

# Software Quality Assurance in a CMM Level 5 Organization

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*This article shares the evolution of the Ogden Air Logistics Center, Software Engineering Division's philosophy about quality assurance (QA), its perspective on applying the principles of QA from the CMM, and how the QA group has been used as a tool for process maturity measurement and to improve the organization.*

Many people think that software quality assurance (SQA) is a mystifying or a dull subject. I have had many experiences that have brought this to my attention. The most frequently recurring one is when friends or acquaintances ask what I do for a living. Usually, I respond by saying that I am a software engineer. This response results in two types of reactions. The first type is, "Wow, that's interesting. So, how about this weather we've been having?" The second is more rare and a little more difficult to answer: "Does that mean you write software?" Surprised by their interest, I respond, "Well, actually I used to write software, but now I'm involved in doing quality assurance work." At this point, a bit of explanation seems appropriate, given the slightly puzzled look, so I add, "That means that I make sure that software projects are doing all of the right things in order to build quality products." The reaction to this also is predictable: "Cool. So, did you see the game on TV last night?" Here, in the Software Engineering Division (TIS), the attitude is a bit more favorable. QA is not perceived as interesting or fun by the typical engineer in TIS, but most have come to understand what QA is and also appreciate its contribution, within the framework of process improvement, to improve our quality, efficiency, and morale as an organization.

But process improvement initiatives were not always appreciated. This attitude metamorphosis has happened gradually over several years. Initially, the efforts in SQA were viewed as dimly by the software "cowboys" as the coming of a sheriff to the old Wild West. But after

having a taste of civilization, these same cowboys found out that the law can help and protect you—that it brings about a common good. In fact, looking back, living in the Wild West had not been as great as the cowboys had once thought. The greatest part of the resistance to process improvement was eventually overcome, and a CMM Level 5 rating was recently achieved largely because of the unwavering commitment of division management to improve the quality of our products and services. SQA was an important tool that management used to continuously measure what we were doing right and wrong and where we stood with respect to our goals to improve as a function of time. It also helped to bring areas that were problems to the attention of all management levels so that attention was kept on them long enough to ensure their correction.

## SQA Defined

According to the CMM, the purpose of SQA is "to provide management with appropriate visibility into the process being used by the software project and of the products being built." [1] Thus, the use of the word "visibility" implies that the SQA group is meant to be the eyes of management on what is going on in the organization. This visibility is not meant to punish perceived offenders but rather to give management data to help them to make bigger-picture decisions and corrections in the organization.

As you read articles on SQA, you will find that most people use the term differently from how the CMM defines it. The CMM defines SQA as "reviewing and auditing products and activities to verify that they comply with procedures

and standards. ..." [1] *Software products* are "the complete set, or any of the individual items of the set, of computer programs, procedures, and associated documentation and data designated for delivery to a customer or end user." [2] Meanwhile, *activities* are "any steps taken or functions performed, both mental and physical, toward achieving some objective. Activities include all of the work the managers and technical staff do to perform the tasks of the project and organization." [3] Activities are the things the process says we will do to complete a project and deliver a product to the customer. So, auditing activities is auditing the process and the adherence to the process by the project. The CMM's definition of SQA is a bit narrower than common usage, which includes testing and peer reviews. Because of this, there is almost always some confusion when using the term. The CMM also accounts for testing and peer reviews, but in different places. Peer reviews are given a separate key process area (KPA), and testing is addressed by the software product engineering KPA.

The reason the KPAs are organized this way is probably because of Total Quality Management (TQM) principles, which are the roots of the CMM. As you may recall (if you experienced TQM training in your organization), one of the principles of TQM is that everyone is responsible for quality. Quality is not something you put in after you build the product but is rather a result of the way it is produced. Consequently, it makes more sense in that context for testing and peer reviews to be considered part of the engineering function as opposed to the SQA function. This way of thinking

also fit the perspective of TIS because the Air Force had encouraged the adoption of TQM principles before the CMM emerged on the scene.

