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Evaluating Process Quality from an Appraisal Perspective

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Abstract

A question currently being argued throughout the appraisal community concerns evaluation of process quality during Standard CMMI® Appraisal Method for Process Improvement (SCAMPI℠) appraisals. Different, conflicting opinions on whether evaluation of process quality during a SCAMPI appraisal is appropriate run from an extremely vigorous "no" to an equally vigorous "yes!"

The main issue in both beliefs appears to be linked to word definitions—specifically, a lack of agreement among SCAMPI Lead Appraisers about what "quality" means in the SCAMPI context.

This technical note examines these beliefs in light of the following questions:

- Do appraisal results, following the current methodology, address the quality of processes examined during the appraisal?
- Can appraisals, following the current methodology, judge the quality of the final product or deliverable?
- Can appraisals, following the current methodology, provide insight into the quality of the final product or deliverable during development?

Having addressed these questions in terms of quality, the technical note discusses approaches acquisition offices may use to gain the insight desired.

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1 Introduction

Gaining insight into the quality of acquired software products implies and requires acquisition offices to (1) continually monitor the suppliers' approach to "building in" the quality and (2) establish a management framework that supports the development of a quality product. In both cases, acquisition offices must obtain such insight through the request for proposal (RFP) (or similar acquisition documents) and contracting processes with associated documentation.

There is currently a belief by some acquisition offices that using process reference models such as the CMMI® framework and applying associated appraisals (such as the Standard CMMI Appraisal Method for Process Improvement, or SCAMPI℠) will automatically yield the needed visibility or insight to allow acquisition offices to manage the development and therefore acquire quality products.

Linked to this belief are questions currently being argued in the appraisal community concerning the evaluation of quality during SCAMPI appraisals. A current philosophy espoused by some appraisal teams appears to be that the quality of processes is not evaluated. However, as discussed below, this may not be precisely correct. We believe the confusion can be attributed to the undefined terminology which results in multiple understandings appraisers have of the word "quality."

This technical note examines the various opinions in an attempt to resolve the confusion. We seek an answer to the following question:

> *Following the current SCAMPI methodology, can and should Lead Appraisers and appraisal teams judge the quality of supplier processes examined during an appraisal?*

To explore the question, we have to understand several aspects surrounding quality and associated terminology:

- What do we mean by quality with respect to processes examined during an appraisal?
- What quality attributes does the SCAMPI allow to be applied to processes, if any?
- What would be the effect of applying the quality attributes to processes during a SCAMPI engagement?

We postulate that the issues noted above stem from the lack of precise definitions of terms in appraisal documentation related to the word "quality." To this end, we introduce, in Section 2, terms that establish a context for the subsequent discussions of quality. In Section 3 we note assertions made by the appraisal community that reflect some differences in that community's thinking about what appraisals can accomplish in determining process quality. Section 4 examines these opinions in light of the current appraisal methodology in a SCAMPI engagement. Section 5 gives a brief summary of the discussions in the technical note.

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2 Terminology

In this section, we introduce and define terminology related to the issue of process evaluation, specifically the term quality.

2.1 Entities—Quality of What

The first question to answer: What entity are we seeking to evaluate for quality during an appraisal? Baker identifies several, such as product, process, artifact, activity, and service, to which we can apply quality evaluations [Baker 2007]. Certainly other entities exist for this application; the concept of quality is generally applicable to almost anything, tangible and intangible. Each entity may have very different quality attributes being evaluated depending on one's perspective. An appraiser must first identify the entity or entities for which the quality is to be evaluated. The appraiser must also establish an evaluation approach that includes quality attributes to be used in the evaluation.

From Baker and the question at hand, the following is the focus of our discussions:

- Processes that produce the artifacts that make up the direct or indirect objective evidence are the entities whose quality we wish to attempt to judge.
- The SCAMPI Method Definition Document (MDD) can provide the needed quality attributes that can be applied to the processes for a more objective quality evaluation than can be obtained through the consensus of individual teams.
- This evaluation approach can result in support for reporting on the quality of the processes as part of the appraisal. (How to use this information is a decision left to the organization being appraised.)

2.2 Quality (What Do We Mean by Quality?)

Cooper provides an operational definition of quality:

> *Quality is the degree to which an object (entity) [e.g., process, product, or service] satisfies a specified set of attributes or requirements* [Cooper 2002].

