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CMM Level 3: How Do I Get There from Here?

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Setting the Stage

You have heard or personally determined that your organization will adopt the Capability Maturity Model for Software v1.1 ® (CMM ®). Perhaps this year's bonus is tied to CMM progress or your customer has announced that all bidders for a key job must demonstrate CMM Level 3. When you say "I'll do it!" what does that mean? How do you get started? How can you make it more likely that your effort will succeed? How can you and your company expect to benefit? How do you identify where your organization fits on the road to process maturity and how do you proceed effectively to meet your goal in the time allotted? This paper should assist you in better understanding the answers to these questions and to envisioning those most applicable to your situation. Some Litton PRC resources are also listed.

Background

The CMM and Level 3 The CMM ® was created by the Software Engineering Institute (SEI), with the collaboration of many individuals from industry, government, and academia. The SEI is a Federally Funded Research Center within Carnegie Melon University in Pittsburgh, PA. (Paulk 1) The CMM was developed in a series of versions and has always been associated with related appraisals of organizations; the CMM's predecessor was a questionnaire in 1987. It has matured through several revisions to its present day CMM v1.1 with a related standard for appraisals (CMM Appraisal Framework) and two SEI methodologies for appraisal (CMM Based Appraisal for Internal Process Improvement (CBA IPI) and Software Capability Evaluation (SCE) v 3.0). (Byrnes 1) In addition to the CBA IPI and SCE methods, numerous other appraisal methods exist to fill various niches.

The CMM is a model that provides a structure for characterizing and describing elements of process maturity in the context of an organization that performs software development. This structure can be used by multiple organizations to determine where they are in terms of "process maturity." In addition, it provides a set of practices for organizations to incorporate in order to diagnose or increase

their process maturity. A commonly used quote is “All models are wrong, some models are useful."[1] The CMM is being used successfully by an increasing number of companies and government organizations as a blue print for process maturity measurement and process improvement planning. The CMM is documented as a pair of technical reports available free on-line from the SEI (see CMU/SEI-93-TR-24 and CMU/SEI-93-TR-25 [Paulk 1 and Paulk 2]). The technical reports have also been packaged with some additional material in a single book, The Capability Maturity Model: Guidelines for Improving the Software Process, available from Addison and Wesley (Paulk 3).

The SEI has also released a “next generation” model, the Integrated CMM (CMMI), which covers both systems engineering and software engineering. The CMMI is on SEI’s web site. The approach described in this paper for model compliance applies to either the CMM or the CMMI. This paper focuses on the CMM as many companies and acquisitions continue to use it as a benchmark for process improvement, and because attempting to cover both models might cause more confusion than clarification.

The CMM is made up of 5 Levels, that characterize process maturity, ranging from Level 1, Initial (ad hoc) to Level 5, Optimizing. These are shown in Figure 1 below along with the key process areas (KPAs) associated with each level. The levels are meant to help prioritize progress from an ad hoc initial state to higher levels of process maturity.

CMM Level	Focus	Key Process Areas
1 Initial	Competent people and heroics	None
2 Repeatable	Project management processes	Requirements management Software project planning Software project tracking and oversight Software subcontract management Software quality assurance Software configuration management
3 Defined	Engineering and organizational support	Organization process focus Organization process definition Training program Integrated software management Software product engineering Intergroup coordination Peer reviews
4 Managed	Product and quality	Quantitative process management Software quality management
5 Optimizing	Continuous process improvement	Defect prevention Technology change management Process change management

Figure 1. CMM Levels and Key Process Areas[2]

[1] Attributed to George Box. (p. 13 Paulk 3)
[2] Based on Figure from Herbsleb 2

Each KPA has 2-4 goals that express its intent. Each KPA is made up of a set of statements, called key practices; many key practices include additional detail at a lower level to assist in interpretation. The CMM organizes key practices within each KPA by "common features." The common features are: commitments (e.g., policies), abilities (e.g., a responsible group, training, resources), activities (e.g., establishing plans and procedures, performing the work, tracking it, and taking corrective actions), measurement and analysis (typically measurements of status related to the process), and verification (e.g., senior management review, management review, quality assurance review). (Paulk 3)

Many CMM-related articles and books have been written concerning the CMM and its use in process improvement. Though many of these are valuable, perhaps the quickest and surest way to develop one's own CMM expertise is to attend a CMM class and to obtain and simply read a copy of the CMM (either the two technical reports or the book version). The CMM provides excellent guidance assisting in its own interpretation (e.g., the "Interpreting the CMM" section), as well as definitions, explanatory graphics, a glossary, an overview, and other helpful material. Reading through the CMM itself allows the reader to have fewer filters in place than when additional authors are in the communication loop. Reading not only the Key Practices of the CMM but also the CMM interpretive material allows one to become knowledgeable fairly quickly. At this point, finding one or more mentors or reading CMM related literature to answer questions can help remove any remaining misconceptions. Additional reading of CMM sections when approaching particular related activities is also an effective way to increase understanding and to gain confidence that the material is useful.

Benefits of CMM Level 3

Several excellent articles and presentations have been developed on the benefits of process improvement and increasing process maturity. Two examples are the following technical reports available on-line from the SEI: CMU/SEI-94-TR-13, Benefits of CMM Based Process Improvement: Initial Results, by Herbsleb et al., and CMU/SEI-95-TR-008, Moving on Up: Data and Experience Doing CMM Based Process Improvement, by Hayes and Zubrow (Herbsleb 2 and Hayes 1).