The key point here is that SQA is defined as auditing two things: products and process. This was important for us because it influenced the way TIS chose to implement SQA.

## Product Quality

When the CMM was adopted as the model TIS would use for process improvement, we already had a group in place that was doing many of the things that fall under product quality auditing. The configuration management (CM) group in the division had for some time been performing tasks such as reviewing software products for compliance with format and ensuring that documentation was in order for the design, testing, reviews, acceptance, and configuration of software products. As time has passed, the role of the CM group has expanded in some cases (as the projects have requested it), giving them something like a watchdog role to ensure that activities are performed before a process block can be exited. As an example, in some projects, the CM person schedules and attends peer reviews, takes minutes, and ensures that all issues are resolved before the process proceeds from that point. The group also verifies that activities are properly completed before projects pass from one process block to another. In some software maintenance projects, the CM person takes a highly active role in attending and witnessing acceptance tests held with the customer. The CM person assures that the tests are held, that tests are performed within the bounds of the established ground rules, that the tests are documented, and that all of the paperwork is properly filled out, correct, and signed off by both parties. All these activities assure quality in the software products.

The CM group is independent from the projects in the management chain to avoid conflicts of interest. CM employees can raise issues of noncompliance as high in the management chain as is necessary to resolve issues that arise.

## Process Quality

One of the premises upon which the CMM is based is that “the quality of a software system is highly influenced by the quality of the process used to develop and maintain it.” [4] Ensuring the quality of the processes in TIS is the job of the Quality Engineering Support Team (QuEST).

QuEST works directly for the TIS division chief. This is important because it creates independence from the projects and their management. Independence is as important in process QA as it is in product QA to avoid conflict of interest. Second, it gives QuEST members the authority needed to perform audits with minimum difficulty. Although many practitioners are sold on following the process and require no prodding, some need to have a reminder to keep focused on doing things in the established way. Without the authority of upper management, it would be easy for project personnel (who are so inclined) to be uncooperative or to not take audits or the results seriously. Enough practitioners would probably be overcome by the irresistible temptation to head back to the Wild West that the process would be inconsistently followed, and the organization would lose its process improvement momentum or perhaps even turn backward.

The QuEST group has historically varied from two to four people. They are software engineers who are selected from projects in the division and are selected to balance the experience on the team between the product lines that are represented in the division. Service in QuEST is voluntary. Management only considers candidates for these positions who have demonstrated a high level of competence in projects where they have worked. Additionally, personnel are rotated so that the term of service is between 18 and 30 months. These are basically the same requirements and ground rules for individuals chosen to serve in the Software Engineering Process Group (SEPG), with whom QuEST works closely. In some cases, positions in the SEPG are filled with employees who have experience in QuEST.

There are some good reasons behind the selection and length-of-service guidelines for QuEST. First, balancing the experience helps the team to have a broader point of view when reviewing projects. Since a QuEST member performing an audit may not have worked in and be familiar with the process specifics of a particular product line, it is helpful to have someone with more experience in that area on the team. Second, for the team to have credibility with projects teams they review, it is important that they have the respect of the team members. Having employees on the QuEST team who have a good reputation as a practitioner also gives the audit process more credibility. Third, the rotation of employees through QuEST (and the SEPG) was calculated as a way to produce employees who are highly trained in process improvement and have an intimate knowledge of projects and their processes throughout the division. When they have finished their rotation, they return to a project where they can be a highly valuable resource, and it is hoped, a champion for process improvement. These individuals also can help projects to improve their processes by sharing information and experience gained from seeing how others in the division and others in industry do things.

## Managing QA

One of the things we believe has contributed to the success of the QuEST group is the decision to manage the group and its activities as a project. Back in the early days, when the division was struggling to implement things such as documented processes, peer reviews, etc., QuEST was often asked if we were practicing what we preached. It turned out that we usually were not. Consequently, it was difficult for QuEST to explain how to do a required activity or to give suggestions when we had not done them ourselves. Changes were made in that area, and now QuEST operates using Level 5 principles tailored somewhat for what we are doing. Some examples follow:

- **Requirements Management** – Determining through discussions with

division and branch managers which software projects and support groups should be audited during the upcoming cycle.

