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The evaluation of project management performance on two software maintenance projects based on a CMMI framework

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THESIS

THE EVALUATION OF PROJECT MANAGEMENT PERFORMANCE ON TWO SOFTWARE MAINTENANCE PROJECTS BASED ON A CMMI FRAMEWORK

by

Karen A. LaFond

June 2006

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THE EVALUATION OF PROJECT MANAGEMENT ABILITY ON TWO SOFTWARE MAINTENANCE PROJECTS BASED ON A CMMI FRAMEWORK

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ABSTRACT

As software systems increase in size and complexity, so does the need to predict and control scope, schedule, and costs. The United States General Accountability Office has acknowledged weaknesses in the software acquisition process. Industry data indicates that improving the software development process can have significant effect on a project team's ability to generate products within planned scope, schedule, and cost estimates. This thesis focus is on software maintenance, one phase of the Army's acquisition process, to demonstrate that stronger management practices are needed to make better predictions and assessments in those areas. Two software maintenance projects were evaluated for success in project management performance against CMMI practices. This research results in a set of recommendations and predicted benefits are provided for use by the organization as input to the next process improvement effort.

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ACRONYMS AND ABBREVIATIONS

CM ..... Configuration Management
CMMI ..... Capability Maturity Model Integrated
SQA .....Software Quality Assurance
LMP .....Laboratory Management Plan
PCR .....Process Change Request
PMC ..... Project Monitoring and Control [CMMI Process Area]
PP .....Project Planning [CMMI Process Area]
RM ..... Requirements Management
RMP .....Risk Management Plan
SCAMPI .....Standard CMMI Appraisal Method for Process Improvement
SQA .....Software Quality Assurance
SCR .....Software Change Request
SEI .....Software Engineering Institute
SMR .....Senior Management Review
SPMP ..... Software Project Management Plan
SQA .....Software Quality Assurance
SQAP ..... Software Quality Assurance Plan
STP ..... Software Test Plan

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I. INTRODUCTION

As software systems increase in size and complexity, the need to predict and control costs increases correspondingly. The United States General Accountability Office has acknowledged weaknesses in the software acquisition process in their March 2004 "Report to the Committee on Armed Services, U. S. Senate, Defense Acquisitions, Stronger Management Practices Are Needed to Improve DOD's Software–Intensive Weapon Acquisitions" which indicates that "… For the most part, in the programs reviewed, DOD garnered poor results from its software acquisition process because it has not employed consistent practices in these areas [setting product requirements, maintaining a disciplined development process, and using metrics] [6]". Effective definition and use of software metrics in the software development process can assist project managers in making decisions and managing risks that affect the extent of project scope, schedule, and cost. Collecting scope, schedule, and cost estimate data, and then comparing actual results to that data over time can help to answer questions about the progress of a project and improve the accuracy of estimates for future projects. If the scope, schedule, and budget are not progressing as good as planned, software teams and managers can use the information to make more informed mid-course decisions to help manage project risks. Changes in software development project costs can translate into major program level savings or losses, in terms of scope, schedule, cost, and quality. The ability to predict the cost of a software project (or the portions of large systems that are made up of software) has a large affect on the success of requesting and planning the funding needed in such a way that actual costs turn out to be as close as possible to expected costs.

Many DOD organizations use Capability Maturity Models developed by the Software Engineering Institute to assess the ability to manage development, acquisition, and maintenance (or "health" of a project) of products [7]. The value of these models has been recognized in typical government contract language,

which recommends that bidders have achieved (or have a plan to achieve) a minimum process maturity level as one of the bidding requirements. Edward Aldridge, Under Secretary of Defense (Acquisition, Technology and Logistics), issued a March 2003 “Memorandum for Secretaries of the Military Departments” with reference to Section 804 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, which requires establishment of software acquisition process improvement programs for defense agencies that manage major acquisition programs [5]. In particular, the Army has recognized that software engineering is an area that is in need of attention [9].

As a result of these military directions, software management organizations are encouraged to implement software development process improvement programs. Aside from improving the organizations’ ability to deliver the most and best products, within allotted time and budget, the primary motivation is to demonstrate capability for bidding on future contracts [10].

This thesis focus is on software maintenance, one phase in the Army’s acquisition process. The purpose of the study is to demonstrate that stronger management practices are needed. Two software maintenance projects (referred to as “Case 1” and “Case 2”) were evaluated for success in these areas against CMMI practices [2]. To keep the results manageable for this thesis, only three CMMI Process Areas were considered. Results of the evaluations were examined to reveal answers to the following questions:

- Was the organization able to manage technical and managerial requirements? Were inconsistencies between requirements and project plans/products identified and managed?
- Was the organization able to establish and maintain project baselines?
- Was the organization able to provide an understanding of project progress so that corrective action could be taken to make changes in project management baselines?

- If not, what process improvements would need to be implemented to be proficient in these practices?
- What benefits might the organization realize as a result of this process implementation?

For proprietary reasons, the organization and particular projects studied will remain anonymous. While both project teams were able to deliver the software within the planned scope, schedule, and cost constraints, more effective project management may have helped them to finish sooner, or to take on more scope within the same limits. The information collected by this study will be available for immediate use by the project team as they are preparing for the next software maintenance project, while at the same time working towards achieving Level 3 goals of the CMMI.

Note that the informal examination of project management practices against three CMMI Process Areas, demonstrated on two similar software maintenance projects conducted for this study, will be referred to as an "evaluation." This term was chosen to distinguish the activity from an "audit" which implies that a corrective action loop is included. The goal was simply to evaluate the projects, compare actual practices to related CMMI practices, and compare them to each other and to the lessons learned reported by the project teams. The term "evaluation" is used to distinguish this activity from a process improvement "assessment" which implies the involvement of independent licensed professionals. Instead, an informal method was developed and used to extract information strictly for internal use. However, it is expected that a formal SEI CMMI assessment would yield the same results.

This thesis documents the steps taken to set up and perform the process evaluations. As a result, the author compiled a list of software development project management process improvement suggestions and potential benefits, which includes successful achievement of the goals in each of the three CMMI Process Areas considered.

A. ASSERTIONS

The SEI's process improvement model (the CMMI) is an accepted and good method to determine the level of process maturity in a software organization. Once conducted, evaluation results can be used to target specific areas for improvement. A comparison of the lessons learned reported by project team can be used as a sanity check against evaluation results. If the project team reported problems that are related to deficient practices then evaluation results may be more believable to them, which may help to give recommended improvements more credibility. Finally, if process improvement suggestions are implemented, benefits are likely (i.e., project managers should be able to rely on quantitative measurement as a tool to build greater accuracy and confidence into planning and progress reporting).

B. SCOPE

This study is limited to process improvement of project management activities and excludes discussion of any other areas of software development process improvement or software development activities. Two separate, but similar, real-world software maintenance projects were evaluated for the purpose of developing thesis conclusions. The evaluations consist of a comparison of the two projects' management practices to those defined in three particular CMMI Process Areas, which were selected because they describe a standard for activities that relate to planning and tracking requirements, schedule, and cost. The three Process Areas consist of: 1) Requirements Management, 2) Project Planning, and 3) Project Monitoring and Control. The primary intention of the research is to produce a relative picture of the two projects, and the differences between actual practices and the selected CMMI practices to provide a launch point for process improvement efforts internal to the organization. Since improvement is a continuous process, further validation and verification of thesis conclusions (predicted benefits) will require implementation and analysis of the improvements suggested.

C. THESIS ORGANIZATION

Following the INTRODUCTION, BACKGROUND, and METHOD chapters, a chapter on the study of each of the three relevant CMMI Process Areas is introduced (REQUIREMENTS MANAGEMENT STUDY, PROJECT PLANNING STUDY, and PROJECT MONITORING AND CONTROL STUDY). Each of those chapters presents the CMMI evaluation results for both projects evaluated, the post-mortem lessons learned reported by the project team, an analysis of the data, and suggestions for improvement in each area. The POTENTIAL BENEFITS chapter is then provided as a basis for process improvement motivation for the organization, and perhaps for other Army software maintenance organizations, or Army organizations that depend on software maintenance organizations for product delivery. It outlines the predicted return values that could result from implementation of the suggested process improvements.

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II. BACKGROUND

A summary of some basic concepts, either used by the projects studied, or used as a standard to compare project practices to, is provided in this chapter. Specifically, a summary of CMMI Levels 1-3 project management goals and practices, and project management process requirements in terms of Unified Modeling Language notation are presented to set the stage for this research. This information was considered as the basis for the evaluations and analysis to follow.

A. PROJECT MANAGEMENT IN THE CONTEXT OF THE CMMI

The CMMI groups Process Areas for the purpose of discussing concepts and interactions. Overall, there are seven Level 2 Process Areas (PAs) and fourteen Level 3 PAs, each with a set of goals defined for achievement.

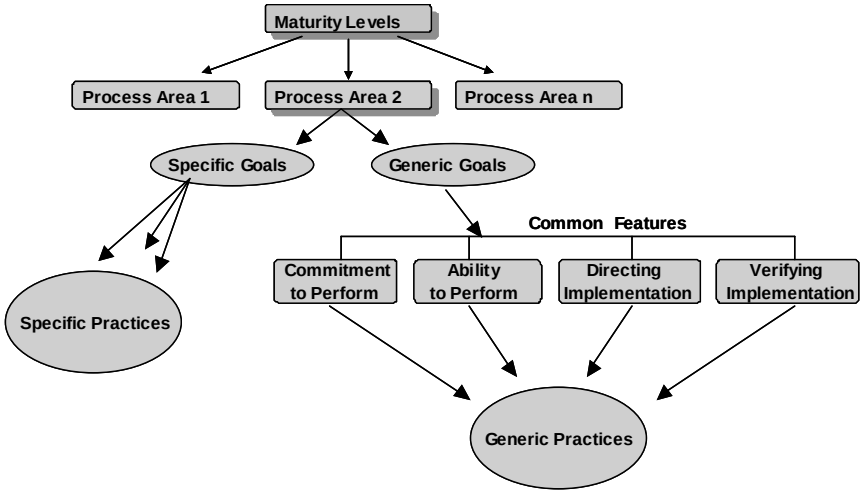

Figure 1. "CMMI Model Components (From [1])"

There are three CMMI Process Areas that address activities surrounding the estimation, collection, tracking, and reporting of the project management data mentioned above. These Level 2 PAs are Requirements Management, Project Planning, and Project Monitoring and Control. PAs are divided into Specific and Generic Practices, as shown in Figure 1 [1]. Specific Practices are model components that are considered important guidance for achieving "specific"

goals. Generic goals and practices are required model components that apply to all Process Areas. Each project was evaluated in all three PAs, in both specific and generic practices. A more detailed description of the three process areas is provided in the following subsections.

1. Basic Project Management Process Areas

The CMMI states, "the purpose of Project Planning (PP) is to establish and maintain plans that define project activities" and "the purpose of Project Monitoring and Control (PMC) is to provide an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan [2]." Together, these two Process Areas are part of the set associated with fundamental project management activities and thus were selected for this research. CMMI presents the whole group of project management PAs as shown in Figure 2 [4].