Since the mid-1990s, PRC has documented successful achievement of CMM Level 3 based on multiple internal and acquisition related SCEs. As of March 2000, Litton PRC has documented its achievement of CMM Level 5, joining fewer than 25 other companies who make the same public claim.[3] Litton PRC has experienced a strong business case to continue to maintain and broaden its high maturity practices; since most companies and acquisition groups target CMM Level 3, the benefits listed below are a sampling of those actually experienced by

[3] Source: SEI web site http://www.sei.cmu.edu/sema/pub_ml.html

one or more projects or corporate groups. The ordering of these qualitative statements reflects an aggregate ranking based on manager responses[4].

Litton PRC Benefits Traceable to CMM Level 2 and 3 Key Practices

- Improved management visibility into technical status and progress
- Higher customer satisfaction due to project control and communication
- Increased ability to manage and control schedule and cost
- Successful avoidance or reduction of risks through risk identification and risk management
- Improved ability to defend bids and perform profitably due to well documented basis of estimate forms (BOEs) based on historic data and proven processes
- Ability to avoid pitfalls and repeat successes through lessons learned
- Improved management insight into process and policy compliance through quality assurance activities
- Fewer mistakes in products shipped to customers and reduced use of profit for retrofitting configuration management (CM) due to improved CM discipline
- Reduced cost to find and fix defects through peer review in addition to test
- Fewer labor hours required to complete some frequently recurring tasks
- Improved past performance profiles for improved process maturity profiles
- Ability to bid on and usually win acquisitions with process maturity qualifiers
- Reduced rework through improved understanding among engineers of expected tasks and product attributes upon completion
- Decreased voluntary turnover on projects with high maturity practices
- Ability to identify and attack business risks associated with CMM gaps
- Reduced cycle time for selected processes resulting in reduced cycle time for product release
- Reduced time and effort to create a technical approach for new project starts
- Reduced defects in late testing stages due to improved tracking of requirements to downstream products
- Ability to track defect report status to forecast expected software quality on scheduled turnover date
- Increased ability to make newly hired engineers effective in their roles

Each organization will develop its own profile of benefits experienced, depending on its approach to process improvement, and its strengths and weaknesses before beginning process improvement. Process improvement initiatives should be implemented based on current areas of pain or business risk to ensure that the approach is well designed for the organization. The CMM was developed to help identify process areas that reduce business risk for the customer and supplier. Working to understand and address business needs in parallel with closing CMM compliance gaps assists Litton PRC projects and the larger organization in creating an approach that serves everyone and results in benefits.

[4] June 2000 survey in Litton PRC conducted by Barbara Dreon.

Target Level 3 From the Start

In order to reach CMM Level 3, a company must meet the goals of all KPAs in Level 3 and in Level 2. The staging of the model suggests that one might attack only Level 2 first and then begin on Level 3 KPAs; some companies have further interpreted the ordering within Levels as further ordering for their process improvement scheduling and prioritization. However, the success of most organizations in attaining Level 3 was not in such a stepwise fashion.

In practice, many organizations successful in reaching Level 3 have implemented some aspects of Level 3 KPAs early as an enabler to achieve compliance in both Level 2 and Level 3 KPAs. For example, to achieve progress, it helps to have a responsible group and a plan for process improvement for any targeted level; implementing these is covered in Organization Process Focus, a Level 3 KPA. Additionally, each KPA in every level calls for some type of training or orientation as a part of its key practices under the abilities common feature. Implementing elements of an organizational training program and tracking both training needs and training delivery assists in rolling out and documenting the training called for in each KPA. Nearly every KPA calls for at least one documented procedure; developing processes and procedures that can be used across projects and tailoring the standard process to meet specific project needs are elements of Organization Process Definition and Integrated Software Management. The organization process set and tailoring information addressed in these two KPAs can assist in process documentation called for throughout the model. When a Level 3 end target has been set, Integrated Software Management should be considered from the start when implementing procedures and methods to meet Software Project Planning and Software Project Tracking and Oversight because of the common threads of the three KPAs. Peer reviews are a Level 3 KPA. However, many organizations have implemented peer reviews early and seen a return on investment even while much of the CMM Level 2 discipline is missing. The early success with peer reviews can be used to develop lessons learned in working towards success in other KPAs.

In terms of appraisals, the impact on an organization is not much different for a thorough appraisal of all 13 Level 2 and 3 KPAs versus a thorough appraisal for only Level 2 KPAs. Diagnostic information through an appraisal for an initial baseline covering all the Level 2 and 3 KPAs helps to identify areas where progress has been made in both levels. It also reduces the impact of conducting appraisals to develop findings for a “fix list” covering all target KPAs versus re-appraising in 18 months or less to get an initial reading on Level 3.

How Long Does it Take to Get From 1 to 3?

Often the directive to "get to Level 3" comes with an end date based on an expected proposal milestone or a managerial edict from above. How can you tell whether the end date is achievable?

Industry data shows that companies typically take about 30 – 60+ months to get from Level 1 to Level 2 (39 months is the median value); and then Level 2 to 3 typically takes an 40 additional months to complete (SEI 1[5]). Litton PRC's initial informal maturity baseline came from a quality improvement team with representatives of 10 projects and support personnel that began in March 1993 with a flurry of internal CMM-based appraisals for each project (with a Level 1 starting point). Elements of both Level 2 and 3 were attacked on each of the projects or through the cross project team based on the initial list of gaps identified through the appraisals. Six of the original 10 projects participated in two externally led SCEs tailored for internal improvement. The first SCE showed a Level 2 profile with nearly all Level 3 KPAs satisfied). The second SCE resulted in a Level 3 rating; this rating was obtained 39 months after the start of the team effort (Hollenbach 1). Thus, Litton PRC's journey from Level 1 to 3 was considerably shorter than benchmark data (39 vs. 79 months).

