

Assessing a Level 5 Organization

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This article describes the assessment of the Ogden Air Logistics Center (ALC) Software Engineering Division (TIS) that resulted in a Capability Maturity Model (CMM) Level 5 rating. It also discusses the issues in preparing for the assessment and reviewing the processes of TIS from both an internal (Putman) and external (Paulk) assessor's viewpoint: concerns going into the assessment and how they were resolved, alternate implementations that were discussed by the assessment team and how the Software CMM practices were judged to be satisfied, and controversial issues that sparked discussion in the assessment team and how a consensus was reached on their resolution. Specific issues include separating process and product assurance responsibilities, stability of continually improving processes and the related data, satisfactory evidence of institutionalization, and adequate implementation of Quantitative Process Management. The article concludes with a description of the challenges that TIS overcame and some of its strengths that may be of use to maturing organizations.

TIS has been actively engaged in process improvement using the Capability Maturity Model® for software (software CMM®) since the early 1990s and was assessed at Level 3 in 1995.

An assessment was performed in 1998 using the CMM-Based Appraisal for Internal Process Improvement (CBA-IPI) method [1]. It resulted in a Level 5 rating for TIS, the highest that can be achieved for the software CMM. The assessment covered all the software development and maintenance activities within the division. The diversity of the software efforts within the division range from well over 100 employees who support a single operational flight program (OFP) update to one-person efforts to support automated test equipment (ATE) test programs. The goals for this assessment were to

- Measure software process improvement progress made since the 1995 assessment.
- Provide a maturity level rating for TIS.
- Provide findings to a level of detail sufficient to enable TIS to refocus the process improvement efforts division-wide and to identify improvement candidates unique to TIS product lines.

The purpose of this article is to discuss the issues involved in preparing for

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the assessment and coming to a team consensus on the TIS processes and how the issues address the key process areas (KPA) in the software CMM.

Preparing for the Assessment

The assessment team consisted of nine people, five of whom were external to TIS (three from the Software Engineering Institute [SEI] and two from Warner Robins Air Logistics Center) and led by Mark Paulk and Brian Larman. Six of the team members were SEI-authorized lead assessors. Before making the assessment, the team went through a refresher on the CBA IPI method plus a tutorial on Level 4 and Level 5 to ensure a common understanding and perspective on the high-maturity KPAs and the assessment method.

The appraisal covered all KPAs of the software CMM with the exception of software subcontract management, which was defined as "not applicable" by TIS. Prior assessments had only covered the Level 2 and Level 3 KPAs and had taken two weeks to complete. In these prior assessments, the team members often began work at 8 a.m. and occasionally worked past midnight. The scope of this assessment added Level 4 and Level 5 KPAs, and the assessment period was shortened by one day because TIS has a 5-4-9 work schedule (work nine days in two weeks and have every other Friday off). To increase the assessment scope while shortening the on-site

period presented a risk, but a high-maturity organization possesses extensive data and can be expected to demonstrate the capability and effectiveness of its processes fairly quickly, so the risk was judged manageable.

The sponsor requested that although TIS be designated as the organization for which the rating was to be awarded, unique findings were to be provided to each of two product lines. One of TIS's stated objectives for the assessment was that the assessment team identify areas in which TIS could improve. As a result, TIS wanted to be sure it could apply the recommendations from the assessment to the proper area. This meant that for each product line, separate observations were maintained for those areas that could potentially compromise the CBA-IPI attribution and confidentiality rules. Four focus projects, two from each product line, were selected as representative samples of the projects within the division. There was some concern that selecting only two focus projects from each product line would limit the assessment team's ability to get complete data and cause difficulty in obtaining adequate corroboration. To address these concerns,

- The team interviewed nine project leaders in group interviews—usually referred to as functional area representative (FAR) sessions—in addition to the individual project leader interviews for the focus projects.

- The team interviewed 25 practitioners in various practitioner interviews. The practitioners were selected to provide representation from all the projects within the organization.
- Assessment participants (interviewees) were informed of the potential for product-line-specific findings in the opening briefing.