- **Documented Plans and Processes** – Written plans that describe how QuEST will perform all required activities, and processes and work breakdown structures that describe the sequence of events as process blocks and the corresponding entry and exit criteria for each, along with the required tasks and methods used to internally verify that the tasks and exit criteria are satisfied.
- **Schedules** – A schedule is created for a QuEST audit cycle as well as for activities performed between them. Progress is tracked as time goes on, and metrics are kept on schedule variance.
- **Training** – Training plans for QuEST are created, tracked, and signed off as the elements are completed.
- **Peer Reviews** – Held to review audit report findings, recommendations, and statistics. Defects found are tabulated and tracked by process block.
- **Intergroup Coordination** – Done with the SEPG, CM, etc.
- **Quality Assurance** – QuEST is audited by the SEPG to verify compliance with policy, plans, and processes.
- **Project Tracking and Oversight** – Regular coordination meetings are held in the QuEST group with all members present. Also, management reviews are held every two weeks with the division chief, where the QuEST schedule, issues, metrics and their trends, action items, goals, etc., are reviewed and discussed.
- **Quality Process Management and Product Quality Management** – Quantitative baselines are established for effort, schedule, and quality. Current performance is calculated and tracked, with corrective actions taken as thresholds are exceeded.
- **Defect Prevention and Process Change Management** – At the end of each audit cycle, QuEST reviews lessons learned, audit question score

averages, customer satisfaction survey statistics, and project metrics to see if our plans, procedures, or questions asked need to be revised. Common root causes are sought for problems that are identified. Changes are made as required.

Now, when somebody asks us, maybe a little sarcastically, if QuEST does all of these things that we look for in our audits, we can honestly say, “Yes.” Then, they wish they had not asked as we explain (probably in more detail than they want) how the team operates. We take pride in the way we do business.

### QuEST Audits

As the CMM requires, TIS has organizational-level documents that are the boundaries within which software projects must operate. Following is a brief synopsis of these documents.

- *TIS Strategic Plan* – Documents vision, mission, and values of the organization as well as goals and objectives and an action plan to achieve them.
- *TIS Policy for Engineering Development and Support Project Management* – The governing policy for project execution and the management of projects. Defines roles, responsibilities, and requirements in the division in order to meet the objectives of each KPA in the CMM. The purpose of the TIS policy is to help the division execute the Strategic Plan.
- *TIS Standard Engineering Process* – General process that the TIS policy requires to be used as the framework from which to build the process for a project.
- *TIS Metrics Implementation Guide* – Designated by the TIS policy as the document that contains the standard formulas to be used for metrics, which are kept and reported to upper management. This helps to maintain consistency of metrics across the organization and thus makes quantitative management easier.

QuEST audits software projects and support functions in the division to verify that they meet the requirements of

the TIS policy. The process to execute audits has the following steps.

- **In-Briefing (if required)** – Explain to new projects the audit process, why we are doing it, and what to expect.
- **Preparation** – Review past audit reports.
- **Project Managers Interview** – Get responses to questions (approximately 100) on standardized questionnaire. Get visual proof of items where possible (see Figure 1).
- **Initial Report Write-Up** – Make rough draft of report.
- **Verify Practitioner Interviews** – Verify that practitioners’ views agree with project managers’ views. Answer their questions about why policy requires certain things. Ask in confidence about their concerns, problems, etc., they wish to share with the division.
- **Draft Report Write-Up** – Finish draft of report and give quantitative scores on questions. Roll these up to scores by KPA, by CMM level, and overall.
- **Peer Review** – QuEST and SEPG review findings, debate them, and make changes as necessary by consensus.
- **Review with Project Manager** – Draft report is sent to the project manager who has five days to bring up and resolve issues with QuEST.
- **Out-Briefing** – Results of the audit are briefed to project employees and management.
- **Send Report** – The final report is sent to the project manager and other management.
- **Action Plan** – An action plan is submitted to QuEST within 30 days after the out-briefing. QuEST reviews the action plan to verify it resolves issues brought up in the report. If it does not, issues are resolved by management at the lowest level possible but the highest necessary.