Now that Litton PRC has achieved Level 3 (and, more recently, Level 5), it has the capability and infrastructure to start up new projects that should be at least Level 3 compliant.[6] Litton PRC's expertise and infrastructure, combined with strong site management commitment, adequate resources, and often a specific target end date, enable projects or sites with Level 2 and 3 gaps to dramatically reduce their time to reach Level 3. Also, while it is not uncommon for companies having once achieved Level 3 to backslide in their process maturity, Litton PRC works continuously to counteract these tendencies and to secure new ground (e.g., working towards CMMI or developing process areas for our business needs).

Litton PRC tracks CMM compliance progress at a much lower level of granularity than CMM Levels or even KPA compliance. Through a tool called the PRC Maturity Questionnaire (MQ), projects track CMM compliance down to the key practices. The MQ produces a radar chart that shows an aggregated profile of the percentage of compliant key practices for each KPA, with these KPA profiles arranged like spokes of a wheel. A key driver for the time to reach compliance in a KPA is how big the gaps are between the current profile and the 100% target. Though there is not a straight mathematical mapping between percentage of key practices satisfied and KPA goal satisfaction, in general, fewer key practice gaps

[5] Based on 25,50, 75 percentiles for projects reporting to SEI's database. Median is 50th percentile. A 1995 SEI of data showed about 55 months to get from Level 1-3 (1995 results, Hayes 1).

[6] Most recent ratings summarized in letters referencing May 1999 (Level 3 scope) and March 2000 (Level 5 scope) appraisals led by Joseph Morin, SEI authorized lead evaluation from Integrated Systems Diagnostics, Inc.

translates to improved goal satisfaction of a KPA. A Level 1 group may be compliant with all but one goal of one Level 2 KPA, while a second Level 1 group may fail to satisfy any goals of any Level 2 KPA. Intuitively, the work to reach Level 2 is significantly larger in the second case. The granular tracking allows managers and sponsors to view incremental progress toward meeting all goals of KPAs and to manage improvement activities accordingly.

How long is it likely to take your organization to go from Level 1 to Level 3? The industry average says 55-79 months; Litton PRC experience says 3 years is achievable if you have strong management commitment, a pressing deadline, sufficient resources and if you can leverage expertise and assets to fit your needs. The key drivers determining how soon your can achieve Level 3 are shown in Figure 2 below. This list reflects Litton PRC's experience, which overlaps with factors recorded in other industry literature. [7]

Factors Affecting Process Improvement Progress

- Management commitment at various levels
- Qualified person or a few qualified people primarily responsible and authorized for process improvement efforts
- Funding and availability of key personnel for completing improvement tasks
- Severity and number of remaining gaps for Level 3 compliance
- Sufficient resources for process definition and process improvement activities
- Buy-in of managers and staff for the effort and for their processes
- Early initial baseline available to target continuing work to reduce gaps in Level 3 compliance
- Ability to recognize and leverage existing local documents or practices that already assist in CMM compliance
- Regular tracking and re-planning of remaining actions to close gaps in Level 3 compliance
- Selective use of outside expertise and assets to guide efforts and fill needs

Figure 2. Process Improvement Factors

An organization's maturity level is determined not only by its documentation but also by its consistent demonstrated use of documented practices. Therefore, an organization not yet at Level 3 cannot expect to achieve Level 3 in just a few months, regardless of the resources, commitment, or inventiveness of the organization. Listening to anyone who says they can sell you a set of processes or a tool that will make you Level 3 virtually overnight is not advisable, as it falls into the category of P.T. Barnum adages.[8] If your organization is new to the CMM, and you expect to find numerous gaps in Levels 2 and 3, what should you do if a bid calls for a Level 3 which is needed in 5 months? Prepare for process

[7] Examples include, Section 3.6, "Who Succeeds" of Systematic Survey of CMM Experience and Results (Herbsleb 3) and comments in "Achieving Higher SEI Levels" by Michael Daskalantonakis. (Daskalantonakis 1)

[8] "There's a sucker born every minute." P.T. Barnum

improvement, conduct a first appraisal, start working the process improvement plan, and simultaneously look for a teaming arrangement where a Level 3 organization can be your prime. If there is more flexibility in the process maturity goal or more time in the schedule, your chances of success increase. But if you don't start, the next bid or bonus opportunity may also pass you by. Further, Litton PRC's early experience in process improvement and acquisition-led SCEs revealed that a realistic documented process improvement plan in place based on an appraisal (coupled with significant progress against the plan) helped to reduce the offerer's assessment of process risk even before the acquisition's target maturity level was achieved.