This identifies "specified requirements" as the quality attributes to be used. The attributes or requirements are to be specified and must adhere to the normal rules for requirements description such as being consistent, clearly stated, testable, or measurable (quantitative in some way).

Significant here is the concept of completely defining the quality attributes being sought. In order to understand the quality of an entity, the context[1] for the quality attributes must be defined and specified. This concept is embedded in the following statement:

> *Just as beauty is in the eye of the beholder, so is quality* [Baker 2007].

[1] Context includes criteria to define quality in quantitative terms and the associated measurements of quality.

Consequently, a set of attributes that one community deems important as a measure of quality may not be deemed important by another community. Rather, each community is likely to have its own set of attributes and attribute values with which to measure quality. This point becomes critical when organizations are asked to establish baselines and prediction models used to help manage statistically the product's quality and process performance during development.

Overall we must describe the entire context of the quality we are looking for to be able to measure or otherwise judge the quality of an entity.

We explore these quality concepts next in the context of appraisals.

3 A Review of Appraisers' Opinions

To establish context for our examination, we first state, without analysis, some of the assertions made by the SCAMPI Lead Appraiser[SM] community. These assertions are examined later in this technical note.

Some Lead Appraisers assert the following:

> *While a SCAMPI doesn't measure effectiveness or efficiency directly, the appraisal team does judge whether or not the organization is measuring the effectiveness and efficiency of its processes. This is done through the generic practices (GPs), product and process quality assurance (PPQA), organizational process focus (OPF), organizational process performance (OPP), and the like.*

A second position taken by some Lead Appraisers is as follows:

> *An appraisal team does indeed judge the "goodness" of the process. The CMMI practices themselves are the characteristics of effective processes. The team judges if these practices are implemented using all the informative material to make that determination.*
>
> *If a practice is documented and not effective (or "good") as executed, then the appraisal team is failing to do its job if it doesn't highlight this as a weakness—either against that practice, a generic practice, or one of the other areas listed earlier.*

Other Lead Appraisers assert another position, reflecting different concepts of quality and quality evaluation during an appraisal:

> *Artifacts are typically judged for "adequacy" as an indication of their quality—the judgments being made by the appraisal team.*

And, while the last statement focuses on artifacts, the philosophy applies to process quality. That is, the evaluation of "adequacy" of the process depends on the experience of the appraisal team. Here adequacy is used as one quality attribute.

[SM] SCAMPI Lead Appraiser is a service mark of Carnegie Mellon University.

4 Judging Process Quality During an Appraisal

4.1 Process and Practices

Many of the difficulties in answering the basic questions stem from the following premise stated in some of the seminal publications by the SEI on process improvement [Humphrey 1989]:

> *The quality of the product is highly influenced by the quality of the process used to acquire, develop, and maintain the product.*

This is a fundamental foundational premise for process improvement efforts, especially for Capability Maturity Model®-based process improvement.

Note that the quality and the context behind or surrounding the quality are not defined for either the process or the product. Also note that there is no guarantee that a quality process, however it is defined, will produce a quality product; this is reflected in the term *"highly influenced."*

Based on the definitions, let's review the assertions provided in Section 3:

> *While a SCAMPI doesn't measure effectiveness or efficiency directly, the appraisal team does judge whether or not the organization is measuring the effectiveness and efficiency of their processes. This is done through GPs, PPQA, OPF, OPP, and the like.*

First, it must be noted that the general view of the generic practices of PPQA is that they only determine if the process, as established, is being followed. PPQA does not check for the adequacy of the process. OPP may be a better vehicle, and organizational innovation and deployment (OID) is a way of making changes that quantitatively show that the process is being improved.

This assertion appears to presume that the organization is actually using measurements of the implemented practices from the CMMI or elsewhere to measure effectiveness and efficiency of its processes. However, although we would hope this is the case, at lower levels of maturity, efficiency and effectiveness may not be defined by the organization in any gainful way, let alone in a measurable way. CMMI-DEV Generic Practice 2.8 for each process area is intended to provide a measure of the process that can be used to monitor and control it (GP 2.8 is "monitor and control the <xxx> process against the plan for performing the process and take appropriate corrective action").