Prior to the assessment, 51 CMM questionnaires were completed by employees across TIS and analyzed by the assessment team. For the assessors, the primary value of these questionnaires was in the comments from the respondents that identified specific processes and documents that the respondents interpreted as addressing the question areas.

Concerns About the Assessment – An External Perspective

From an external perspective, there were three primary concerns:

- Management sponsorship for true improvement, as opposed to obtaining a score.
- Potential conflict of interest for the TIS team members who were in the Software Engineering Process Group (SEPG).
- The definition of “organization.”

One of the hard-learned lessons for lead assessors is that sponsors must be truly motivated to achieve process improvement and create a “quality culture,” as opposed to achieving a high score regardless of true capability. One of the tools in the *Lead Assessor’s Guide* [2] is an assessment readiness survey. It was clear prior to the assessment that there was an expectation or desire that TIS would “score well.” In meetings prior to the assessment, the assessment team leaders probed this issue carefully with the sponsor. Our conclusion was that it did not appear to be a major problem, and as the assessment progressed, the evidence of a quality culture across TIS was convincing.

The assessment team included four people from within TIS: two from the SEPG, one from an extended SEPG, and one from the Software Technology Support Center. Since SEPG members are responsible for process improvement,

there is the potential for a conflict of interest when adverse findings arise. This concern was carefully monitored by the team leaders and never became a significant issue during the assessment. During the SEPG interviews, these four team members switched roles and acted as interviewees rather than assessment team members.

The last concern was over the definition of “organization.” Since TIS consisted of two product lines, with identifiably different organizational processes, it was possible that problems in one product line could limit the maturity level rating for the organization as a whole. Since findings were requested to be specific to product lines where appropriate, the consequences of a lower-than-desired level rating might be traced to a product line, which would lead to a potential confidentiality issue. One alternative was to rate the two product lines separately. This concern was discussed with the sponsor, and the decision was made to go with the division-level definition of organization, based on the argument that it was divisional process capability that was the concern of the sponsor.

Preparing for the Assessment – An Internal Perspective

One TIS goal in preparing for the assessment was to make the assessment as easy as possible, from both the assessor’s and the interviewee’s points of view. For the interviewee’s point-of-view, TIS was able to draw on personal experience from previous assessments. In order to address the assessor’s point of view, the TIS SEPG reviewed the documentation (reports, lessons learned, etc.) from previous assessments and requested input from prior SEPG members who were involved with the previous assessments. (SEPG members are assigned on a rotational basis. As a result, the SEPG members involved with the previous assessments had left the group.)

The TIS Quality Engineering Support Team (QuEST) provides process quality assurance with regard to the requirements identified in division-level policy. It was decided to perform a Snapshot assessment in addition to the nor-

mal QuEST activities because QuEST is not chartered to look for differences in interpretation between division-level policy and the CMM. This Snapshot was the first time that the organization’s practices relating to the Level 4 and Level 5 CMM issues were assessed from the interpretation of the CMM. This Snapshot assessment helped assure TIS that it was on the right track.

Since the focus of QuEST reviews and the Snapshot assessment were different, TIS required that the action plans for the Snapshot findings be separate from the action plans generated from the QuEST reviews. However, in order to manage the two action plans, the tasks identified in the two action plans were combined into one process improvement Gantt chart.

The SEPG took the approach that the assessment was not only an assessment of the maturity of the organization but also an assessment of how well the SEPG helped the projects prepare for the assessment. Six months before the assessment, the SEPG prepared a high-level Gantt chart that planned the remaining activities necessary to prepare for the assessment. These activities helped to reduce the anxiety and stress experienced by the organization as it went through the formal assessment. The activities also proved to be extremely beneficial in helping the assessment team adequately assess the organization’s maturity.

It has always been a requirement that TIS managers manage their process improvement efforts as a project. Following a QuEST audit (see “QuEST Audits,” page 13), each project is responsible for defining its process improvement activities in an action plan. The general format of TIS action plans is to respond to the QuEST findings with a proposed corrective action and a proposed completion date for each finding. The action plans can be lengthy for fledgling projects. Even a two- or three-page action plan for a mature project can be difficult to manage if the tasks are not properly planned. As a result, the projects convert their action plans into condensed Gantt charts.