When and How to Conduct Appraisals to Measure Status

A rigorously conducted appraisal with an experienced, trained team leader and trained team members results in a set of findings that the organization should use to prioritize remaining work to reach Level 3. To receive a thorough baseline appraisal or an appraisal that results in a documented level rating, plan for an appraisal team to spend at least 5 days on site with significant overtime for team members. Better yet, plan for a somewhat extended schedule to allow time for initial document review. Using a team composed of both external and internal members balances multiple needs for objectivity, mentoring, and the increased knowledge of personnel expected to continue to lead the process improvement effort. Because an appraisal includes both documentation review and interviews with managers and staff, along with a few presentations to all participants, there is an impact on the organization. In addition, preparation and coordination tasks for an appraisal usually fall to the process improvement champions. For these reasons, one should conduct an appraisal early in the timeline, but then plan to balance resources and needs for review of status against those for tasks resulting in progress to be reported.

Many organizations delay the initial CMM-based appraisal hoping to improve their first profile of maturity; this is usually a mistake. The initial appraisal solidifies organizational buy-in to speed remaining progress. Also, the initial appraisal is often a learning experience that helps highlight which areas are truly gaps and which are not; organizations often waste effort by failing to recognize existing assets that meet the CMM key practices and directing resources to create an unneeded solution. An early appraisal also protects against "blind spots," misconceptions about the CMM or appraisal methods can lead a group into a false sense of confidence about the existence or severity of remaining gaps which can require months to address. By undergoing the appraisal process, the organization also learns some of the specifics of preparing for and conducting an appraisal that will aid it in performing more smoothly the next time. An organization with a planned end date to reach a maturity Level in less than 24 months should schedule an initial appraisal as soon as possible to enhance the probability of meeting the end target.

When to Schedule an Additional Appraisal

After the initial appraisal, an expert or small team can conduct spot checks of areas where improvement is claimed or where there is a tendency for backsliding. Depending on the severity and number of gaps (weaknesses) in the first appraisal and the time available to reach the maturity goal, it may be beneficial to conduct an additional appraisal before expecting to reach a Level rating. This helps to ensure that significant remaining weaknesses can be corrected before an organization must achieve and document a maturity level.

When an appraisal identifies one or more weaknesses sufficient to fail a KPA goal, one should typically expect a minimum of three to six months to address the area sufficiently to demonstrate weaknesses have been replaced with practices that are stable in the organization and conform to the model. Addressing numerous weaknesses that affect goals normally takes longer. In general, weaknesses that cause goal failure are not quick fixes. Therefore, when planning appraisals for information gathering or dry runs for a final goal, allow sufficient time (minimally three months, ideally more) between them to address remaining weaknesses.

Process improvement can be based on other types of appraisal activity to identify areas of pain in an organization. Examples of ways to identify possible targets for improvement include: risk identification exercises, the initial stages of defect prevention, lessons learned results, and brainstorming.

Our focus so far has been on process appraisals, which yield the most focused results when a maturity level is a firm near-term goal. In cases where buy-in to the CMM or appraisals is a stumbling block and where no specific targets loom, the following alternate sources of improvement targets provide inputs to work from.

How to Get from Where You Are to Where You Want to Be

A six step approach is provided below that provides generic activities each organization needs to perform to get from Level 1 to Level 3 (or other target). Steps 2-5 are cycled through as needed. A seventh step addresses the need to continue to work after initially reaching the goal. In the figure below, the steps are summarized and mapped to the IDEAL approach to software process improvement.[9] The IDEAL approach was developed by the SEI and is often used in industry to help describe the cycle of process improvement. (Paulk 3)

[9] IDEAL stands for 5 stages: initiating, diagnosing, establishing, acting, and leveraging. (Paulk 3)

Litton PRC's 7 Steps to Process Maturity	IDEAL Approach, Stages	IDEAL Approach, Steps Within Stages
1. Create a team structure to accomplish improvement activities.	Initiating	Stimulus for improvement; Set context and establish sponsorship; Establish improvement structure
2. Identify the current situation (conduct appraisal).	Diagnosing	Appraise and characterize current practice; Develop recommendations and document phase results
3. Plan (or re-plan) improvement actions.	Establishing	Set strategy and priorities; Establish process action teams; Plan actions
4. Implement planned actions for improvement.	Acting	Define processes and measures; Plan and execute pilots; Plan, execute, and track installation
	Leveraging	Document and analyze lessons; Revise organizational approach;
5. Repeat improvement cycle after significant activity and at least 4-10 months.	(Leveraging) Diagnosing (recycle through IDEAL)	
6. Where possible, conduct final "dry run" appraisal expected to result in target level rating 3-5 months before "Must Have" date.	Diagnosing	See above
7. Continue to conduct process improvement after reaching Level 3.	Recycle through IDEAL	

Figure 3. Process Improvement Steps

The following text provides detail on steps to accomplish and document increased process maturity.

1. Create a team structure to accomplish improvement activities
   (not time dependent with other activities, suggest initiating early)

- ❑ Identify sponsors and resources for process improvement.
- ❑ Identify leader for an engineering process group (EPG) responsible for improvement as a project.
- ❑ Matrix in or provide full time resources as EPG team members.
- ❑ Identify as needed EPG responsibility or working groups to conduct planned improvements.
- ❑ Plan and hold regular meetings to review status, make decisions, resolve issues, and do work.
- ❑ Plan and hold regular meetings between sponsor and EPG leader to review status, make decisions, review priorities, and resolve issues.

2. Identify the current situation (conduct appraisal)

- ❑ Plan and prepare for appraisal.
- ❑ Conduct appraisal.
- ❑ Receive findings (communication to organization).