Often, the measure that is selected is actual schedule status for that process relative to the planned schedule. Such a measure may not always be adequate to monitor and control the process. So, the focus of the GPs and supporting process areas may not yield desired results. (In general, we would hope the organization is measuring the efficiency and effectiveness, regardless of how the organization defines these attributes, of its own processes, to collect historical data for creating process performance baselines and models. This may not be the case unless the organization has been exposed to statistical techniques and knows how to apply them to its processes.) From a practical perspective, most organizations are not thinking ahead in terms of ultimately achieving maturity level 4 or 5 and are more focused on achieving the current lower target maturity level.

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To elaborate further, it can be said that metrics actually selected by an organization may not be meaningful or not be particularly easy to define. The problem is not what the model requires but how the organization implements GPs, specifically GP 2.8, as described in the previous paragraph. Some organizations may choose something just to satisfy GP 2.8, whether it is useful or not, in order to ensure they achieve largely implemented[2] (LI) characterization for that practice [MDD 2007]. The problems being experienced with the quality of the products may, in some respects, be attributed to appraisers' interpretations of the CMMI.

A second assertion presents the following argument:

> *An appraisal team does indeed judge the "goodness" of the process. The CMMI practices themselves are the characteristics of effective processes. The team judges if these practices are implemented using all the informative material to make that determination.*

From this statement, one may conclude that the quality of an organization's processes and practices could be evaluated by using the CMMI model as a gauge of quality. That is, from the above statement, appraisals can use the CMMI model as a quality reference since the model contains "effective" practices as defined by the CMMI community, and adherence to these practices would potentially be an indication of process quality in terms of effectiveness and efficiency if these attributes are properly defined, ignoring the possibility that uncontrollable outside factors may also negate the benefits of using a set of best practices.

Stated another way, appraisal teams use the model to check adherence of the organization's implemented processes and practices to CMMI. Further, customers of the appraisal typically conclude—based on the developer achieving a maturity or capability level ratings during an appraisal—that since the model is a compendium of "effective" processes or practices, adhering to them, as shown in an appraisal, would be enough to produce quality products.

However, it is not clear that the adherence of the implemented practices to the CMMI practices actually can be used to "measure" the efficiency and effectiveness of the related processes and practices and produce the desired quality product.

> *If a practice is documented and not effective (or "good") as executed, then the appraisal team is failing to do its job if it doesn't highlight this as a weakness either against that practice, a GP, or one of the other areas listed earlier.*

It is not clear from this assertion that "if a practice is implemented by the organization" means the organization's process is effective in producing what the organization desires or needs. It is also not clear that the appraisal team can evaluate that a process is effective for the organization just because the organization has implemented the CMMI practices. For example, there may be many more practices the organization must implement within its environment to make the process effective (e.g., when domain specific practices, such as those associated with space versus ground based systems, enter the equation).

[2] Largely implemented is defined In the MDD glossary as a practice characterization value assigned to a process instantiation when (1) one or more direct artifacts are present and judged to be adequate, (2) at least one indirect artifact and/or affirmation exists to confirm implementation, and (3) one or more weaknesses are noted.

Much of the confusion may be attributed to terminology, since terms like "efficiency" and "effectiveness" should be considered quality attributes. Even here these terms need to be further defined in some way. And, the entire context surrounding these attributes needs to be specified.

Another view of the issue is explored in an article by Charette in *CrossTalk*. (Note that Charette uses definitions different from the CMMI model for process adherence, process capability, process performance, and program/project process performance.) He defines "…process adherence adequacy or performance as the ability of an organization to adequately define and implement the technical and management processes required of its programs" [Charette 2004].

Charette goes on to describe two types of process adherence shortfalls found in his assessments[3] that are different than the maturity level achievement typically rated in a SCAMPI appraisal:

> *First are the technical and management processes that are poorly executed— meaning that they are ineffectively implemented or performed for a particular program.*
>
> *The second type of process adherence shortfall … is constrained process. These are technical and management processes that are not fully implemented or executed because the program team … no longer supports them*

The article never quite ties process adherence adequacy to these types of process adherence shortfalls. However, the reader is led to make that connection.

More important were his findings on shortfalls in process capabilities where the discussion on judging the quality of something during an appraisal comes into play.

Charette defines process capability as "….the effectiveness of the defined and implemented organizational processes in meeting a specific program's technical and management requirements. In general, process capability refers to how well an organization's process models or standards have been adapted and applied to address the specific characteristics and needs of a particular program."