In preparing for the assessment, the SEPG took the approach that the results

Tag	CMM Requirement	Organizational-Level Documents				
		OI 63-1	SP	MIG	SEP	QP
Ability 1	For each project, responsibility is established for analyzing the system requirements and allocating them to hardware, software, and other system components.	Paragraphs A2.2, A2.2.1-3			Paragraph 4.2.1-2	
Ability 1	A group that is responsible for coordinating and implementing SQA for the project, i.e., the SQA group, exists.	Paragraphs A6.2.4, A6.2.4.1-2			Paragraph 4.1	Paragraph 2.1.3
Commitment 1	The organization follows a written policy to measure and quantitatively control the performance of the project's defined software process.	Attachment 3, Attachment 4, A10.1.1, A10.1.1.1-2, Attachment 11	Chapter 2, Section 1.3.6.2, Chapter 3, Section 6.1.1.1	The overall TIS-MIG	Paragraph 5.2	Paragraphs 4.14, 4.20

Table 1. Mapping of TIS organizational-level processes to CMM practices. This same detail of mapping was performed using the product-line documents in place of the organizational-level documents.

of the assessment should not come as a surprise. To make sure there were no surprises, the first step was to develop a spreadsheet that mapped every goal, commitment, activity, etc., for each KPA to the corresponding paragraph in each of the documents, at the organization level and product lines. An abbreviated example of this mapping is shown in Table 1.

This activity provided TIS with four major benefits:

- A verification that a critical item had not been overlooked. In a few cases, the comment was heard, "We are doing the activity, but the wording in our process is vague." This exercise enabled TIS to improve the areas that were vague.
- The organization was comforted to know they had covered all of the issues.
- The mapping gave the interviewees confidence in their ability to easily find any reference necessary.
- The mapping helped the assessment team easily follow "the thread" from the CMM reference down through all of the organizational-level and product-line documents.

A potential problem with the implementation of this mapping was discovered: If not maintained properly, the spreadsheets quickly become outdated as changes are made to the processes. For example, the insertion of a paragraph in

the TIS policy could have a ripple effect on the paragraph numbers that followed in the policy. The benefits of mapping TIS documents to the CMM are considered worth the effort necessary to keep the mapping up-to-date.

TIS took the same approach to the assessment as a college student might take in preparing for an open-book oral examination in which the student is given the questions in advance. It was known that the assessment team would want to see examples of TIS activities. To ensure that the examples were readily available, the SEPG chose to have all the project leaders place their examples in three-ring binders with pre-labeled tab pages and check-sheets that corresponded to the KPAs in the CMM. The check-sheets were not exhaustive; they were meant to be used as an example of the type of documents that would demonstrate that the activity was being performed.

The project leaders were responsible for placing proper examples in the binders. In addition to the examples, the SEPG recommended that a reference be included on how the assessment team could get additional examples, such as indicating the point-of-contact and where the documents were located.

Many of the TIS processes have been automated, and all of the documentation is available on internal networks. As it turned out, the online systems are ex-

tremely beneficial for day-to-day TIS activities, but they quickly proved to be cumbersome for the assessment team. Tracing the process thread through the documents often required jumping back and forth between the documents. Using hard-copy printouts proved to be easier than tracing the thread online. As a result, the SEPG printed copies of all TIS processes, plans, procedures, etc., for each of the four miniteams.

The SEPG saw the TIS familiarity with the CMM as both an asset and a risk. Many of the day-to-day activities were no longer perceived as CMM issues. There also were concerns about the wording of the interview questions because TIS terminology is often different from terms used in the CMM. Table 2 contains a mapping of some of the TIS terms to the CMM-equivalent concept. Note that in some cases, multiple TIS terms map to a single CMM concept and vice versa. These relationships had to be understood by the assessment team and communicated to the assessment participants as needed.