3. Plan (or re-plan) improvement actions

- ❑ Identify and prioritize fixes based on findings (or update older plan).
- ❑ Document fixes in improvement plan as action items (who, what, when).
- ❑ Provide rough order of magnitude for resources for fixes.
- ❑ Obtain management approval of documented improvement plan.
- ❑ Communicate plan to managers, EPG, and staff.

4. Implement planned actions for improvement

- ❑ Actionees in plan perform tasks and notify EPG of status.
- ❑ EPG maintains status of plan activities and regularly reports progress.
- ❑ Re-plan as needed based on schedule changes, resource conflicts, lessons learned, etc. and note updates in plan.
- ❑ Communicate progress and major milestones, major issues as needed (to EPG, managers, and staff).

5. Repeat improvement cycle after significant activity and at least 4-10 months

- ❑ Recycle through steps 2-4 to verify progress, re-plan, and complete remaining actions.
- ❑ (After initial appraisal, smaller spot checks by experts may suffice to verify progress between formalized appraisals).

6. Where possible, conduct final “dry run” appraisal expected to result in target level rating 3-5 months before “Must Have” date

- ❑ Plan and conduct as in step 2; ask for a level rating with findings (allows time to recover from unexpected failure to meet target level).

- (where time is compressed, opt for early initial appraisal and potentially forgo interim or dry run appraisals).

7. Continue to conduct process improvement after reaching Level 3
- Plan and conduct actions to maintain current gains in CMM.
- Identify new challenges (higher maturity, wider roll out, enhanced processes based on pain, improved use of measures, other process models, etc.).
- Continue to cycle through plan/do/check/act cycle through modified steps 2-5.

Important tips for successfully and efficiently implementing these steps include:
- Identify who is responsible for aspects of process improvement and provide them with the authority and the resources to complete their tasks.
- Create the organization structure for improvement (e.g., EPG and management forum) early on.
- Perform the initial appraisal as soon as possible and expect areas of improvement to be identified.
- Don't hold an appraisal until your sponsor is ready to commit to the following: attend the opening and closing (findings) briefings, direct participants to make the appraisal their top priority, and commit to action based on the findings.
- To begin planning and preparation for a formal appraisal, work with the appraisal team leader preferably three or more months in advance and not less than a month in advance.
- Document the plan so it is quick to capture, and easy to track and update.
- Plan and implement some quick fixes early in the schedule.
- Plan realistically and avoid vagueness in actions or completion dates.
- Avoid a "big bang" approach to rolling out changes; learn by documenting, training and rolling out a few processes and get smarter for the next cycle.
- Get through the planning stage quickly; re-plan based on experience.
- Don't back-load the schedule; slips are normal but deadly for tight deadlines.
- Keep the documented plan short so it is quick to read, approve, and update.
- Identify long lead time actions for improvement; ensure progress is steady.
- Listen to management concerns regarding the plan and modify activities to gain approval and commitment.
- Use regular EPG meetings with action items to help stimulate progress.
- Communicate progress and interim milestones or changes of note to staff.
- Communicate plan status to management often (both successes and issues).
- Ensure that those who use a process participate in its development.
- Understand and emphasize that reaching Level 3 takes action from managers, engineers, support staff, and the EPG; not just one or two groups.
- Requests for changes in draft work indicate that target users are engaged.
- If numerous gaps exist between the current and desired state, plan an interim appraisal or at least spot checks by an expert to determine the risk of reaching the desired level by the planned end date.
- There will often be a few places where a weakness persists even though the planned action took place in an attempt to address it.
- Scheduling the next appraisal creates an incentive to close assigned actions.

- Expect that the appraisal team will look for repeated, consistent use of a practice rather than good intentions or evidence of sporadic or pilot use.
- Ensure that the organization is prepared to continue to use procedures after a Level 3 appraisal is complete.

Typical Actions in Reaching Level 3

Litton PRC usually divides actions for appraisal readiness into two categories: appraisal preparation and remedial activities (work to fix gaps between current and desired CMM compliance). Litton PRC maintains checklists and task breakdowns of preparation activities to assist in planning and preparing for appraisals or SCEs with corporate leadership or participation. Each appraisal also includes a tailored plan that documents appraisal goals and scope, information about the team and the organization, the expected schedule and outputs, and other aspects of the appraisal.

Typical remedial activities fall into the categories listed below in Figure 3.

Example Generic Version of Weakness Statement in Appraisal Findings [generic term] (example possible model tag)	**Typical Severity** (5 = highest, 1 = lowest)	**Typical Complexity or Effort to Fix** (5 = highest, 1 = lowest)
No policy addresses [the KPA] (RM.CO.1)	2-3	1-2
Affected staff are unaware of existing policy, though they follow its intent (RM.CO.1)	1	1
A policy addresses the KPA, but is not adhered to by the organization (RM.CO.1)	2-3	1-4
A group responsible for most of a KPA has not been formed (e.g., CM group, QA group, EPG) and no other group performs the activities (QA.AB.1)	2-5	3-5
Shortfalls in training or resources impact the organization's ability to implement a KPA (SM.AB.1)	3-4	2-5
Training to address [a KPA] does not exist (PP.AB.4)	2-3	2-4
Training exists but has not been received by the target audience (PP.AB.4)	2-3	1-3
Some of the target audience has not received training to address [a KPA] (PP.AB.4)	1-2	1-2
Training has been received but the training requirement is missing (ISM.AB.4, TP.AC.1)	1-2	1-3
Received training is not documented (ISM.AB.4)	1-2	1-3
Missing orientation for [the KPA] apparently affects effective implementation of [the KPA] (SM.AB.3)	1-3	1-3
No document was found to cover QA Plan/CM Plan	2-4	2-4