This assertion resembles the CMMI organizational maturity level 4 process area of quantitative project management (QPM). QPM asks the project to establish (from the organization's process models and baselines and from imposed requirements such as by a contract) the quality and process performance objectives for the project. Then, the process area asks that the project use these objectives to manage project execution. The definition in CMMI for process performance is "a measure of the actual results achieved by following a process. It is characterized by both process measures, (e.g., effort, cycle time, and defect removal efficiency), and product measures (e.g., reliability, defect density, and response time)" [Chrissis 2006].

Here, an appraisal does have the ability to gain insight into how the organization has defined process and product quality for the project, where there may be interim products, and the final product or deliverable from the development. While the usual concern from an acquisition perspective is the quality of the final product or deliverable, there is always a need by the acquisition office to know if there are or will be problems throughout the development. Hence, the acquisition office should be interested in the process performance models that the organization is using to provide a "heads up" on any potential quality issues in the delivered product.

[3] Charette uses the term "assessment." His work did not apply the SCAMPI methodology.

Two significant points arise.

First, "getting" to the maturity level 4 aspects noted above is typically looked at as conducting an appraisal to that maturity level. This requires the organization and projects to be at a maturity level 4 to "properly" implement the needed practices. From an acquisition perspective it may be seen as only using maturity level 4 organizations—possibly limiting competition. And, no quantitative link has been established between maturity levels and resulting project performance and product quality [Baker 2007].

Secondly, an appraisal reflects a point in time. If an appraisal occurs during the development, it typically will not yield "continuous" insight into the building of quality into the deliverable. For example, an appraisal could take place after product coding phase. In this case, the activities of building quality into the design (such as with architectural decisions) may be missed. On the other hand, if the appraisal occurs before a contract is signed, there will be no insight into the approach actually implemented and decisions made in building quality into the final deliverable.

Other things being equal, appraisals, even for organizational maturity level 4, do not provide the desired insight for the customer (acquisition offices) throughout the development. The assumption here is that there are not numerous appraisals for each phase of development. However, appraisal-type methods could be used to get this insight. However, any of these alternative methods (such as process monitoring or process in execution reviews), need to be in the RFP and contract.

4.2 Deliverables

Two questions relating to the quality of the final product or deliverables remain to be addressed.

1. Can appraisals, following the current methodology, judge the quality of the final product or deliverable?
2. Can appraisals, following the current methodology, provide insight of the quality of the final product or deliverable during development?

On question 1, based on the Process and Practices section above, appraisals—using the current methodology—determine adherence of the processes to the CMMI-DEV model.

Combined with the premise that

> *The quality of the product is highly influenced by the quality of the process used to acquire, develop, and maintain the product*

there appears to be no guarantee that appraisals can determine that the final product will possess the quality desired or specified, if the quality is specified along with its context. In fact, there is ongoing work trying to make a quantitative connection [Baker 2007]. Let us emphasize that this premise applies to both acquisition and development processes and there are relationships between the two sets of processes. What the acquirer does or does not do can impact the supplier's implementation of the development processes.

Of course, determining quality after the product is developed is typically accomplished through verification and validation. But then the quality is already in the product.

Turning to question 2 (can appraisals, following the current methodology, provide insight of the quality of the final product or deliverable during development?), there is the potential for appraisals to provide some insight into the quality of the final product during development. This was discussed in the Process and Practices section, using the elements of QPM to see if, through adherence with the model, the practices document the approach to specify and manage the quality and process performance.

At maturity level 4 and using QPM, the development project uses the organization's performance models and tailors these to set up the project's quality and process-performance objectives which "support" the needs and priorities of customers, end user, and other stakeholders. Appraisals, using the artifacts from the practices, gain insight as to the possibility that the specified quality of the final product is going to be achieved. (In general, it is thought that tailoring means "tightening" the baselines established by the organization. However, with approval some projects may "loosen" the baseline as appropriate to the project needs, but not more than the customer requirements allow.)

Depending on the number of appraisals during development, the use of formal appraisals for maturity level 4 may be too expensive and too late to help make the decisions to build the quality into the product. In case an organization was appraised at maturity level 4 before contract award, it does not guarantee that the project is following the processes against which the appraisal was accomplished.