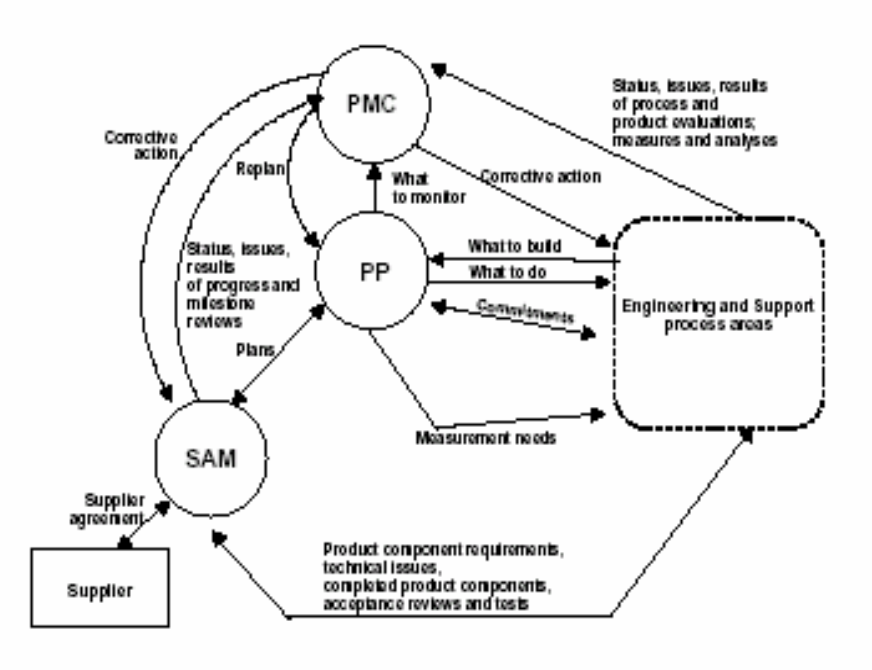

Figure 2. "Basic Project Management Process Areas (From [4])"

2. Engineering Process Areas

The CMMI states, “The purpose of Requirements Management (REQM) is to manage the requirements of the project’s products and product components, and to identify inconsistencies between those requirements and the project’s plans and work products [4].” In the case of software maintenance performed by the organization, a requirement refers to the “Statement of Work” which is approved by the customer. It includes project requirements (schedule and cost constraints) and technical requirements (a statement of work). This Process Area is part of a group defined by the CMMI as the “Engineering Process Areas.” Figure 3 [4] shows that requirements management is an activity that affects the engineering process and continues with a loop of feedback and control throughout the project.

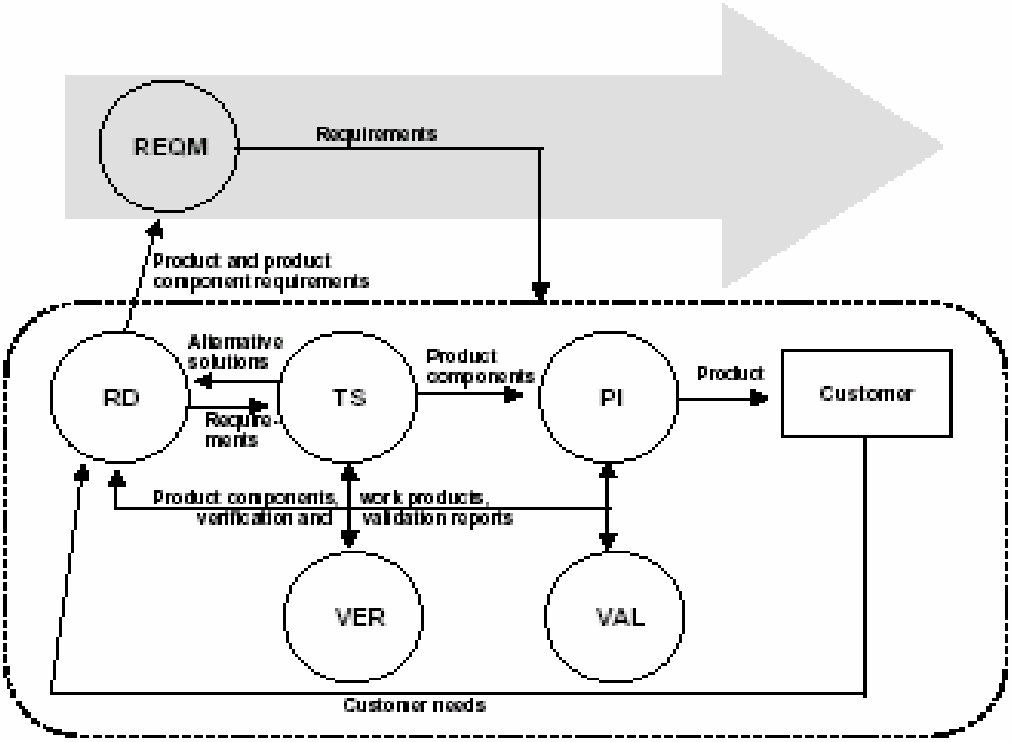

Figure 3. “Engineering Process Areas (From [4])”

B. PROJECT MANAGEMENT IN THE CONTEXT OF UML

Another way to view process requirements is to use Unified Modeling Language, which provides a visual representation of a system (in this case, a project management system) from the users (users of the process) perspective. Abstraction can be used to define concepts and relationships between system components without cumbersome detail.

1. Project Management System Functions

At the most general level, a Project Management System can be shown as a collection of elements in Figure 4. The box shows the boundary of the system, the class diagrams show the subsystems whose functionalities (functional requirements of the process) can be expressed as use cases in the following subsections.

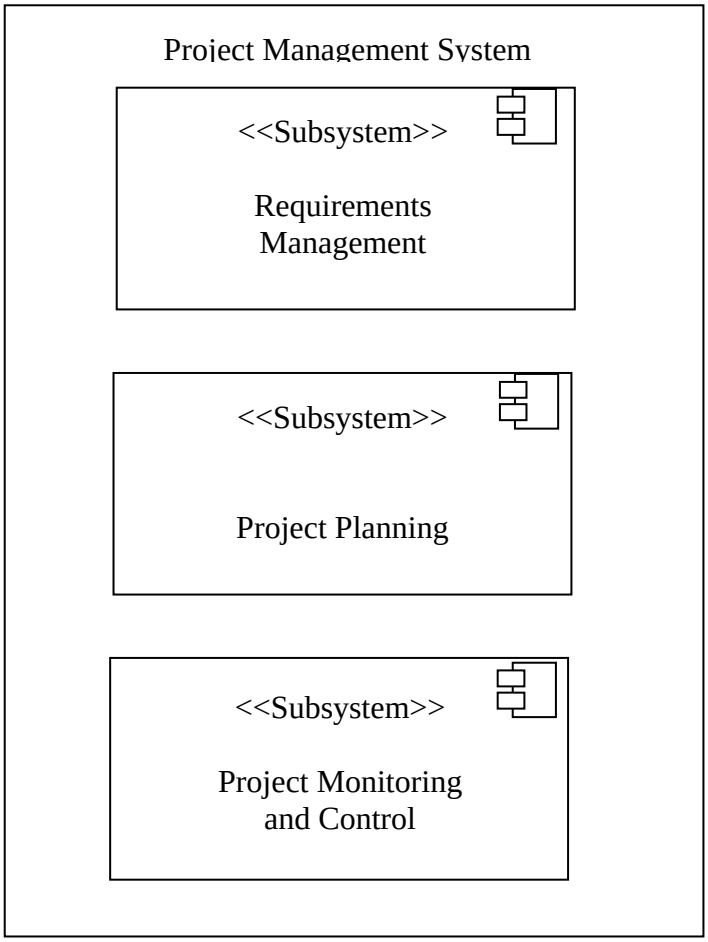

Figure 4 Project Management System

Further detailed notation of each subsystem includes actors that represent points of interaction. Connections between these symbols describe the interaction needed to accomplish the objective of the use case (subsystem behavior). The following subsections describe each element of the project management system. These diagrams provide visual representation of the benchmark to be used as a comparison to the process performance of the projects studied. Each element in the subsystem use case diagrams addresses the requirements and interactions that represent the behaviors described in the CMMI practices for that Process Area, now with the participants (or, actors) included.

2. Requirements Management Element

Requirements management occurs both external and internal to the organization. At this level of abstraction, these aspects are not distinguishable. What can be seen is that for this subsystem, three actors are involved in the five practices shown in Figure 5.

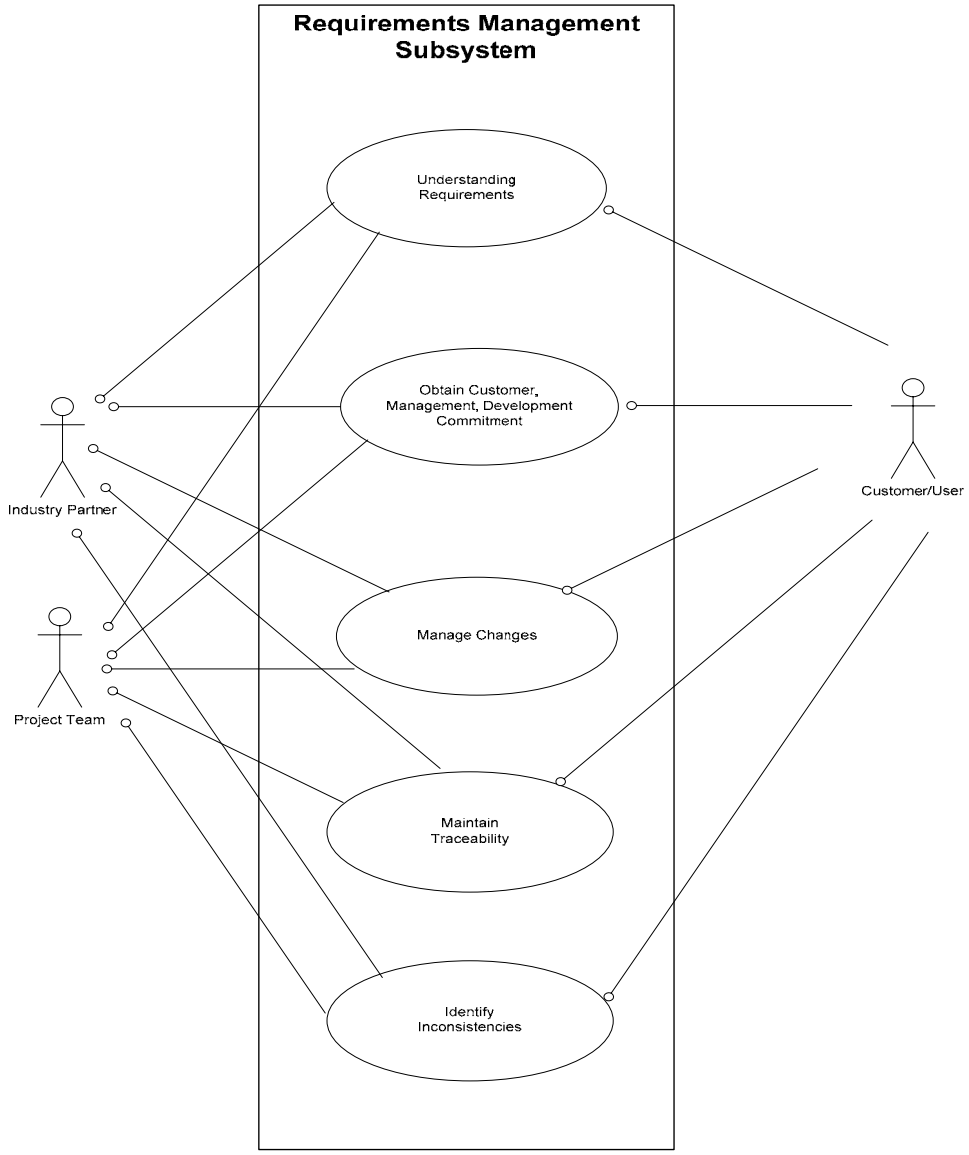

Figure 5. Requirements Management Use Case Diagram

3. Project Planning Element

Project Planning includes activities both internal and external to the organization. At this level of abstraction these aspects are not distinguishable. What can be seen is that for this subsystem, two actors are involved in the eight practices shown in Figure 6.