During the Site Visit – Coming to Team Consensus

There is a difference between describing *what* must be done vs. describing *how* something must be done. The KPAs in the CMM were written to show what an organization should be doing; they often include examples that may help the

Acronym	TIS Term	CMM-Equivalent Concept
ATE	Automatic Test Equipment	Organization and Project
	Branch Chief	Senior Management
CBA-IPI	CMM-Based Appraisal for Internal Process Improvement	CMM-Based Appraisal for Internal Process Improvement
CM	Configuration Management	Software Configuration Management and Software Quality Assurance
CMM	Capability Maturity Model	Capability Maturity Model
	Division Chief	Senior Management
ECP	Engineering Change Proposal	
ESEPG	Extended Software Engineering Process Group	
FAR	Functional Area Representative	
GCAR	General Corrective Action Report	
KPA	Key Process Area	Key Process Area
MEP	Maintenance Engineering Process	Organization's Standard Software Process
MIG	Metrics Implementation Guide	
MIP	Material Improvement Project	
OCP	Organic Change Proposal	
ODG	OFP Development Guide	Organization's Standard Software Process
OJT	On-the-Job Training	
OFP	Operational Flight Program	Organization
OO-ALC	Ogden Air Logistics Center	Organization
PIPR	Process Improvement Peer Review	
PMR	Program Management Review	
PSP	Personal Software Process	
QuEST	Quality Engineering Support Team	Software Quality Assurance
ROM	Rough Order of Magnitude	Estimate
	Section Chief	Senior Management
SEP	Standard Engineering Process	Organization's Standard Software Process
SEPG	Software Engineering Process Group	
SPC	Statistical Process Control	
SQA	QuEST and CM	Software Quality Assurance
TIS	Technology and Industrial Support Directorate	Organization
TPM	Technical Program Manager	Project Manager and Project Software Manager

Table 2. Mapping TIS terms to CMM concepts.

organization meet the goals of a stated objective. The organization is responsible for determining how to design their processes to fulfill the stated objectives. Pat Cosgriff's article, "The Right Things for the Right Reasons" on page 16, describes how TIS learned to fully understand the underlying concepts and intent of each KPA. By understanding the concepts and intent, TIS was able to implement processes that met both the needs of the organization and the requirements of the CMM.

Four miniteams of two people each were assigned the primary responsibility for investigating each of the KPAs. Although each KPA had its miniteam, all team members participated in the interviews with the branch chiefs, section chiefs, technical program managers (TPMs), and FARs, and all assessment observations and conclusions were obtained by consensus of the entire team.

The appraisal team interviewed TPMs in individual sessions for each of the four focus projects as well as in a FAR session with TPMs from several other projects within TIS. In addition, a broad sampling of employees from across the organization at all levels—from managers through practitioners, plus members of the SEPG and QuEST—were also interviewed. In all, the assessment team interviewed 67 people during the two-week site visit.

From the interviews, document reviews, and questionnaire data, the team crafted 477 observations about the TIS processes. The following sections will present some specifics of the assessment and address some of the assessment teams findings and recommendations.

Software Project Planning

In TIS, project team members assist the TPMs in developing estimates for the project across both product lines. These estimates are documented in a variety of artifacts. As the tasking matures, the estimates are refined and documented in approved project directives, schedules, requirements documents, etc., in accordance with the project's defined software process. The project's defined process is documented in the OFP development guide (ODG) for the OFP product line

or in the maintenance engineering process (MEP) for the ATE product line.

Project plans were distributed across several documents; the ODG and MEP did not explicitly describe the components of the project plan. The assessment team, with some difficulty, located the areas in which the project plan criteria, as identified in CMM, Version 1.1, were satisfied. A new program manager could have difficulty following and understanding the project planning process. To address this potential deficiency, the assessment team agreed that although the plan criteria were in place, it would be desirable to add an introductory paragraph before the product-line processes that describes the various components of the plan and how project planning is accomplished.

The TPMs establish interdisciplinary project teams at the beginning of the project to plan intergroup activities. These project teams meet periodically to track and resolve intergroup issues.

The assessment team had no difficulty agreeing that the product-line processes in the ODG and MEP were consistently used by projects across TIS. It also was apparent that TPMs used extensive product-line data in planning and establishing thresholds to trigger corrective action.