Example Generic Version of Weakness Statement in Appraisal Findings [generic term] (example possible model tag)	**Typical Severity** (5 = highest, 1 = lowest)	**Typical Complexity or Effort to Fix** (5 = highest, 1 = lowest)
/Software Development Plan material (CM.AC.1,2)		
Elements expected in the [KPA] Plan were missing in the plan and not noted elsewhere (e.g., schedule) (QA.AC.1,2)	1-3	1-3
The QA Plan/CM Plan /Software Development Plan is not followed (QA.AC.2, CM.AC.2, other)	1-3	1-3
Some projects do not perform [expected practice, e.g., unit test for code] SPE.AC.4	2-4	2-5
[The key practice activity e.g., size estimation] is not performed and no evidence of a related documented procedure was found (PP.AC.9)	3-5	4-5
No evidence of a documented procedure for [key practice, e.g., size estimation] was found (PP.AC.9)	2-4	2-4
Some projects do not adhere to documented procedure for [key practice, e.g., size estimation] (PP.AC.9)	1-4	1-4
Documented thresholds were not found for [size/effort/cost/critical computer resources] (IM.AC.xx)	2-5	2-4
No evidence of measurements for [KPA] (OD.ME.1)	1-3	1-4
No/Limited evidence of use of measurements for [KPA] (OD.ME.1)	1-2	1-3
No evidence of regular senior management review of [KPA] activities (QA.VE.1)	1-2	1-2
No evidence of regular project management review of [KPA] activities (QA.VE.2)	1-2	1-2
No evidence of QA reviews or audits of [KPA] activities or products (IC.VE.3)	1-2	1-3
No library exists for process-related documentation (OD.AC.6)	3-5	3-5
No organization mechanism exists to collect and make accessible process metrics across projects (OD.AC.5)	3-5	3-5
Historic data are not used to create estimates (PP.AC.9, other)	2-4	2-5
No evidence of documentation for the project's defined software process (PE.AC.1-9 , other)	4-5	3-5
No evidence of QA reviews or audits of [item listed in detail KPA key practice as minimal items, e.g., the process for developing the risk management plan] (ISM.VE.3)	1	1-2

Figure 3. Generic Versions of Typical Weaknesses to Address

While an appraisal identifies weaknesses or gaps between an organization's practices and the CMM reference model, not all weaknesses are expected to carry equal weight in terms of CMM compliance or in terms of your organization's business risks. For example, some projects have received the weakness "No evidence was found for use or collection of intergroup coordination measures. (IC.ME.1)" When this KPA is otherwise healthy, our EPG experts often counsel the projects to accept this finding (since it is accurate) but to plan process improvement efforts elsewhere where there is more expected benefit in removing a weakness, both from a business risk and a CMM compliance standpoint.

Not every weakness finding needs to be addressed to achieve Level 3 or to reduce business risk. In general, concentrate most on weaknesses related to the "activities" portion of the model, and concentrate least on findings where the tagged key practice does not map to any failed goal and where little or no business risk appears to be linked to the finding. However, be aware that strings of related weaknesses with typically low severity can combine to create a greater obstacle to CMM goal satisfaction. The CMM in book form contains the mapping of goals to key practices used by appraisal teams (Paulk 3). This is also available through other SEI and Litton PRC resources.

Some fixes to identified weaknesses are not totally straightforward, but often times they are. One can begin by planning "obvious" fixes for most weaknesses. The EPG can then focus root cause analysis on a few weaknesses that either are not well understood or those that have been resistant to earlier attempts to resolve. For weaknesses where a practice does not match documentation, remember that two typical solutions are available: one is to alter the practice, the other is to alter the documentation. Assistance is available through Litton PRC or other process improvement groups to help understand fixes that might work in your environment. Usually, implementing what seems to be a common sense and low cost initial approach and checking its results is a good first cut.

Many groups get mired in overly detailed or wordy creation of process improvement plans to address the fixes. Ensure that the length and level of detail assist you in quickly and succinctly communicating process improvement tasks and goals so that you can spend more time on actual fixes, quick status, and inevitable re-planning. Litton PRC groups have had great success using concise action plans to tackle identify groups of related weaknesses. These are documented much like a series of action items (with task, actionee, and expected end date) and whose status is reviewed at least monthly by the EPG and periodically by the responsible managers.

See the 7 steps outlined in an earlier section for the context for documenting the plan for fixes and implementing the fixes. Most of the effort in achieving a new CMM level should be focused on activities for remedial actions rather than on

elaborate coaching of interviewees or extremely detailed arrangement of data for an appraisal team. Other organizations that achieved success have also used a similar game plan to the one defined here.[10]

Summary

Many organizations have adopted the CMM as a model for process improvement and targeted a goal of achieving CMM Level 3. A number of them have succeeded, including Litton PRC, which has achieved CMM Level 5 in March, 2000 (this implies achievement of the lower levels.) Numerous benefits of process maturity have been touted in the past; organizations have actually experienced many of these. This paper identifies 20 qualitative benefits related to CMM Levels 2 and 3 experienced by one or more Litton PRC projects.

Industry averages show a mean time of 55 months to move from Levels 1 to 3. Litton PRC's initial 10-project effort resulted in the attainment of CMM Level 3 in 39 months. Litton PRC projects building on the earlier legacy have significantly reduced the time required for them to remove gaps to reach Level 3. Nevertheless, a new organization can expect to measure progress in months rather than weeks; a few significant CMM weaknesses normally take 3 months or longer to address before re-appraisal is appropriate.