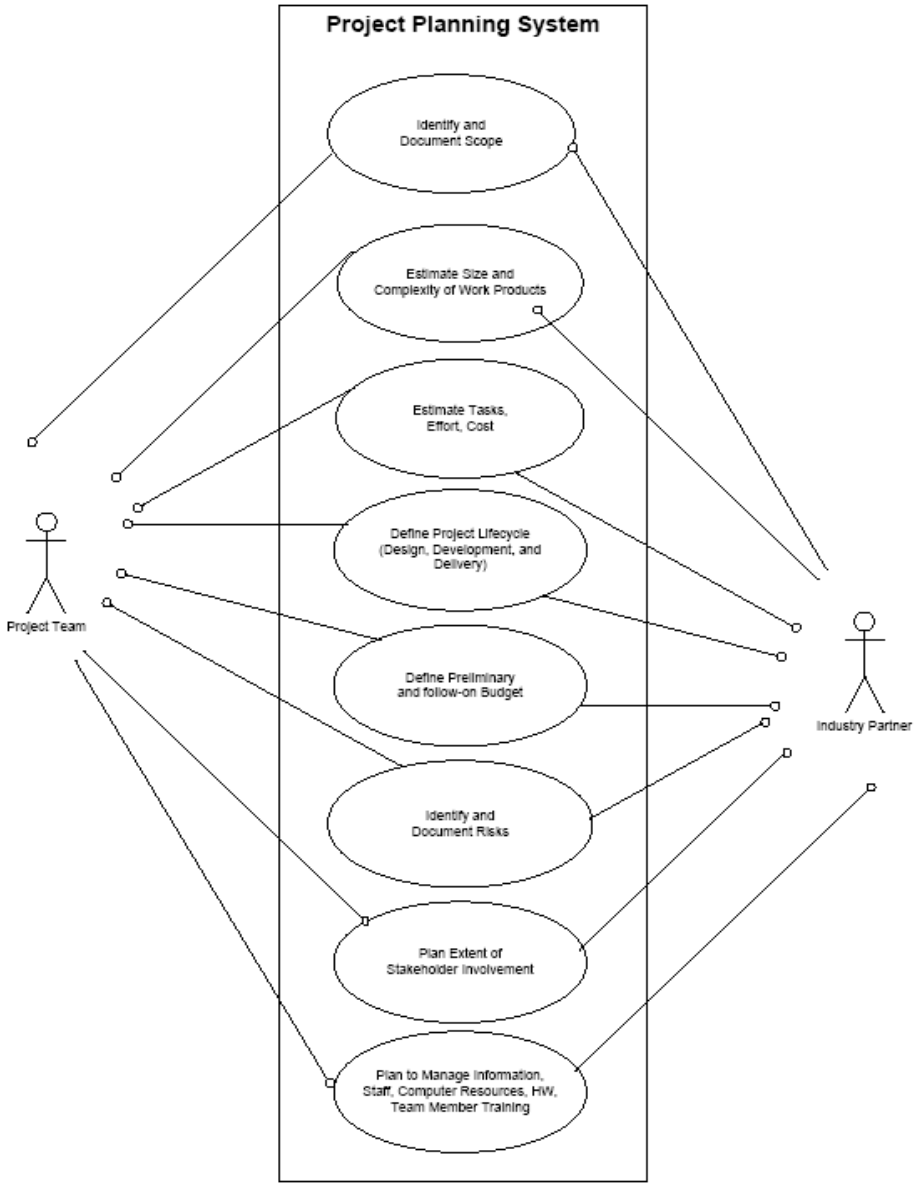

Figure 6. Project Planning Use Case Diagram

4. Project Monitoring and Control Element

Project Monitoring and Control includes activities both internal and external to the organization. At this level of abstraction these aspects are not distinguishable. What can be seen is that for this subsystem, two actors are involved in the eight practices shown in Figure 7.

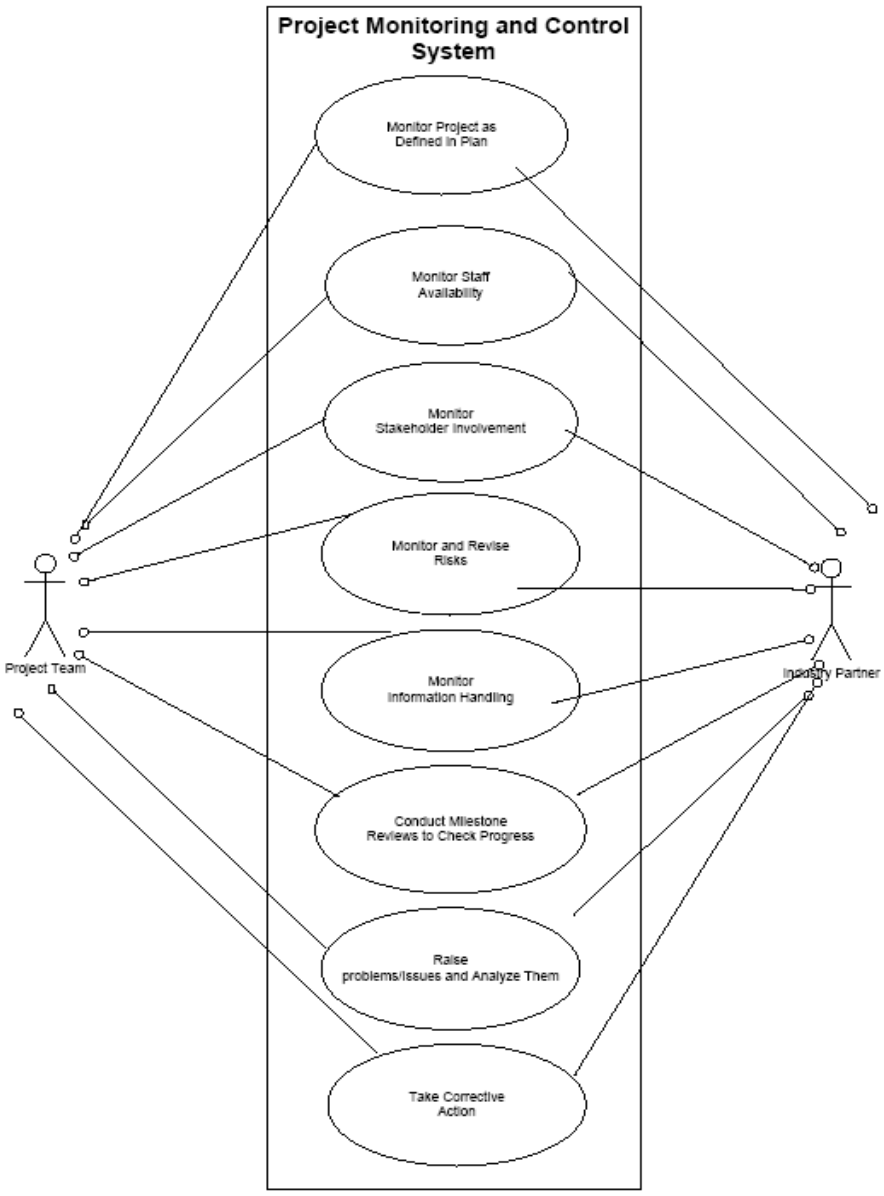

Figure 7. Project Monitoring and Control Use Case Diagram

III. METHOD

Two projects were selected for this study. The projects had similar project teams, requirements, schedules, artifacts, and staff. A checklist was developed for each of the three CMMI Process Areas chosen for the study (see sample in Appendix). A rating system to categorize the level of performance of each practice was developed, utilizing one of three possible outcomes for each practice evaluated: "Not Performed," "Not Performed Adequately," "Performed Adequately (or Better)." It is understood that two of the performance categories are subjective, and were designed to reveal the amount of improvement that would be necessary in certain areas. Results from both Case 1 and Case 2 were recorded on the same evaluation checklist. Information included in the evaluation results was provided to and reviewed by the project team members who participated in the evaluation.

A. PROCESS EVALUATION

1. Entry Criteria

The conditions (work products, activities, or events) that must have taken place before the activities described in the Procedure can be executed are as follows:

- Selection of the CMMI as the model as a benchmark for comparison purposes
- Development of checklists, rating scale, approach, and goals of process evaluations
- Ensure that the project team participants understand the criteria (CMMI practices) for comparison, the goals, and the rating system to be used
- Obtain permission from the organization's senior management for team members to participate in reviewing and discussing evaluation results

2. Input

Information, work products used by this procedure, or actions that are needed before the procedure can be executed are as follows:

- Previous project lessons learned (The lessons were derived from comments provided by project team members on an initial anonymous survey and from subsequent feedback sessions held with the project team to discuss the survey's findings.)
- Project artifacts such as project plans, project/senior management review/customer meeting minutes, configuration and quality assurance records, etc.
- CMMI Process Area Evaluation Checklists (see Appendix for example)

3. Exit Criteria

The list of the conditions (completed work products or actions) that are needed before the procedure can be considered complete and the next activity can begin is as follows:

- Collection of information such that a basis for a rating on each practice can be formed
- Consensus by participants, or resolution of disputes by the SEPG Lead, on evaluation results

4. Output

The list of the benefits and work products produced or actions that will result when the three evaluations are complete is as follows:

- Better understanding of the processes used by the organization
- Better understanding of the CMMI
- Evaluation results for two software maintenance projects in terms of suggested CMMI practices for three chosen Process Areas
- Better understanding of the organization's current capability
- Better understanding of the gaps between the organization's practices and suggested CMMI practices

- Better understanding of how the organization could do process audits
- Process evaluation checklists that can be tailored later to add more organization specific processes, and then used as process audit checklists for internal CMMI assessments
- Outlined procedures were generated for some procedures that were not documented prior to the evaluation
- Process Improvement artifacts (evaluation results demonstrate whether the organization has improved, maintained, or digressed in certain areas) from project to project
- Draft procedure for conducting process audits
- A sense of accomplishment, as a team, for having reached consensus together. Project team members worked together with SEPG members (some wore both hats).

5. Procedure

The following list summarizes the steps taken to conduct the process evaluations:

- Evaluation team participants were briefed on the approach, goals, and review checklists by the evaluator (author of this paper). A consensus on format, content, and rating system of the checklists was obtained. Checklists were revised by the evaluator as recommended.
- The process evaluator reviewed project artifacts, and when necessary, conducted interviews with project members to get input on processes and artifacts used.
- The process evaluator drafted evaluation results based on research and initial feedback.
- Draft evaluation results were released to the evaluation team for review.

- The evaluator and evaluation team met to discuss results. The rating and justification for each rating were reviewed for each practice, and each project. The evaluator noted clarification and identification of missing artifacts or supporting information.
- The evaluator finalized evaluation results by making recommended changes.
- The evaluator released the results to the evaluation team for final review, and to a few additional project team members who may have been able to offer additional feedback. Once all feedback was incorporated, the results were considered final.
- The evaluator and evaluation team presented the evaluation results to the project team together.