Product and Process Software Quality Assurance

Software quality assurance (SQA) activities are divided between QuEST and configuration management (CM); QuEST ensures process quality, and CM ensures product quality. QuEST focuses on ensuring compliance to division policy and product-line processes and procedures. The CM staff ensures compliance of work products to style guides, templates, and standards. The assessment team identified this as an alternate practice to the traditional independent SQA group responsible for both process and product assurance but agreed that this satisfied the "objective verification" goals for SQA. As seems characteristic of most high-maturity organizations, a significant portion of the SQA function is embedded in the process [3].

The assessment team observed that project members value the discipline provided by the CM group and the recommendations and training provided by QuEST. The implementation of this CMM alternate practice has worked particularly well for TIS. The alternate practice of dividing SQA between CM and QuEST has allowed QuEST to focus on measuring and reporting status on software engineering practices as well as providing informal training to all levels of TIS.

Organizational Process Focus – Process Definition and Improvement

When TIS began its process improvement efforts, it developed many individual processes. As the organization matured, it slowly embraced the concept of (or recognized the existence of) two main software product lines within the division: OFP and ATE. (See "Product Lines," page 17.) Over time, the numerous individual processes were divided into one of the two main product-line processes, the ODG and MEP.

TIS has a high-level standard engineering process (SEP) from which the product-line processes are tailored. The SEP provides a framework to embrace the strengths and diversity of each product line, and the associated product-line process documents reflect the product-line view of the SEP. The assessment team was easily able to trace from TIS policy through the SEP to the product-line process documentation.

The assessment team quickly identified the product-line processes as one of the strengths of TIS. The environment and terminology of these two product lines differ greatly. TIS has captured a great deal of product and process expertise in the ODG and MEP. The benefits that TIS has experienced as a result of adopting the product-line processes are a reduction in the cost to maintain the processes, and CMM activities have become more common across the product lines.

The TIS Metrics Implementation Guide (MIG) defines cost, schedule, and quality measures to be collected across

TIS. This is particularly important for defining operational definitions of TIS measures that are consistent and comparable across the division. Operational use of the MIG data, however, is within a product line, and some measures are defined differently for different product lines. For example, the term "size" has a different meaning in each product line. The OFP product line produces major capability upgrades, whereas the ATE product line produces numerous and frequent upgrades. To measure the number of source lines of code works well in the OFP product line. Throughput, or the number of products produced, provides a better "size" estimate in the ATE product line. Cost, schedule, and quality data are tracked to the process block. This level of granularity is crucial to analyzing process performance and determining process capability accurately.

The assessment team had no difficulty agreeing that people across TIS understand and are committed to the stable processes achieved through implementation and institutionalization of the CMM. The team observed the use of detailed procedures, templates, and checklists on all projects in a culture where process discipline and process improvement are considered integral to success.

Process improvement activities are managed like a project and briefed monthly at program management reviews. Extended SEPGs (ESEPGs), (see page 18), work closely with the SEPG to identify strengths and weaknesses in the processes. Anyone in the organization can submit process improvement recommendations via an automated submission process, which is also used to track technology change proposals.

Process improvements are planned following each formal assessment and QuEST audit. The assessment team observed a strong quality and process culture that has been instilled across TIS.

Training Issues

TIS has sophisticated and powerful processes, yet there is little "formal" training specific to the TIS ODG and MEP processes. TIS has established a

mentoring program, with well-defined criteria, as a form of training new employees. TIS training is planned and tracked through a training matrix, a project skills document, and individual development plans. Some formal training takes place, for example, process training by the SEPG, but most training is informal and on the job.

Training was extensively discussed by the assessment team. This implementation was a conscious decision by the TIS Training Board, which is responsible to oversee the training requirements for the division. It was clear that there had been few problems from reliance on mentoring and on-the-job training, and the stability of the TIS work force was a significant factor in this success. At the same time, however, TIS was actively working to expand its workload and customer base. A significant influx of new employees could put the stability of the TIS processes at risk. This risk was, however, one that TIS had considered and has deliberately chosen to accept. The assessment team concluded that the training program KPA had been adequately addressed.