### Results of QuEST Audits

TIS has found the results of QuEST audits to be extremely useful to measure where we stand as an organization, as well as where projects stand, in relation-

ship to the KPAs and CMM levels. It is true that some perspective is needed by the organization to avoid the trap of getting a CMM level rating. The goal should be to improve. But there are some good reasons to measure this way. One is that the CBA-IPI is set up as all or nothing with respect to its levels. This is, in a way, unfortunate because it does not tell you quantitatively how close or how far you are from compliance with the KPAs required for each level. Another problem is that such assessments are often done for the whole organization; therefore, the findings can be at too high a level to provide a basis for a detailed project action plan. So, issues that pertain to only one project may not make it to the assessment findings.

The other consideration is the substantial expense associated with CBA-IPIs. When planning for these formal assessments, it is a great bonus to know with some certainty where you stand. It would be disappointing to the organization to fail to achieve a certain level because of minor areas of noncompliance—especially when these issues could have been discovered and corrected before the money was spent.

For these reasons, QuEST uses a measurement method to quantify TIS policy compliance and hence CMM compliance. Questions on the question-

naire are scored on a 0-3 scale, where the scores represent different levels of compliance. The scoring correlates with possible answers as follows: No evidence of compliance or evidence of noncompliance = 0, some evidence of compliance or occasional compliance = 1, mostly satisfied (some evidence of noncompliance) = 2, and institutionalized compliance to policy = 3. A percentage of compliance is then calculated for each KPA, for each CMM level, and for overall compliance to TIS policy. Using these measurements, we can calculate where a project stands. A roll-up of the measurements from projects is used to measure where a product line and where the organization as a whole is, in terms of compliance. Because we have been doing this for several years, we can also show the trends for these measurements historically (see Figure 2).

These types of measurements have helped management in our organization manage process improvement efforts better because we know where to focus our SPI efforts.

In preparation for the July 1998 CBA-IPI, we had a great deal of data from prior QuEST reviews. We also participated in a mini- or Snapshot CBA-IPI with the SEPG and some employees from the Software Technology Support Center (STSC), where a report

of strengths and weaknesses for each KPA was produced. When all was said and done, we found that the results of our QuEST audits, the miniassessment, and the CBA-IPI were consistent. In many ways, the QuEST data is better because these audits are more detailed than formal assessments, the measurements are taken more often, they cost less (because the organization must do SQA anyway), and they are much more quantitative than CBA-IPI results. This experience has given the organization an increased measure of confidence in the data produced by QuEST audits.

Another benefit that results from QuEST audits is the flow of information from practitioners up to the top of the management chain. Confidentiality is important for QuEST in order to create an atmosphere of nonretribution. But information about the concerns, gripes, praise, or suggestions of practitioners in general is often heard in the course of interviews. Practitioners' concerns are expressed to management in general terms to give them a feel for what is going on in the division.

Additionally, QuEST audit reports are not merely scores on questions. They detail why the project received the score, what verification was seen, and most important, what QuEST recommends they do to comply with the policy re-

Figure 1. Examples of questions from the questionnaire.