B. ANALYSIS

The next three chapters present discussion from a variety of perspectives on observed project management ability. First, a summary of both Case 1 and Case 2 CMMI Process Area evaluation results is presented. Analysis of each project is then presented. In addition to presentation of a brief summary of evaluation results, each analysis section includes review of post mortem lessons learned (which were reported by project team members). Next, a discussion on the comparison of Case 1 to Case 2 evaluation results shows whether or not the organization has improved, maintained, or digressed in process capability given the goals and practices examined. A comparison of the lessons learned to the evaluation results was made to determine if there is a correlation between the comments and the gap in practices. The purpose is to determine if there are similarities between the lessons learned and the evaluation results.

Rating categories can be viewed as a measure of the amount of improvement that will be required for the organization to reach success in each practice (i.e., “Not Performed” means there is room for every improvement, “Not Performed Adequately” means there is still room for significant improvement, and

“Performed Adequately” means that there is still room for some improvement). Process improvement is never done!

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IV. REQUIREMENTS MANAGEMENT STUDY

The results and analysis of the requirements management process for the two case studied are shown in the following subsections. An outline of the goals and associated practices defined for the CMMI Requirements Management Process Area, a score for each project studied (Case 1 and Case 2), and justification for each rating is first provided. A general analysis of the evaluation results for each case follows the data presentation. The analysis includes presentation and comparison to the post-mortem lessons learned to determine if there are correlations with the evaluation results. Note that the lessons are unique to the individual projects, and that only the lessons that apply to the area of study are included. Finally, a comparison of the two cases is made and a list of suggested improvements is provided.

A. CASE 1 AND CASE 2 EVALUATION RESULTS

CMMI interpretation notes, the score, and the basis for the rating for the Case 1 and Case 2 projects are provided below:

- Specific Goal (SG) 1 – "Requirements are managed and inconsistencies with project plans and work products are identified."
  - Specific Practice (SP) 1.1 – "Develop an understanding with the requirements providers on the meaning of the requirements" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. "Requirements" was interpreted as the statement of work, budget, and delivery schedule constraints.
    2. The organization demonstrated that they worked externally with the industry partner and customer to get more familiar with the requirements for both projects. The allocation of requirements to the organization and industry partner was then negotiated, and an agreement was made with the customer.

3. Internally, development and test personnel were involved in validating software trouble reports before they were added to the scope, thereby demonstrating their understanding of the project scope.

- SP1.2 – “Obtain Commitment to the requirements from the project participants” was “***Performed Adequately***” for Case 1. The practice was “***Not Performed Adequately***” for Case 2.
    1. Note that this practice was interpreted as referring to “initial” commitment made to a specific set of requirements.
    2. The organization demonstrated that an external initial commitment was made as a result of negotiation of the project requirements with the industry partner, and then approved by the customer.
    3. The organization demonstrated internal commitment by involving the organization project management, functional leads (software development, test, CM, and SQA) in the planning activities, including peer review of the project plan(s). A baseline is created for this organization following successful senior management review and approval.
    4. The Case 1 project team was successful at completing the above process. The Case 2 project team did not get the project plan through the peer review process until very late in the program, and did not get senior management approval until after the work was done, thus received the lesser rating. As a result, during the program the test and development teams were well aware of the schedule. However, the CM and SQA groups were not fully involved in these planning activities and were forced to accommodate the schedule after the fact.

- SP1.3 – “Manage changes to the requirements as they evolve during the project” was “***Not Performed Adequately***” for both Case 1 and Case 2.
    1. This practice was interpreted as referring to changes made after initial baselines were established.
    2. At the program level, as requirements changed for any reason, the baseline statement of work was reviewed, updated, and approved.
    3. As a result, the internal schedule and scope were updated, informally for both Cases. Peer reviews to make sure all functional teams were well aware of the changes, and the senior management approval process were neglected for the Case 1 baseline. The Case 2 baseline was never established to begin with.
- SP1.4 – “Maintain bi-directional traceability among the requirements and the project plans and the work products” was “***Not Performed Adequately***” for both Case 1 and Case 2.
    1. This practice was interpreted as referring to both the initial set of requirements, and to any changes made to the requirements.
    2. Final code and test procedure peer review packages from both projects demonstrate that affected requirements were accurately identified, and indeed, if requirements changes were necessary, system requirements were affected accordingly.
    3. However, for both projects, traceability of the requirements as stated in the internal project plans were not maintained via the planned peer review or senior management approval process, thus, the lesser rating was assigned.

- SP1.5 – “Identify inconsistencies between the (project plans and work products) and the requirements” was “***Performed Adequately***” for Case 1. The practice was “***Not Performed Adequately***” for Case 2.
    1. Note parenthesis added for interpretation to the practice definition.
    2. As requirements changed, the internal schedule was revised, albeit informally. As some requirements were eliminated, others were added. Development and test plans were revised accordingly. Changes were maintained informally by the software development lead. However, the changes were not added to the project plans to undergo the planned peer review and senior management approval process.
    3. Both projects were successful at micro-managing the requirements (work and services were performed by development, test, CM and SQA groups). However, the macro-management (coordination of activities) was missing for the Case 2 project. In fact, there was a major schedule misunderstanding between the organization and the industry partner. This could have been due to the lack of a dedicated project manager. The project team was able to recover anyway.
    4. Note that because of the small size of the project ream (around 20 members), a high-level of daily face-to-face communication took place to help maintain smooth interfaces. In addition, many of the same project members from the Case 2 team worked on the Case 1 project, and on a similar project prior to the work done for Case 1. The team

was able to rely on established relationships and processes to help with the success of the project.

- Generic Goal (GG) 2 – "The process is institutionalized as a managed process."
  - Generic Practice (GP) 2.1 – "Establish and maintain an organizational policy for planning and performing the Requirements Management process" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. The organization does have a formulated and documented Requirements Management policy that is used by the project teams. The plans for each of the projects provided a statement declaring that no special process tailoring was needed to execute the plan.
  - GP2.2 – "Establish and maintain the plan for performing the Requirements Management process" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Both project plans (which included the plans for the project's requirements management process) were developed, reviewed, and agreed to by team members.
    2. The project team decided that it was immaterial that the Case 2 project plan did not complete the peer review or senior management approval process successfully.
  - GP2.3 – "Provide adequate resources for performing the Requirements Management process, developing the work products, and providing the services of the process" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Resources for conducting the projects requirements management process were assigned by the project plans.
  - GP2.4 – "Assign responsibility and authority for performing the process, developing the work products, and providing the services

of the Requirements Management process" was "***Performed Adequately***" for both Case 1 and Case 2.

1. Each project plan had a "roles and responsibility" section, which assigned the responsibilities and authority to all of the requirements management activities.

- GP2.5 – "Train the people performing or supporting the Requirements Management process as needed" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Training for the project team consisted of previous experience, individual education, and on the job training for more current experiences. The project team had the skills necessary to execute the requirements management activities.
    2. For Case 2, the project team did receive training on changes to the development and test environment alongside the industry partner.
- GP2.6 – "Place designated work products of the Requirements Management process under appropriate levels of configuration" was "***Not Performed Adequately***" for both Case 1 and Case 2.
    1. The internal project plans (including scope, and schedule documents) and other work products were stored in a shared computer folder for easy access. Many copies have not yet been placed into the "Rational ClearCase" database, which is the organizations designated CM tool, thus the lesser rating was assigned.
- GP 2.7 – "Identify and involve the relevant stakeholders of the Requirements Management process as planned" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Relevant stakeholders (external and internal) were all identified in the project plans. While the plans were not

formally maintained via the peer review and senior management approval processes, all were involved in the discussions and decisions made regarding which requirements would be added, changed, or deleted. It would have been better if the formal processes had been followed, as it could have prevented a schedule misunderstanding with the industry partner that occurred. The project team was able to recover anyway.

- GP2.8 – "Monitor and control the Requirements Management process against the plan for performing the process and take appropriate corrective action" was "***Performed Adequately***" for Case 1, and was "***Not Performed Adequately***" for Case 2.
    1. As requirements changed, the internal schedule was revised, albeit informally. As some requirements were eliminated, others were added. Development and test plans were revised accordingly. Changes were maintained informally by the software development lead. However, the changes were not added to the project plans to undergo the planned peer review and senior management approval process.
    2. Both projects were successful at micro-managing the requirements (work and services were performed by development, test, CM and SQA groups). However, the macro-management (coordination of activities) was missing for the Case 2 project. In fact, there was a major schedule misunderstanding between the organization and the industry partner. This could have been due to the lack of a dedicated project manager. The project team was able to recover anyway.

3. Note that because of the small size of the project team (around 20 members), a high-level of daily face-to-face communication took place to help maintain smooth interfaces. In addition, many of the same project members from the Case 2 team worked on the Case 1 project, and on a similar project prior to the work done for Case 1. The team was able to rely on established relationships and processes to help with the success of the project.

- GP2.9 – "Objectively evaluate adherence of the Requirements Management process against its process description, standards, and procedures, and address noncompliance" was "***Not Performed Adequately***" for both Case 1 and Case 2 projects.
    1. The overarching process for SQA discussed independently evaluating the requirements management process. This was done by SQA at project meetings and senior management reviews. However, since a formal audit was never conducted the lesser rating was assigned for both projects. The project team indicated that a formal audit could help to improve the process.
- GP2.10 – "Review the activities, status, and results of the Requirements Management process with higher level management and resolve issues" was "***Performed Adequately***" for Case 1, and was "***Not Performed Adequately***" for Case 2.
    1. Requirements development and changes were discussed at project and senior management meetings. While both meetings were held diligently for the Case 1 project, the Case 2 project team conducted only two senior management reviews early on in the project. In addition, the occurrence of Case 2 project meetings also dropped off dramatically which prevented this practice, and thus the lesser rating was

assigned. This could have been due to the lack of a dedicated project manager.

- Generic Goal (GG) 3 – "The process is institutionalized a defined process."
  - GP 3.1 - "Establish and maintain the description of a defined Requirements Management process" was "***Performed Adequately***" for both Case 1 and Case 2 projects.
    1. The organization level requirements management procedure is a general process description that was used by the project teams, and has not changed. Both project plans provided a declaration statement indicating that no special process tailoring was needed to execute the project activities.
  - GP 3.2 - "Collect work products, measures, measurement results, and improvement information derived from planning and performing the Requirements Management process to support the future use and improvement of the organization's processes and process assets" was "***Not Performed Adequately***" for both Case 1 and Case 2 projects.
    1. For both projects, the software lead maintained a list of the number of initial requirements, how many were deemed not applicable, and how many were added. In addition, data on the estimates of difficulty and time to resolve problems were made, and compared to actual time spent. While this data was recorded it was not compiled for analysis with process improvement in mind, thus, the lesser rating was assigned.

B. CASE 1 ANALYSIS

1. Evaluation Results

The following observations were made based on process evaluation ratings given:

- 100% of the practices were performed to some degree (all were rated either "***Not Performed Adequately***", or "***Performed Adequately***" – none were rated "***Not Performed).***" In terms of the CMMI Model, all goals in this Process Area have been achieved since all practices are being performed to some extent.
- Overall, 12/17 or 71% of the practices were rated "***Performed Adequately***." This describes the success of most practices associated with each of the three goals in this Process Area indicating that the improvements will not need to be concentrated on one particular goal, rather, a few practices in each area will need to be improved.