Quantitative Process Management – Managing the Process and the Product

The toughest decision for the assessment team regarded the satisfaction of the quantitative process management KPA. Although the use of data and management by fact were thoroughly embedded in the TIS processes and culture, there also were incorrect applications of statistical techniques.

TIS frequently used “control charts,” but the “control limits” were not always calculated according to control charting principles. In some cases, the control limits were thresholds set by management.

Some control charts used standard deviation as an estimator for sigma, which is a common mistake. Control limits for some processes were extremely wide—too wide to provide value.

The assessment team discussed these concerns in depth. The consensus was that although there were some mistakes in the analytical techniques used to

control some processes, the general culture of measurement-driven decision making was good, and the analyses, both good and bad, were comparable to those of other Level 4 and Level 5 organizations. Few, if any, software organizations have truly mastered statistical process and quality control when initially assessed at Level 4 or Level 5. The journey of continual process improvement addresses these types of problems, and the issues were reported in the findings.

Another challenge for TIS and the assessment team is the validity of process data when the processes are being continually improved. Many process changes occurred during the months prior to the assessment, which affected the reliability of the process data to predict and control the process. Capability baselines for OFP and ATE were established using 12-month averages for closed projects, but four-month averages were also charted to allow for process changes (plus other analyses to confirm data validity). The assessment team agreed that TIS had recognized this risk and was managing it effectively.

Quality goals for projects are based on product-line history and revised quarterly, although projects keep their initial goals from project initiation. Software quality performance is reviewed by the project teams, ESEPGs, and management. The assessment team observed that the goal of releasing fewer defects to the customer was being achieved. The assessment team concluded that the project results reflected the high process capability observed.

Non-CMM Observations

The assessment team concluded that TIS is composed of professionals who are highly motivated, greatly experienced and knowledgeable, proud of the significance of the work they perform, cooperative in their team work, and focused on product quality and continual improvement. TIS’s quality culture is thoroughly established.

There were a number of business issues concerning adding work and expanding the customer base, and TIS management was actively working on these issues. The team reported on these

concerns, which had been repeatedly expressed by the assessment participants, but they were ultimately outside the scope of the software process improvement effort.

After the Assessment

The assessment team documented its findings and recommendations in a final findings report. The TIS staff and managers were delighted to hear that they had achieved Level 5, but the challenge of continual process improvement remains. Even a Level 5 organization must pro-actively deal with the stresses of a dynamic business environment.

Achieving Level 5 is not the end of the journey. Following the assessment, TIS immediately began to plan for the future, which included the following issues.

- Planning the next QuEST process quality review cycle.
- Updating the organization’s strategic plan to address the recommendations from the assessment team.
- Planning for an off-site meeting of the Executive Board to thoroughly review the strategic plan and update the organization’s long-term goals and objectives.
- Evaluating the Capability Maturity Model–Integrated Software/System Engineering (CMMI SW-SE) and addressing the possibility of piloting the CMMI SW-SE at an enterprise-wide level of implementation.

Conclusion

The preparations for the assessment were worth the effort. The SEPG believes that it achieved its goal of making the assessment as easy as possible, from both the assessor’s and the interviewee’s points of view. To assess a Level 5 organization is much easier than assessing a Level 1 organization, because the data to demonstrate a process and its effectiveness are readily available and easily understood.

The organization achieved its goals of achieving the Level 5 maturity, re-establishing a baseline of its capability, and of identifying areas on which TIS can focus while continuing its journey of continual process improvement.

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Additional Reading

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USDA's National Finance Center Receives CMM Level 2 Rating

The National Finance Center (NFC), an agency of the U.S. Department of Agriculture, completed its external assessment Sept. 18, 1998 and received a Software Engineering Institute Capability Maturity Model (CMM) Level 2 rating. NFC's efforts, under the direction of John Ortego, place the center among the top 30 percent of all

federal organizations assessed under the CMM since 1986. NFC also received the *Government Computer News Award* in March 1999 for its CMM efforts. Look for an article in the June 1999 issue of *CROSSTALK* that describes NFC's 10-month journey to Level 2, their challenges and successes, and the help they enlisted from the Software Technology Support Center.