This paper provides advice on preparing for and scheduling appraisals as part of the process of obtaining a target CMM rating. One key is scheduling the initial appraisal early rather than late in the process and planning a second appraisal to document progress, or if appropriate, to document the target level rating.

The following 7 step process was recommended for the improvement effort.
1. Create a team structure to accomplish improvement activities.
2. Identify the current situation (conduct appraisal).
3. Plan (or re-plan) improvement actions.
4. Implement planned actions for improvement.
5. Repeat improvement cycle after significant activity and at least 4-10 months.
6. Where possible, conduct final "dry run" appraisal expected to result in target level rating 3-5 months before "Must Have" date.
7. Continue to conduct process improvement after reaching Level 3.

This paper has provided a list of improvement approaches and has important tips for successfully and efficiently implementing the seven steps noted that both appraisal preparation activities and remedial activities (focusing on fixes for CMM weaknesses) must take place before an appraisal. A list of example generic findings was provided, along with their potential impact on CMM goal compliance, as well as the estimated difficulty of implementing related fixes.

[10] One example of similar advice is found in Wiegers 1.

With dedication, focus, resources, and support at various levels, an organization can succeed in moving from CMM Level 1 to Level 3. In addition to this numeric rating, the organization should gain substantial business benefits as a reward for the sustained and sometimes challenging work of changing organization culture and practices to achieve CMM Level 3.

Litton PRC Resources

Litton PRC has numerous customers and solution offerings for services and products. A large portion of our business involves the integration of large systems and the deployment and maintenance of complex systems. As a by-product of our own journey of process improvement that has resulted in a CMM Level 5 rating (first documented in March 2000), we have developed numerous products, services, and capabilities to help ourselves and others succeed in process improvement. Litton PRC and Logicon projects or groups have access to these resources (most at no cost for internal use); we also are able to offer these for customers and team-mates. The versions noted below are those widely available as of May 2001. The list below contains highlights of the most frequently used items; numerous other resources are also available and can be identified through discussion with a member of the Litton PRC Systems and Process Engineering (S&PE) group or other knowledgeable company point of contact. The resources are listed in roughly the order in which they are often used (e.g., overview precedes appraisal precedes post appraisal planning).

The items shown are listed in roughly the order in which many groups use them (e.g., CMM Overview Training before starting an engineering process group). This list is of most direct use to employees in Litton PRC or the company hierarchy under which it falls. The external reader may choose to use this list to understand what products or services Litton PRC can provide or to better understand the types of training and tools that a successful company has found useful in pursuing process maturity.

CMM Overview Training This course can be run as a 1-2 hour briefing or it can provide the basis for a 4-8 hour workshop with more interactive portions and more in-depth review of key process areas. The short version covers CMM background and structure, as well as the expected benefits of process improvement using the CMM. It also begins to develop participant skills so each can navigate the CMM to answer targeted needs as they arise. The course description and other supporting material are available on the Litton PRC PAL (see below). This course is on the Litton PRC Organization and Workforce Development (OWD) training schedule or available upon request. CMMI Overview training is also available.

Litton PRC CMM Wall Chart This chart displays all key practices of the CMM and organizes them into their structural components. Detail below the key practice level is not shown. The SEI has adopted Litton PRC's Wall Chart idea for other models. Very limited quantities are available upon request. Litton PRC or Logicon employees should normally request through their Engineering Process Group leaders (see the Litton PRC PAL for information). A CMMI wall chart is also available.

Litton PRC Process Asset Library (PAL) The PAL contains many of the items listed elsewhere on this list, as well as CMM links, CMMI links, access to Litton PRC's processes to cover all CMM and CMMI elements, and numerous other assets. It is accessible to Litton PRC employees via http://epi.prc.com/PAL/ from within PRC Headquarters and from some PRC facilities. Other Litton PRC or Logicon employees should contact Litton PRC's Internal Information Systems group for access information; others with interest should ask their Litton PRC counterpart about how this resource might be leveraged to add value for their task.

Litton PRC Process Asset Library (PAL) Overview Brown Bag This one hour briefing and demonstration is designed to make employees aware of the PAL , its functionality, and some of its contents. It is also designed to make participants ready to go back to their desks and be more effective at locating and reusing PAL assets to assist them in recurring tasks. Course description and other supporting material are available on the Litton PRC PAL. This course is on the Litton PRC OWD schedule or available upon request.

Litton PRC Process Set The Litton PRC PAL provides processes for all procedures called for in the CMM; projects are expected to use these as the basis for tailoring their own processes. In some cases, projects adopt the process directly. Many of the Litton PRC processes can also be used by other organizations as a guide for creating their own organization process. PRC's process set covers each CMM key process area and also covers many of the processes/procedures called for in systems engineering process areas, the Integrated CMM (CMM-I), ISO 9001, and some business areas outside these models (e.g., web page development, seat management).

PRC Maturity Questionnaire (MQ) The MQ is available for the CMM, with a version for the CMMI (integrated CMM). This Excel workbook is a starting point for CMM based assessments; it is also used for cataloging current status or tracking progress. The MQ produces a "radar chart" ,a graphic overview of CMM compliance to key practices. Instructions are included as part of the workbook. The MQ is available on the Litton PRC PAL as version e or higher. A similar questionnaire is also available for the CMMI.