2. Lessons Learned Reported

The lessons learned that affect the requirements management process is described below.

a. Project Requirements Were Not Well Understood

Some confusion resulted from the team not having a good understanding of project plans (including project goals, schedules, constraints, documentation required, processes to be used, the "big picture" of how the project management interacts with the industry partner and customer, and any organization goals or initiatives to improve project performance). In addition, the project team did not know exactly where to look for project data on the share drive to obtain up-to-date information on status.

C. CASE 2 ANALYSIS

1. Evaluation Results

The following observations were made based on process evaluation ratings given:

- 100% of the practices were performed to some degree (all were rated either “Not Performed Adequately”, or “Performed Adequately” – none were rated “Not Performed).” All practices are being performed to some extent.
- Overall, 8/17 or 47% of the practices were rated “Performed Adequately.” This describes the success of most practices associated with each of the three goals in this Process Area indicating that the improvements will not need to be concentrated on one particular goal, rather, a few practices in each area will need to be improved.

2. Lessons Learned Reported

a. It Was Hard to Get Next SOW Accepted by Industry Partner

The SOW for the organization was not finalized and approved before work began. This resulted in the industry partner starting/completing work on issues that the organization had planned to work on, and in fact, had started working on.

b. There Was Not Enough Coordination of System Integration Lab Activities with Developers and Testers

There was a lack of lab resources when needed (i.e., lab was going down so machines were not available for testing). Testing had to be done at the industry partner’s lab at the mercy of their schedule.

D. COMPARISON OF CASE 1 TO CASE 2

A comparison was done to determine the similarities and differences between Case 1 and Case 2 evaluation results.

1. Goals

The goals associated with the Requirements Management Process Area are as follows:

- Specific Goal (SG) 1 - Requirements are managed and inconsistencies with project plans and work products are identified.
- Generic Goal (GG) 2 – The process is institutionalized as a managed process.
- Generic Goal (GG) 3 – The process is institutionalized as a defined process.

The achievement by Case 1 and Case 2 in terms of goal success can be described by a comparison of the number of practices given the "Performed Adequately" rating to the total number of practices for that goal. The results of this analysis follow:

Case 1 - SG 1 - 3/5 or 60%
GG 2 - 8/10 or 80%
GG 3 – 1/2 or 50%
Case 2 - SG 1 - 1/5 or 20%
GG 2 - 6/10 or 60%
GG 3 – 1/2 or 50%

No overall goal improvements can be demonstrated by this data, only digression for SG 1 and GG 2.

2. Practices

Practice	Case 1		Case 2	
	Not Performed Adequately	Performed Adequately	Not Performed Adequately	Performed Adequately
SP 1.1		X		X
SP 1.2		X	X	
SP 1.3	X		X	
SP 1.4	X		X	
SP 1.5		X	X	
GP 2.1		X		X
GP 2.2		X		X
GP2.3		X		X
GP 2.4		X		X
GP 2.5		X		X
GP 2.6	X		X	
GP 2.7		X		X
GP 2.8		X	X	
GP 2.9	X		X	
GP 2.10		X	X	

GP 3.1		X		X
GP 3.2	X		X	

Table 1 Summary of Requirements Management Evaluation Results

The results do not demonstrate improvement from Case 1 to Case 2 in any requirements management practice evaluated. They do show digression in the following practices (highlighted rows):

- SP1.2 Obtain Commitment to the requirements from the project participants
- SP1.5 Identify inconsistencies between the project plans and work products and the requirements
- GP2.8 - Monitor and control the Requirements Management process against the plan for performing the process and take appropriate corrective action
- GP2.10 - Review the activities, status, and results of the Requirements Management process with higher-level management and resolve issues.

In addition, results indicate that for both projects, the following practices were "***Not Performed Adequately***:"

- SP1.3 - Manage changes to the requirements as they evolve during the project
- SP1.4 - Maintain bi-directional traceability among the requirements and the project plans and the work products
- GP2.6 - Place designated work products of the Requirements Management process under appropriate levels of configuration
- GP2.9 - Objectively evaluate adherence of the Requirements Management process against its process description, standards, and procedures, and address noncompliance

GP 3.2 Collect work products, measures, measurement results, and improvement information derived from planning and performing the

Requirements Management process to support the future use and improvement of the organization's processes and process assets.

3. Comparison of Evaluation Results to Lessons Learned

Examination of the Requirements Management process evaluation results shows that both projects had some practices that were assigned the "Not Performed Adequately" rating. Looking closer at the comments reveal that both lacked the use of the peer review, senior management approval, and formal CM process on project requirements, which resulted in a lack of maintaining traceability of project requirements to project plans.

It makes sense that if project requirement information is not up to date or missing in plans, and not accessible, the project team reported, "project requirements were not well understood" (the lesson learned for Case 1).

The Case 2 project had additional practices that received the "Not Performed Adequately" rating. Further examination of detailed comments for those evaluation results shows that the basic problems included the fact that the project team did not get the project plan through the peer review process until very late in the program, and did not get senior management approval until after the work was done. In addition, macro-management (coordination of activities) was missing for the Case 2 project. In fact, there was a major schedule misunderstanding between the organization and the industry partner. In addition, the Case 2 project team conducted only two senior management reviews early on in the project, and the occurrence of project meetings dropped off dramatically. The team indicated that this could have been due to the lack of a dedicated project manager and Senior Management Reviews were delayed while waiting for plan completion.

One of the lessons learned for Case 2 involved lack of coordination between lab activities with developers and testers. The same comment can be made (as above), that is, if project requirement information is not up to date or missing in plans it was not accessible. As a result, the lack of coordination between the project team functional groups is not surprising. For Case 2, this

could have been due to the lack of a dedicated project manager. Note that because of the small size of the project team (around 20 members) a high-level of daily face-to-face communication took place to help maintain smooth interfaces. In addition, many of the same project members from the Case 2 team worked on the Case 1 project (and on a similar project prior to the work done for Case 1). The team was able to rely on established relationships and processes to help with the success of the project.

The evaluation results also showed that while "[process improvement] data [this time referring to technical requirements] was recorded, it was not compiled for analysis with process improvement in mind," and that a formal process audit [addressing handling of project and technical requirements] had not been conducted.

The other Case 2 lesson learned (It was hard to get the next SOW accepted by Industry Partner) resulted from the fact that the SOW for the organization was not finalized and approved before work began. This resulted in the industry partner starting/completing work on issues that the organization had planned to work on, and in fact, had started working on (duplication of effort). While this lesson involves technical requirements instead of project requirements, the lesson is similar in that it is a logical result if requirement information is not up to date or missing in (internal, and/or external) plans.

It is interesting to note that one characteristic of a CMMI Level 1 organization is that people create their own processes to do the work, creating the potential for duplication, and even conflict later on in the project. Looking only at the instance of duplication (the organization and industry partner working on the same technical requirements) it might appear that this is a Level 1 organization. However, Level 2 organizations share lessons learned and best practices across projects, or across the organization. Requirements Management is a Level 2 Process Area. While the organization did not have outstanding performance on all practices, it was demonstrated that something is being done by the project team in every area. The transition from simply

managing requirements to actually managing plans takes place as the organization advances from Level 2 to Level 3. It appears that the source of risk lies within managing the plans for this organization.

This information can be used to identify a business goal on which to base targeted process improvement, such as “to improve the project requirements baseline and change process.”

E. SUGGESTED IMPROVEMENTS

As a result of the above Case 1 and Case 2 analysis, the following list of improvement suggestions was compiled. Some suggestions are a direct reflection of the lessons learned reported, some are specific to CMMI practice requirements that need to be fulfilled, and some are more general and would contribute indirectly to all reported deficiencies. The list can be used to improve the project performance by targeting process improvement in these areas.

- Make sure that a project manager is assigned and dedicated to initiating and following through on requirements management activities for the project.
- Hold a project kick-off meeting with the project staff to brief the team on the project plan(s). Understanding the project requirements will help to alleviate some misunderstanding within the project team and focus on successfully achieving them in a more efficient manner.
- Make sure that project plans (including schedule and scope requirements and constraints) are reviewed and approved by functional leads and senior management early on in the project (complete the peer review and management approval process for managerial and technical requirements).
- There needs to be more coordination between the organization’s lab and project work. A work plan where all activities are scheduled and coordinated with all affected parties should be developed. If communication within the project team fails and there isn’t a project

manager to keep things on track, senior management must step in to avoid negative consequences.

- The organization needs to get involved with the industry partner earlier in the planning stages. In fact, the organization should brief the industry partner on the goals of the partnership.
- Develop questions and metrics to measure accomplishments in response to the business goal to “improve the project requirements baseline and change process.”
- Make sure project plans (including schedule and scope documents) are updated to reflect program level changes. Use “baselining” (accomplished at the organization by completing the senior management approval process) to keep a record of current agreements made for the duration of the project.
- Make sure that project and senior management review meetings are held as planned, on a regular basis.
- Place all requirements management work products under formal CM control.
- Conduct a formal audit on the requirements management process at least once during project execution.
- Update policy, process, and procedure documentation to reflect the additional activities recommended.

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V. PROJECT PLANNING STUDY

The results and analysis of the project planning process for the two case studied are shown in the following subsections. An outline of the goals and associated practices defined for the CMMI Project Planning Process Area, a score for each project studied (Case 1 and Case 2), and justification for each rating is first provided. A general analysis of the evaluation results for each case follows the data presentation. The analysis includes presentation and comparison to the post-mortem lessons learned to determine if there are correlations with the evaluation results. Note that the lessons are unique to the individual projects, and that only the lessons that apply to the area of study are included. Finally, a comparison of the two cases is made and a list of suggested improvements is provided.

A. CASE 1 AND CASE 2 EVALUATION RESULTS

The goals and associated practices defined for the CMMI Project Planning Process Area, and individual practice ratings assigned by the project team are as follows:

- Specific Goal (SG) 1 – "Estimates of project planning parameters are established and maintained."
  - Specific Practice (SP) 1.1 – "Establish a top-level work breakdown structure (WBS) to estimate the scope of the Project" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. "Established" was interpreted as formulated, documented, and used, and not necessarily baselined.
    2. The initial Work Breakdown Structure for both projects was identified in the project schedule.
    3. Case 1 schedule underwent and passed the peer review and senior management approval process.
    4. Case 2 schedule did not undergo the peer review or senior management approval process. However, the project team

indicated that the project team was well aware and working to the proposed WBS. The WBS was presented at the senior management review meetings, two of which were held early on in the project.

- SP 1.2 – “Establish and maintain estimates of the attributes of the work products and tasks” was “***Performed Adequately***” for both Case 1 and Case 2.
    1. “Attributes” was interpreted as “inputs to estimating models, such as complexity, or skills/effort, or estimates for similar previous experience (values that affect calculation of the size of the project).”
    2. For both Case 1 and Case 2, attributes identified were collected and maintained by the functional leads (software development, test, CM, and QA) on an informal basis. This information was shared between the leads, and some had been combined in the project plan.
- SP1.3 – “Define the project life-cycle phases upon which to scope the planning effort” was “***Performed Adequately***” for both Case 1 and Case 2.
    1. For both cases, project life cycle phases were described in the project plans as task categories under which effort would be organized for recording actual time spent. Estimates were separated, and actual effort recorded, under these categories.
- SP1.4 – “Estimate the project effort and cost for the work products and tasks based on estimation rationale” was “***Performed Adequately***” for both Case 1 and Case 2.
    1. For both projects, cost and effort estimates were provided in the project plans, and schedule estimates in the project

schedules. As noted in the project plans, historical data was used to generate the estimates.

