibility 4.2 - Quality System 4.9 - Process Control 4.13 - Control of Nonconforming Product 4.14 - Corrective & Preventive Action 4.16 - Control of Quality Records 4.17 - Internal Quality Audits 4.20 - Statistical Techniques
PA09 - Manage Configurations	4.4 - Design Control 4.5 - Document & Data Control 4.7 - Control of Customer-Supplied Product 4.8 - Product Identification & Traceability
PA10 - Manage Risk	4.14 - Corrective & Preventive Action 4.17 - Internal Quality Audits
PA11 - Monitor & Control Technical Effort	4.9 - Process Control 4.17 - Internal Quality Audits
PA12 - Plan Technical Effort	4.2 - Quality System 4.4 - Design Control 4.9 - Process Control 4.17 - Internal Quality Audits 4.20 - Statistical Techniques
PA13 - Define Organization's Systems Engineering Process	Not Addressed
PA14 - Improve Organization's Systems Engineering Processes	Not Addressed
PA15 - Manage Product Line Evolution	Not Addressed
PA16 - Manage Systems Engineering Support Environment	Not Addressed
PA17 - Provide Ongoing Skills & Knowledge	4.18 - Training
PA18 - Coordinate with Suppliers	4.3 - Contract Review 4.6 - Purchasing
Not Addressed	4.1.1 - Quality Policy 4.11 - Control of Inspection, Measuring, & Test Equipment 4.15 - Handling, Storage, Packaging, Preservation, & Delivery 4.19 - Servicing (Part of product definition)

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Author Biography

Ilene Minnich is currently a full time director of SECAT LLC responsible for training and consulting on systems engineering process improvement and assessment. Prior to forming the company, Ms. Minnich spent three years leading the Systems Engineering Process Assessment Team at Hughes Aircraft Company. It was during this time that she began her participation in the Systems Engineering Capability Maturity Model[sm] (SE-CMM[sm]) as both an author and steering group member. Ms. Minnich also became a member of INCOSE's Capability Assessment Working Group (CAWG) and worked to develop the earlier versions of the INCOSE Interim model. Currently she remains active in INCOSE and on the SE-CMM steering group as the SECAT representative.

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