Appraisal Services These services are available to both internal and external customers. Litton PRC projects and organizations can ask for support to comply

with Litton PRC policy calling for model based appraisals or to fill needs for acquisition related appraisals including Software Capability Evaluations (SCEs). The market sector engineering process group (EPG) leader should be contacted to start arranging an appraisal. Appraisal services are also available for other Litton and Logicon groups and non-PRC groups; the requestor or Litton PRC point of contact should contact their local EPG contact or the Litton PRC Systems and Process Engineering Group to request details on support. Litton PRC maintains lists of trained team members and leaders for Litton PRC's internal CMM based appraisal method, and for certified team members and team leaders for SCE v3.0, which can be tailored for internal appraisals as well as acquisition related appraisals. Litton PRC has developed an extensive set of training, tools, and templates to assist groups in effectively preparing for and conducting appraisals.

Appraisal Team Member Training This 1.5 - 2 day workshop trains a person to become a team member for a Litton PRC method internal CMM based appraisal. The process taught is CMM Assessment Framework compliant; the training is required for all appraisal team members. Course description and other supporting material are available on the Litton PRC PAL. This course is on the Litton PRC OWD schedule or available upon request.

SCE Participants Guide, Version 2 This handbook was developed to assist Litton PRC employees in becoming better prepared to participate in a Software Capability Evaluation (SCE); it can also be used for internal appraisals. The Guide includes typical questions by project role and tips on interviewing. The Guide is not meant as a means of communicating "correct answers"; rather it allows participants to gather their thoughts on how their daily work translates to typical questions they may be asked.

Action Planning Workshop This 1-2 day workshop can be used to train participants to perform action planning later, but is normally provided to a group as facilitation for the current round of planning after a CMM based appraisal. Upon completion of the workshop, the group normally has completed over 80% of the software process improvement plan work to reach a draft agreed to by the plan developers and ready for management approval. This planning method and its outputs dramatically decrease time to plan over industry average and also contribute to ease of tracking. Course description and other supporting material are available on the Litton PRC PAL. This course is available upon request.

How to Start an EPG This tutorial covers typical steps on starting a software engineering process group SEPG (or in Litton PRC, the wider focused engineering process group (EPG)). It also includes tips on avoiding common pitfalls. As an information briefing, the session can be fit to 1-2 hour slots; it can also be run as a half day or full day workshop in which a number of decisions are made and information recorded to start up a new EPG. It is adaptable for internal

or external audiences. Course description and other supporting material are available on the Litton PRC PAL. This course is available upon request.

Process Owners Checklists Litton PRC has found it helpful at the local and organizational levels to identify champions responsible for improvement in one or a few related process areas. Projpo.doc is a file found on the Litton PRC PAL. This is a strawman list of process owner responsibilities for use at the project level. The list addresses the set of tasks or responsibilities that might be addressed by someone who has responsibility for a particular process or process area on a project. It is tailored from the corporate Process Owner's Responsibilities List. This file, Kpald.rtf is the file on the Litton PRC PAL that contains a fairly extensive list of responsibilities for process owners at the Litton PRC level.

Litton PRC Operational Policies Litton PRC has a policy set covering all key process areas of the CMM as well as additional areas for systems engineering. The policies relate to the commitment common feature of the CMM. Litton PRC projects are expected to comply with these policies; other groups may use these policies as a starting point for their own organizational set of policies for CMM compliance. The policies are available on the Litton PRC public folders.

PRC Metrics Office To support measurement (aka metrics) across projects, Litton PRC has a group of trained, experienced personnel that supports metrics requests and assists projects and proposals in effectively implementing metrics and correctly interpreting data. The PRC Metrics Office facilitates the collection and analysis of project data to support CMM Level 4 and maintains a Litton PRC baseline derived from project data. This group has access to Litton PRC benchmark data and extensive experience in what works and what doesn't for metrics and their use. The PRC Metrics Office also works with the Litton PRC Metrics Lead Team, which includes project representatives from across the company. The Litton PRC PAL has links to metrics (http://epi.prc.com/PAL/documents/metrics/). You may also use email to contact the Metrics Office, smith_doug@prc.com, or dreon_barbara@prc.com for more information or specific requests.

Litton PRC Process Training Litton PRC maintains an extensive set of courses and workshops designed to make attendees more successful at implementing Litton PRC processes on their projects. Course offerings include: process improvement and process engineering (several listed above), requirements management, risk management, software product engineering, configuration management, data management, quality assurance, subcontract management, measurement and its use, project management, system architecture, internal verification and validation, technology change management, and defect prevention, to name a few. Course description and other supporting material are available on the Litton PRC PAL. These courses are on the Litton PRC OWD schedule or available upon request.

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Acronym List

AB Ability
AC Activity
Aka also known as
BOE Basis of Estimate
CBA IPI CMM-Based Assessment for Internal Process Improvement
CM Configuration Management
CO Commitment
CMM Capability Maturity Model for Software v1.1
CMU Carnegie Mellon University
EPG Engineering Process Group
ISO International Standards Organization
KPA Key Process Area
ME Measurement
MQ Maturity Questionnaire
OWD Organization and Workforce Development
PAL Process Asset Library
PIP Process Improvement Plan
QA Quality Assurance
ROI Return on investment

SCE Software Capability Evaluation
SEI Software Engineering Institute
S&PE Systems and Process Engineering
SPE Software Product Engineering