2. For Case 2, the QA Lead documented the comparison and analysis of Case 1 estimated and actual effort data to generate estimates for Case 2. Other functional leads called upon previous experience, instead of examining actual values collected, to develop their estimates.

- Specific Goal (SG) 2 – "A project plan is established and maintained as the basis for managing the project."
  - Specific Practice (SP) 2.1 – "Establish and maintain the project's budget and schedule" was "***Not Performed Adequately***" for Case 1 or Case 2.
    1. For both projects, cost and effort estimates were provided in the project plans, schedule estimates in the project schedules.
    2. For Case 1, estimates underwent the peer review and senior management approval process. However, estimates were not revised when there was a significant scope increase early in the project, nor for the remainder of the project.
    3. For Case 2, the estimates did not go through the peer review or senior management approval processes, therefore, were never baselined (nor maintained).
  - SP2.2 – "Identify and analyze project risks" was "**Performed Adequately**" for Case 1 and "***Not P*erformed Adequately**" Case 2.
    1. For both projects, initial risks were identified in the project plans, which for Case 1 underwent the peer review and senior management approval process (Case 2 risks did not go through these processes).
    2. For both projects initial risks were reviewed and updated regularly at project and senior management review meetings

held early in the projects. A “risk exposure” was calculated to sum up the risks identified for each project.

3. Subsequent review and revision of this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project for Case 2 as the leadership in the project engineer (manager) role also dropped off.

- SP2.3 – “Plan for the management of project data” was “***Performed Adequately***” for both Case 1 and Case 2.
    1. Plans for managing project data were documented in the project plans for each project.
- SP2.4 – “Plan for the necessary resources to perform the project” was “***Performed Adequately***” or both Case 1 and Case 2.
    1. Plans for resource allocation were documented in the project plans for each project.
- SP2.5 – “Plan for knowledge and skills needed to perform the project” was “***Performed Adequately***” for both Case 1 and Case 2.
    1. Plans for training needed to accomplish the work were documented in the project plans for each project.
- SP2.6 – “Plan the involvement of identified stakeholders” was “***Performed Adequately***” for both Case 1 and Case 2.
    1. Identification of (and plans for interaction with) major stakeholders was documented in the project plans for each project.
- SP2.7 – “Establish and maintain the overall project plan content” was “***Not Performed Adequately***” for both Case 1 and Case 2.
    1. For Case 1, the project plan was developed, and passed the peer review and senior management approval processes.

2. For Case 2, the plan was developed. However, it did not go through the same review and approval processes, so an initial baseline was never established.
3. While for both Case 1 and Case 2, project plans were established, they were not maintained for either project (to reflect changes in scope, schedule, or effort estimates).

- Specific Goal (SG) 3 – "Commitments to the project plan are established and maintained."
  - Specific Practice (SP) 3.1 – "Review all plans that affect the project to understand project commitments" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. For Case 1, the project plan was developed, and passed the peer review and senior management approval processes.
    2. For Case 2, the plan was developed, and underwent the peer review process.
  - SP3.2 - "Reconcile the project plan to reflect available and estimated resources" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. For Case 1, the project plan was developed, and passed the peer review and senior management approval processes.
    2. For Case 2, the plan was developed, and underwent the peer review process.
  - SP3.3 – "Obtain [initial] commitment from relevant stakeholders responsible for performing and supporting plan execution" was "***Performed Adequately***" for Case 1 and "***Not Performed Adequately***" for Case 2.
    1. For Case 1, the project plan was developed, and passed the peer review and senior management approval processes.
    2. For Case 2, the plan was developed, and underwent the peer review process, but not until well into the performance

period. It was not approved by senior management until after the project work was done.

3. The team lead (senior management) was involved in several informal reviews and the peer review. However, the plan was not approved until after the project work was done.

- Generic Goal (GG) 2 – "The process is institutionalized as a managed process."
  - Generic Practice (GP) 2.1 – "Establish and maintain an organizational policy for planning and performing the Project Planning process" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. The organization has a project planning policy albeit very general. The process did not change from the time the Case 1 project was executed to the time the Case 2 project was executed.
  - GP2.2 – "Establish and maintain the plan for performing the Project Planning process" was "***Performed Adequately***" for Case 1 and "***Not Performed Adequately***" for Case 2.
    1. The organization project plan procedures describe how to create a project plan.
    2. Schedules for both Case 1 and Case 2 projects have development milestones for the plans, under a main "Project Planning" category.
    3. For Case 1, the project plan was developed, and passed the peer review and senior management approval processes.
    4. For Case 2, the plan was developed but did not go through the same review and approval processes.
  - GP2.3 – "Provide adequate resources for performing the Project Planning process, developing the work products, and providing the services of the process" was "***Performed Adequately***" for Case 1 and "***Not Performed Adequately***" for Case 2.

1. Resources were provided for both projects to do planning, as evidenced by the project plans developed.
2. However, for Case 2, primary responsibility was passed from one to another person more than once. When action wasn't taken, no "quick" attempt was made by management to reassign this responsibility.

- GP2.4 – "Assign responsibility and authority for performing the process, developing the work products, and providing the services of the Project Planning process" was "***Performed Adequately***" for Case 1 and "***Not Performed Adequately***" for Case 2.
    1. Resources were provided for both projects to do planning, as evidenced by the project plans developed.
    2. However, for Case 2, primary responsibility was passed from one to another person more than once. When action wasn't taken, no "quick" attempt was made by management to reassign this responsibility.
- GP2.5 – "Train the people performing or supporting the Project Planning process as needed" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. For both projects, training consisted of previous experience of the members of a small management team; in fact, the same team was used for both projects.
    2. In addition, on the job training was provided to some team members by functional leads, and some had a college course in project management, which included planning aspects.
- GP2.6 – "Place designated work products of the Project Planning process under appropriate levels of configuration" was "***Not Performed Adequately***" for Case 1 or Case 2.

1. All project plans, schedules, and other project planning artifacts were stored in the team shared folder. However, the documents were not put into ClearCase, the designated CM tool.
2. The Case 2 project plan was put into ClearCase, but not until after the project was over.

- GP 2.7 – "Identify and involve the relevant stakeholders of the Project Planning process as planned" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Relevant stakeholders were all part of the team that developed and reviewed the project plans for both projects.
    2. These activities were monitored by the QA group, during project and senior management review meetings.
- GP2.8 – "Monitor and control the Project Planning process against the plan for performing the process and take appropriate corrective action" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Project plans for both Case 1 and Case 2 underwent the peer review process. However, corrective action was not taken to address getting plan changes incorporated.
    2. These activities were monitored by the QA group, during project and senior management review meetings.
- GP2.9 – "Objectively evaluate adherence of the Project Planning process against its process description, standards, and procedures, and address noncompliance" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Planning activities were monitored (albeit informally) by the QA group, during project and senior management review meetings.
- GP2.10 – "Review the activities, status, and results of the Project Planning process with higher-level management and resolve

issues" was "***Performed Adequately***" for Case 1 and "***Not Performed Adequately***" for Case 2.

1. Senior management review meetings were conducted for the Case 1 project on a regular basis throughout the entire project.
2. Only 2 senior management review meetings were conducted early on for the Case 2 project.

- Generic Goal (GG) 3 – "The process is institutionalized a defined process."
  - GP 3.1 - "Establish and maintain the description of a defined Project Planning process" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Four organization level procedures were identified; the "Software Schedule Procedure", the "Senior Management Review Procedure", the "Software Development Plan Procedure", and the "Software Project Planning and Estimating Procedure."
  - GP 3.2 – "Collect work products, measures, measurement results, and improvement information derived from planning and performing the Project Planning process to support the future use and improvement of the organization's processes and process assets" was "***Not Performed Adequately***" for Case 1 or Case 2.
    1. Metrics on the planning process (such as the number of pages for the project plan, length of time to prepare the plan, and number of peer reviews held for previous projects) was available. However, the data was not used to generate estimates for either Case 1 or Case 2.
    2. Lessons learned from previous projects and for both of these projects were identified, collected, and analyzed to assist in planning the next project.

3. All of these activities were done on an informal basis. Data was not complied and analyzed with process improvement in mind.

B. CASE 1 ANALYSIS

1. Evaluation Results

The following observations were made based on ratings assigned:

- 100% practices were performed to some degree (all were rated either "***Not Performed Adequately***", or "***Performed Adequately***" – none were rated "***Not Performed***)." All practices are being performed to some extent.
- Overall 22/26 or 85% practices were rated "***Performed Adequately***". This describes the success of most practices associated with each of the three goals in this Process Area indicating that the improvements will not need to be concentrated on one particular goal.

2. Lessons Learned Reported

a. The Project Lacked a Single Unified Software Project Management Plan

The lack of a single coordinated plan resulted in individual functional plans whose schedules were not necessarily in synch. This led to significant delays in getting senior management approval.

b. The Lab Facility Had Much Unplanned Lab Down Time

Organization lab facility schedules and resources directly affected the development and test efforts, in fact, forced the need to utilize resources at the industry partner facility at their convenience (with some inconvenience to the developers and testers). As a result there were significant delays in development and testing activities that required lab use.

C. CASE 2 ANALYSIS

1. Evaluation Results

- 100% practices were performed to some degree (all were rated either "***Not Performed Adequately***", or "***Performed Adequately***" – none were rated "***Not Performed***"). All practices were performed to some extent.
- Overall, 16/26 or 62% practices were rated "***Performed Adequately***". This describes the success of most practices associated with each of the three goals in this Process Area indicating that the improvements will not need to be concentrated on one particular goal.

2. Lessons Learned Reported

a. The Project Plan Took too long to Produce and Review

The project plan was not completed, peer reviewed, and approved by senior management until well after the work was done. New persons, the industry partner, and even existing team members did not know about and understand all parts of the plan so there was confusion about several aspects, especially how one group handed off their work to the next group (development, test, SQA, CM).

b. Effort Estimates Were Not Revised to Reflect Increased Scope

Early on in the project there was a significant increase in the scope. Effort estimates were not revised, peer reviewed, and approved by senior management. As a result, after that point it was impossible to compare actual to estimated data (it did not make sense anymore.

c. Effort Data Was Not Organized Consistently

There does not appear to be a consistent way to organize the data (i.e., to record time spent on multiple projects, or for multiple tasks on the same project). SQA records ALL data for 100% hours spent in one worksheet for each group member. This enables overhead/direct effort and project-to-project comparisons. There appears to be a separate worksheet for some activities. Yet, the data it contains has not been considered in audits. In some cases there

is no way to determine which project the data is recorded for, and the existing data does not appear to be complete.

D. COMPARISON OF CASE 1 TO CASE 2

1. Goals

- Specific Goal (SG) 1 - Estimates of project planning parameters are established and maintained.
- Specific Goal (SG) 2 - A project plan is established and maintained as the basis for managing the project.
- Specific Goal (SG) 3 - Commitments to the project plan are established and maintained.
- Generic Goal (GG) 2 – The process is institutionalized as a managed process.
- Generic Goal (GG) 3 – The process is institutionalized a defined process.