Project Planning		
Question	Answer	Rating
1. Are project commitments, i.e., plans, bids, quotes, and schedules approved by the appropriate branch chief? (A3.1.3) (LEVEL II)	Yes	3
2. Are workload estimate schedules derived from the WBS? (A3.1.4.) (LEVEL II)	Yes	3
3. Is a complete WBS prepared and consistent with the project's process? (A3.1.5.) (LEVEL II)	Yes, the WBS is documented on the SCF form.	3
4. Are cost-estimating procedures, assumptions, and parameters documented and stored for historical review? (A3.1.8.) (LEVEL II)	Yes, historical data is located in the SCF folders, which are online. The procedure is located in the MDPSEP beginning at Section 4.3.1.3, "Create an SCF Audit Form." Visually verified.	3
5. Have the required planning activities been performed, and have the plans been documented (Process, Schedule, Requirements, Acceptance Criteria, WBS, Quality, CM, Risk Analysis)? (A3.1.9.) (LEVEL II)	Yes, all information is located in the MDPSEP, MIP database, TIS data forms, MIP data spreadsheet, and SCF folders. Visually verified.	3

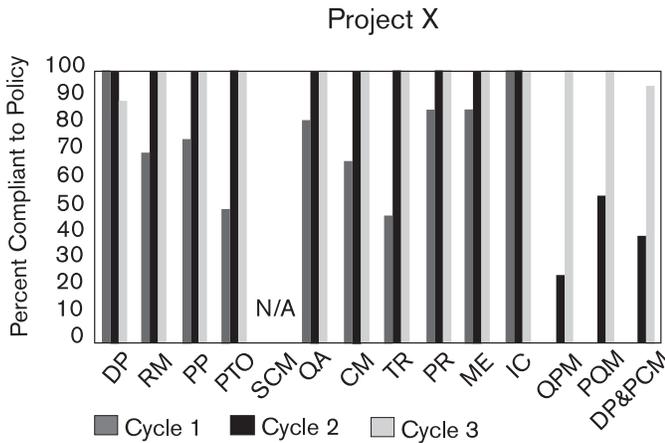


Figure 2. Example of how to track project compliance to organizational policy over time. The KPAs listed on the X-axis are a slight modification of those in the CMM. QuEST combines some CMM KPAs into one. The percentages in the figure are examples. Subcontract management (SCM) does not apply to most projects in TIS.

quirements. These recommendations often explain why the project needs to do certain things and why they are important. When projects are struggling in a specific area, suggestions are made to look at ways other particular groups are successfully implementing the activity in question. We believe it is important to be as helpful to the project as possible rather than merely be process police. When you are helpful to a project rather than a critic, it makes the job of SQA a lot easier. People are more receptive if they believe your recommendations are well thought out and are relative to their specific project.

## Dealing with Resistance

As previously mentioned, the resistance to process improvement in our division was significant in the beginning of our CMM efforts. But the resistance has largely been overcome, because we now have a different culture—the way of doing business has changed, and part of that way of doing business is the acceptance of the idea that changing, to improve, is a virtue. Still, there are always some people who will only be comfortable with the status quo. Others accept the idea of change but still feel uncomfortable when they are going through it. Being Level 5 does not mean standing still, so there is always going to be some degree of resistance and discomfort. Change can be hard.

QuEST members earnestly try to adhere to the following strategies to minimize the effects of resistance.

- Do not take it personally. SQA people are magnets for jokes and high jinks, so have a sense of humor about it.
- Listen. Practitioners and project managers have lots of experience and knowledge.

- It is better to get a negative reaction than indifference. If someone has a negative attitude in an SQA audit, it may just be that they have not been sold on an idea yet. This is often an opportunity to show that person the bigger picture, which perhaps they have not seen or understood.
- Some people will never accept the idea of process improvement, so just deal with that reality.
- SQA's job is to measure, help, and encourage—not to expose and punish.

## Is Level 5 Perfection?

So you might wonder if being in a Level 5 organization is the software development Utopia that some might imagine. I think it is safe to say that no one in TIS believes that our processes or our implementation of the CMM is perfect. There are many things that we believe should still be modified and improved. But the CMM does not say that a Level 5 organization is perfect. It merely means that you are doing the right things in the effort to be as good as possible at providing your customer with a quality product at the right time at the right price. SQA has proven to be a highly valuable tool in our organization for ensuring that we are striving to meet these goals. As for Utopia, I will know that we are there when the heating and air conditioning always work properly in my office. ♦

## About the Author



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