To overcome some of these difficulties with appraisals, acquisition offices can evaluate through other means during source selection (assuming a competitive situation) the developer's approach to developing the software product along with specified quality and deciding if it is reasonable and feasible. The acquisition office then must carry though with trend analyses of the developer's various appropriate processes [Cooper 2002].

For maturity level 4 development organizations, the acquisition office must also have the capability to understand statistical techniques that the contractors may be using for managing the software development.

In general for this approach, acquisition offices must do the following:

- Specify the desired quality attributes of the final product, or specify in the RFP or statement of work that the developer will determine quantitatively the quality attributes as part of the development approach, with acquisition office approvals.
- Add the correct wording to the RFP to allow evaluation of the development approach during source selection and then allowing the acquisition offices access to results of the processes followed, so that trend analysis can be implemented. In this way, it may be possible to call out the CMMI level 4 process area of QPM and call out the CMMI level 3 process area of technical solution to help ensure the requisite quality is built in.
- Add words to the RFP and to the resulting contract as appropriate to be able to evaluate the developer's approach to overall software development. Wording may be in the form of a software development plan (SDP). Such an approach to source selection and contract management has been suggested in the past in the SA-CMM V1.03 and the Navy memorandum [Cooper 2002, Navy 2006]. In source selection, appropriate wording for Evaluation Factors for Award is required to ensure discrimination among offers.

- Add words to the RFP and to the resulting contract as appropriate to allow initial evaluation of the developer's approach to building quality into the product and allow the acquisition office access to appropriate documentation. Request that the potential development organizations describe in detail the plans, tools, methods, practices, processes, and prediction models that will provide the insight into deliverable product quality throughout the development project life cycle—not simply at the end of the project. Tests can be made at the end of the project, but that is typically too late. In source selection, appropriate wording for Evaluation Factors for Award is required to ensure discrimination among offerors.

5 Summary

Appraisals do not necessarily give a good indication of the quality of the processes used for product development, only adherence to the reference model. In this technical note we concentrated on the CMMI-DEV as a reference model and the SCAMPI appraisal method.

Appraisals can provide some insight into deliverable product quality. However, the insight can be somewhat indirect. That is, appraisals compare the organization's implementation of the CMMI-DEV practices and the adherence of the implementation of these practices to the reference model.

> *This comparison evaluates the process adherence and not necessarily the quality of the processes and resultant product. (A tacit assumption is that the development organization has processes that not only adhere to the practices in CMMI-DEV but also contribute to the organization's business objectives.)*

However, the process premise itself, upon which many process improvement programs are based, implies that the quality of a process does *not guarantee* the needed product quality will be achieved. (Here, we have not defined "needed.") Another way of saying this is that appraisals do not guarantee that the quality of the deliverable product is *built in* by the development processes used. Thus, using only an appraisal does not necessarily give you insight into product quality, especially throughout the development.

On the other hand, we discussed how one might get this insight by using CMMI-DEV organization maturity level 4 process areas of OPP and QPM. While an appraisal, even at organizational maturity level 4, can be used to obtain more insight into deliverable product quality, one cannot assume that it guarantees you the insight. You must continue to analyze the developer's process and practices from the start and throughout the development. That continual analysis is fundamental to QPM.[4]

During an appraisal, one can use the organization's or project's own quality and performance objectives to assess or judge the adequacy of the implemented process and practices to produce a quality work product, rather than relying on the appraisal team experience and common sense to evaluate the quality of the work products or final products. However, the objectives have to be established for anything to be judged. And the objectives may not be established for all processes.

The recommendation is for the acquisition office to generate request for proposal, statement of work, and contract language to ensure the needed insight is obtained throughout development. Critically, the acquisition offices must follow through during development to gain and exploit this insight into processes and resultant work product quality throughout the development to help make the decisions that affect the quality of the final product.

[4] There is a potential problem here in relying on a maturity level 4 appraisal. It assumes that the development organization is at maturity level 4, and this may limit what development organization can bid on the acquisition (i.e., limit competition).

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13. **ABSTRACT (MAXIMUM 200 WORDS)**

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The main issue in both beliefs appears to be linked to word definitions—specifically, a lack of agreement among SCAMPI Lead Appraisers about what "quality" means in the SCAMPI context.

This technical note examines these beliefs in light of the following questions:

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