Case 1 – SG 1 – 4/4 or 100%
SG 2 – 5/7 or 71%
SG 3 – 3/3 or 100%
GG 2 – 8/10 or 80%
GG 3 – ½ or 50%

Case 2 – SG 1 – 4/4 or 100%
SG 2 – 4/7 or 57%
SG 3 – 2/3 or 67%
GG 2 – 4/10 or 40%
GG 3 – 1/2 or 50%

Unfortunately, no overall goal improvements can be demonstrated by this data, only digression for SG 3 and GG 2.

2. Practices

Practice	Case 1		Case 2	
	Not Performed Adequately	Performed Adequately	Not Performed Adequately	Performed Adequately
SP 1.1		X		X
SP 1.2		X		X
SP 1.3		X		X
SP 1.4		X		X
SP 2.1	X		X	

SP 2.2		X	X	
SP 2.3		X		X
SP 2.4		X		X
SP 2.5		X		X
SP 2.6		X		X
SP 2.7	X		X	
SP 3.1		X		X
SP 3.2		X		X
SP 3.3		X	X	
GP 2.1		X		X
GP 2.2		X	X	
GP 2.3		X	X	
GP 2.4		X	X	
GP 2.5		X		X
GP 2.6	X		X	
GP 2.7		X		X
GP 2.8		X		X
GP 2.9		X		X
GP 2.10		X	X	
GP 3.1		X		X
GP 3.2	X		X	

Table 2 Summary of Project Planning Evaluation Results

The results do not demonstrate improvement from Case 1 to Case 2 in any project planning practice evaluated. They do show digression in the following practices (highlighted rows);

- SP 2.2 – Identify and analyze project risks.
- SP3.3 – Obtain commitment from relevant stakeholders responsible for performing and supporting plan execution.
- GP2.2 – Establish and maintain the plan for performing the Project Planning process.
- GP2.3 - Provide adequate resources for performing the Project Planning process, developing the work products, and providing the services of the process.

- GP2.4 - Assign responsibility and authority for performing the process, developing the work products, and providing the services of the Project Planning process.
- GP2.10 - Review the activities, status, and results of the Requirements Management process with higher-level management and resolve issues.

In addition, results indicate that for both projects, the following practices were "***Not Performed Adequately:***"

- SP 2.1 – Establish and maintain the project's budget and schedule.
- SP2.7 – Establish and maintain the overall project plan content.
- GP2.6 – Place designated work products of the Project Planning process under appropriate levels of configuration.
- GP 3.2 – Collect work products, measures, measurement results, and improvement information derived from planning and performing the Project Planning process to support the future use and improvement of the organization's processes and process assets.

3. Comparison of Evaluation Results to Lessons Learned

Examination of the comments from the evaluation results for which both projects had "Not Performed Adequately" rating show that while for both Case 1 and Case 2, project plans were established, they were not formally maintained or controlled for either project (to reflect changes in scope, schedule, or effort estimates). Some metrics were collected, some artifacts were stored, and some lessons learned were collected. However, those activities were also conducted informally, without process improvement necessarily in mind.

The Case 1 project team noted negative impacts to the project due the lack of a single unified software project management plan, and the fact that the lab facility had much unplanned down time (lessons learned). As a result, there were schedule and resource misunderstandings, including delays in development and testing. These results are a logical conclusion (could have been predicted) given the process evaluation results.

The Case 2 project had additional practices that received the “Not Performed Adequately” rating (noted above). The Case 2 project digressed quickly by never establishing a requirements baseline (which for this organization translates into following the management approval process), by not following through on project and senior management review meetings, and more important by not having a dedicated project engineer (manager). The project team and senior management knew what to do (they had been done well for the Case 1 project). However, they lacked the discipline required to follow through with previously followed processes. Without conducting a formal project planning process audit, the project management activities degraded slowly, without much notice. After all, the team worked to the draft project plans and products were getting generated in spite of the circumstances. However, when project management duties fell by the wayside after obvious need several team members became frustrated

The Case 2 project team noted that the Project Plan took too long to produce and review, effort estimates were not revised to reflect increased scope, and effort data was not organized consistently. As a result, there were misunderstandings, miscommunications, and a general lack of commitment and interest in completing the project plan, and recording effort data. The decisions (not) made put the team in the position whereby it became necessary to rely on the small size and experience, instead of disciplined project management activities. The lack of team and senior management interaction caused the team to drift apart in the way effort data was organized and recorded.

Again, it is interesting to note that one characteristic of a CMMI Level 1 organization is that people create their own processes to do the work, creating the potential for duplication, and even conflict later on in the project. This is exactly what happened with the project plan and the effort data records.

While the organization did not have outstanding performance on all practices, it was demonstrated that something was being done by the project team in every process area. The transition from simply managing requirements

to actually managing plans takes place as the organization advances from Level 2 to Level 3. It appears that the source of risk lies within managing the plans for this organization.

This information can be used to identify a business goal on which to base targeted process improvement, such as “to improve the project plan baseline and change process.”

E. SUGGESTED IMPROVEMENTS

As a result of the above Case 1 and Case 2 analysis, the following list of improvement suggestions was compiled. Some suggestions are a direct reflection of the lessons learned reported, some are specific to CMMI practice requirements that need to be fulfilled, and some are more general and would contribute indirectly to all reported deficiencies. The list can be used to improve the project performance by targeting process improvement in these areas.

- Make sure a dedicated resource is assigned to perform the project engineer (manager) role (to follow up on project plan peer review and approval process, project and senior management review meetings, the change control process, etc.). If a dedicated resource is unavailable, duties should be reassigned aross available resources (in this case, Functional Leads).
- A single Software Project Management Plan (SPMP) should be developed that coordinates all of the functional area plans for the project – Software Development Plan (SDP), Risk Management Plan (RMP), Software Test Plan (STP), Software Configuration Management Plan (SPMP), Software Quality Assurance Plan (SQAP), and Laboratory Management Plan (LMP).
    - The schedule and resources available for the organization lab facilities should be included in planning and estimating activities. The acquisition of laboratory equipment and any related down time for installation should be included in overall project planning. This

would ensure that lower priority items would be managed at the same time immediate problems are being resolved quickly. This would prevent significant delays in development and testing activities that require lab use. The lab played a huge part in the ability to follow the planned processes, for both cases. This implies that management needs to improve the lab situation (i.e., provide more staffing/resources/oversight).

  - A new focused process for producing the plan is needed. The plan can be stripped down to its essential elements to further reduce the time it takes to produce and review. Finish the plan well before delivering software. Define specific authority and criteria to catch a significant slip in plan completion.

- Make sure project plans (including schedule and scope documents) are updated to reflect program level changes. Use “baselining” (accomplished at the organization by completing the senior management approval process) to keep a record of current agreements made for the duration of the project.
- Updates to effort estimates must be documented and maintained. Correct information on the location of the data and who should be on the audit roster needs to be communicated to the auditor.
- Develop a plan for effort data organization such that short term (ease of entry) and long term (combining data for overall comparison purposes) goals are considered.
- Develop questions and metrics to measure accomplishments in response to the business goal to “improve the project planning process.”
- Archive all project planning work products using the organization’s designated CM tool.

- Conduct a formal audit on the project planning process at least once during project execution.
- Update policy, process, and procedure documentation to reflect additional activities.

VI. PROJECT MONITORING AND CONTROL STUDY

The results and analysis of the project monitoring and control process for the two case studied are shown in the following subsections. An outline of the goals and associated practices defined for the CMMI Project Monitoring and Control Process Area, a score for each project studied (Case 1 and Case 2), and justification for each rating is first provided. A general analysis of the evaluation results for each case follows the data presentation. The analysis includes presentation and comparison to the post-mortem lessons learned to determine if there are correlations with the evaluation results. Note that the lessons are unique to the individual projects, and that only the lessons that apply to the area of study are included. Finally, a comparison of the two cases is made and a list of suggested improvements is provided.

A. CASE 1 AND CASE 2 EVALUATION RESULTS

The goals and associated practices defined for the CMMI Project Monitoring and Control Process Area, and individual practice ratings assigned by the project team are as follows:

- Specific Goal (SG) 1 – "Actual performance and progress of the project are monitored against the project plan."
    - Specific Practice (SP) 1.1 – "Monitor (after documenting initial estimates, changed estimates if project parameters changed) actual values of the project planning parameters against the project plan" was "***Performed Adequately***" for both Case 1 and Case 2. *Note: "Attributes" are "inputs to estimating models, such as complexity, or skills/effort, or previous estimates of the software changes" (i.e., values that affect calculation of the size of a project).*
        1. The Case 1 project schedule, effort, and scope were identified, reviewed, and baselined (approved by senior management) during planning stages of the project.

Subsequent review and revision of this data took place at regular project and senior management review meetings.

2. The Case 2 project schedule, effort, and scope were identified and reviewed during planning stages of the project. However, they were never baselined (approved by senior management). Subsequent review and revision of this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule, cost anyway.
3. For both projects, project plans were based on parameters. Resources and delivery contents are allocated, and affected by, actual attributes (i.e., problem analysis may reveal a lesser or greater actual complexity factor).

- SP1.2 – "Monitor commitments against those identified in the project plan" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Case 1 project commitments (internal and external) to scope, schedule, and cost were reviewed regularly at internal project and senior review management review meetings, and external overarching integrated product team meetings. This demonstration is evident from copies of associated minutes and presentation materials.
    2. Case 2 external commitments were reviewed with industry partners on a regular basis. Internal commitments were reviewed initially at project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make

planned scope deliveries within schedule and cost anyway since commitments were reviewed with the software and test teams, even though it was a less formal process.

3. Also, planned SQA audits were conducted for both projects, in addition to monitoring peer review activity.

- SP1.3 – “Monitor risks against those identified in the project plan” was “***Performed Adequately***” for Case 1 and “***Not Performed Adequately***” for Case 2.
    1. Case 1 risks were identified, reviewed, and baselined (approved by senior management) during planning stages of the project. A separate Risk Management Plan was prepared. Subsequent review and revision of this data took place at regular project and senior management review meetings.
    2. Case 2 risks were identified and reviewed during planning stages of the project, as a Risk Management section was included in the project plan. Subsequent review and revision of this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule and cost anyway. However, the project team indicated that monitoring risks informally was not sufficient.
- SP1.4 – “Monitor the management of (internal) project data (schedule, cost in terms of effort, and scope) against the project plan” was “***Performed Adequately***” for both Case 1 and Case 2.

1. Project data was interpreted as “documents required to support the project such as work products, action item lists, meeting minutes, or lessons learned reports.”
2. For both projects, the plan to manage project data was provided in the project plan. It included directions for generation and distribution of both deliverable and non-deliverable work products, CM (SCR database), and QA artifacts. Meeting minutes, QA audit results, and the project action item list served as records used to monitor the management of project data.
3. The Case 1 project schedule, effort, and scope were identified, reviewed, and baselined (approved by senior management) during planning stages of the project. Subsequent review and revision of this data took place at regular project and senior management review meetings.
4. The Case 2 project schedule, effort, and scope were identified and reviewed during planning stages of the project. However, they were never baselined (approved by senior management). Subsequent review and revision of this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule and cost anyway.

- SP1.5 – “Monitor stakeholder involvement against the project plan” was “***Performed Adequately***” for both Case 1 and Case 2.
    1. Case 1 stakeholder involvement was identified, reviewed, and baselined (approved by senior management) during planning stages of the project. Subsequent review and revision of this data took place at regular project and senior

management review meetings, overarching integrated product team or software meetings with the industry partner.

2. Case 2 stakeholder involvement was identified and reviewed during planning stages of the project. However, they were never baselined (approved by senior management). Subsequent review and revision of this data took place at regular project and senior management review meetings, overarching integrated product team or software meetings with the industry partner. However, internal senior management review and project meeting activities dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule and cost anyway. External stakeholders were involved, and when there was a schedule misunderstanding, it was an exception (it was not typical for the industry partner not to have informed the organization of a critical change).

- SP1.6 – "Periodically review the project's progress, performance, and issues" was "***Performed Adequately***" for both Case 1 and Case 2.

  1. Case 1 project progress, performance, and issues were identified (in terms of software drops), reviewed, and baselined (approved by senior management) during planning stages of the project. Subsequent review and revision of this data took place at regular project and senior management review meetings.

  2. Case 2 project progress, performance, and issues were identified (in terms of software drops) and reviewed during planning stages of the project but never baselined (approved

by senior management). Subsequent review and revision of this data took place at regular project and senior management review meetings but this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule, cost anyway. The project team began to use meetings with industry partner and internal "change control board" meetings as a forum to exchange project information. While the process was less formal, it was enough.

- SP1.7 – "Review the accomplishments and results of the project at selected project milestones" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. "Milestones" was interpreted as "software releases" for the organization.
    2. Case 1 project progress, performance, and issues were identified (in terms of software drops), reviewed, and baselined (approved by senior management) during planning stages of the project. Subsequent review and revision of this data took place at regular project and senior management review meetings. In addition, planned product audits were conducted following the delivery of each software drop (including QA build/functional/configuration/test tool, and change control board audits). In addition, the software and test leads review product release notes to ensure that the results of change control board activities were reflected.
    3. Case 2 project progress, performance, and issues were identified (in terms of software drops) and reviewed during planning stages of the project but never baselined (approved by senior management). Subsequent review and revision of

this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule, cost anyway. The project team began to use meetings with the industry partner and internal "change control board" meetings as a forum to exchange project information. While the process was less formal, it was enough.

- Specific Goal (SG) 2 – "Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan."
  - SP2.1 – "Correct and analyze the issues and determine the corrective actions necessary to address the issues" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Note that the goal (SG 2) refers to the project plan versus actual performance.
    2. Issues were identified, assigned (resource and expected closure date), and logged on the Case 1 project action item list. Team members would use the project or senior management review meetings to make collective decisions on how to resolve issues. Subsequent review and revision of this data took place at regular project and senior management review meetings
    3. Issues were identified, assigned (resource and expected closure date), and logged on the Case 2 project action item list. Team members would use the project or senior management review meetings to make collective decisions on how to resolve issues.

4. Subsequent review and revision of this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The process became less formal, and the project team was still able to make planned scope deliveries within schedule, cost anyway. Meetings with the industry partner and internal change control board meetings were used as forums to exchange project information.

- SP2.2 – "Take corrective action on identified issues" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Because of the activities conducted (identified above), issues got resolved. Both projects had action item lists to demonstrate that corrective action was taken.
- SP2.3 – "Manage corrective actions to closure" was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Because of the activities conducted (identified above), issues got resolved. Both projects had action item list's to demonstrate that corrective action was taken, and closure reached.

- <u>Generic Goal (GG) 2 – "The process is institutionalized as a managed process."</u>
    - Generic Practice (GP) 2.1 – "Establish and maintain an organizational policy for planning and performing the Project Monitoring and Control" process was "***Performed Adequately***" for both Case 1 and Case 2.
        1. The organization has an established "Software Project Tracking and Oversight Policy."

- GP2.2 – “Establish and maintain the plan for performing the Project Monitoring and Control process” was “***Performed Adequately***” for Case 1 and “***Not Performed Adequately***” for Case 2.
    1. “Establish and maintain” implies “baselining”, which for the organization translates into senior management approval (sign-off).
    2. A plan for monitoring and controlling the Case 1 project schedule, effort, and scope were established in the project plan, which was reviewed and baselined (approved by senior management) early in the project. The plan did not change.
    3. A plan for monitoring and controlling the Case 2 project schedule, effort, and scope were established in the project plan, which was reviewed early in the project but never baselined (approved by senior management). The plan did not change.
- GP2.3 – “Provide adequate resources for performing the Project Monitoring and Control process, developing the work products, and providing the services of the process” was “***Performed Adequately***” for Case 1 and “***Not Performed Adequately***” for Case 2.
    1. “Resources” could be persons (such as the project manager) or tools (such as the effort worksheets, action item lists, or MS project)
    2. Senior management provided the Case 1 project management resource to monitor and report on the project’s progress, performance, and issues related to the schedule, effort, and scope.
    3. Senior management provided the Case 2 project management resource to monitor and report on the project’s progress, performance, and issues related to the schedule,

effort, and scope. Other priorities took precedence and it became necessary to identify a new person to fulfill this role. Delays in this decision, and other priorities, caused significant lack in these activities.

- GP2.4 – "Assign responsibility and authority for performing the process, developing the work products, and providing the services of the Project Monitoring and Control process" was "***Performed Adequately***" for Case 1 and "***Not Performed Adequately***" for Case 2.
    1. Senior management provided the Case 1 project management resource to monitor and report on the project's progress, performance, and issues related to the schedule, effort, and scope.
    2. Senior management provided the Case 2 project management resource to monitor and report on the project's progress, performance, and issues related to the schedule, effort, and scope. Other priorities took precedence and it became necessary to identify a new person to fulfill this role. Delays in this decision, and other priorities, caused significant lack in these activities.
- GP2.5 – "Train the people performing or supporting the Project Monitoring and Control process" as needed was "***Performed Adequately***" for both Case 1 and Case 2.
    1. Training consisted of previous experience, individual education, and on the job training for both the Case 1 and Case 2 project teams. The project team indicated that the training was adequate to accomplish Project Monitoring and Control goals.

- GP2.6 – “Place designated work products of the Project Monitoring and Control process under appropriate levels of configuration” was “***Not Performed Adequately***” for Case 1 or Case 2.
    1. The project monitoring and control work products were identified as configuration items in both Case 1 and Case 2 project plans, and were placed under CM in accordance with the draft. While the SPMP was not approved, the work was done. The NPA rating was given instead of the PA rating since the products are stored in the NextGen shared folders (not in ClearCase – our designated CM tool).
- GP 2.7 – “Identify and involve the relevant stakeholders of the Project Monitoring and Control process” as planned was “***Performed Adequately***” for Case 1 and “***Not Performed Adequately***” for Case 2.
    1. Case 1 project progress, performance, and issues were identified, reviewed, and baselined (approved by senior management) during planning stages of the project. Subsequent review and revision of this data took place at regular project and senior management review meetings. External stakeholders were identified and regularly involved as planned.
    2. Case 2 project progress, performance, and issues were identified and reviewed during planning stages of the project but never baselined (approved by senior management). Subsequent review and revision of this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule, cost anyway. External

stakeholders were identified and regularly involved as planned.

- GP2.8 – “Monitor and control the Project Monitoring and Control process against the plan for performing the process and take appropriate corrective action” was “***Not Performed Adequately***” for both Case 1 and Case 2.
    1. The process was defined in the project plans for both projects, but reports of the data did not materialize as often planned, nor were they as complete as planned. No changes in the process or corrective action resulted from this omission.
- GP2.9 – “Objectively evaluate adherence of the Project Monitoring and Control process against its process description, standards, and procedures, and address noncompliance” was “***Not Performed Adequately***” for both Case 1 and Case 2.
    1. The organization’s overarching process for SQA discusses independently evaluating the project monitoring and control process. This was done by SQA at senior management review meetings (more often for Case 1 than for Case 2). However, since an independent formal audit was not performed for either project, the lesser rating was assigned.
- GP2.10 – “Review the activities, status, and results of the Project Monitoring and Control process with higher-level management and resolve issues” was “***Performed Adequately***” for Case 1 and “***Not Performed Adequately***” for Case 2.
    1. Case 1 project progress, performance, and issues were identified, reviewed, and baselined (approved by senior management) during planning stages of the project. Subsequent review and revision of this data took place at regular project and senior management review meetings.

External stakeholders were identified and regularly involved as planned.

2. Case 2 project progress, performance, and issues were identified and reviewed during planning stages of the project but never baselined (approved by senior management). Subsequent review and revision of this data took place at regular project and senior management review meetings. However, this activity dropped off early in the project as the leadership in the project engineer (manager) role also dropped off. The project team was able to make planned scope deliveries within schedule, cost anyway. External stakeholders were identified and regularly involved as planned.

- Generic Goal (GG) 3 – "The process is institutionalized a defined process."

o GP 3.1 – "Establish and maintain the description of a defined Project Monitoring and Control process" was "***Performed Adequately***" for both Case 1 and Case 2.

1. The following organization procedures have been established, and have not changed during the time that both Case 1 and Case 2 projects were executed: "Effort Tracking Procedure", "Formal Reviews at Milestones Procedure", "Development Hours Tracking Form", "Verification Hours Tracking Form", and "Weekly One-Liners Report Form"

o GP 3.2 – "Collect work products, measures, measurement results, and improvement information derived from planning and performing the Project Monitoring and Control process to support the future use and improvement of the organization's processes and process assets" was "***Not Performed Adequately***" for both Case 1 and Case 2.

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B. CASE 1 ANALYSIS

1. Analysis of Evaluation Results

The following observations were made based on process evaluation ratings given:

- 100% of the practices were performed to some degree (all were rated either “Not Performed Adequately”, or “Performed Adequately” – none were rated “Not Performed”). All practices are being performed to some extent.
- Overall, 18/22 or 82% of the practices were rated “Performed Adequately”. This describes the success of most practices associated with each of the three goals in this Process Area indicating that the improvements will not need to be concentrated on one particular goal, rather, a few practices in each area will need to be improved.

2. Lessons Learned Reported

a. The Initial Set of Identified Risks Was Not Effectively Tracked

New risks were not effectively elicited from the full project staff. Some staff members were not aware of the risks being tracked. Training in the risk management process should be provided to ensure that true risks to project completion are identified, assessed, prioritized, mitigated, and that contingency plans are in place should a risk be realized. The current set of risks should be available to all project staff in a shared repository. For the Case 1 project, not all of the initial risks were true risks that could affect project completion. The initial set of identified risks was not effectively tracked. New risks were not effectively elicited from the full project staff. Some staff members were not aware of the risks being tracked.

b. More Complicated Problems ere Being Resolved, But the Effort Audits Didn't Show How Much Effort Was Expended On Each Problem

There should be more detail recorded in planning and estimating resource requirements. For Case 1, hours estimates were not done over time intervals. Instead, there was just one big lump sum. More complicated problems were being resolved, but the effort audits didn't show how much effort was expended on each problem. With other projects competing for human resources, we need to keep in mind that the project can lose people.

c. One Large All-Encompassing Schedule Became Too Complex and Unwieldy

The project should be tracked at two levels – project and functional. All of the schedules should be posted on a shared repository so that all project staff are aware of key dates. For the Case 1 project, an initial attempt to track progress on one large all-encompassing schedule became too complex and unwieldy. Instead, the project was tracked by the Project Lead to a joint industry partner and organization schedule. The functional leads (software, test, SCM, and SQA) tracked the project at the software requirement level.

d. There Was a Significant Lack of Compliance in Recording Effort Data

Provide feedback to the project team on the definition, collection, and use of metrics. For example, the project collected the hours expended by each member of the project team. In order to do this effectively, each functional area needs well-defined categories in which to record their hours. The method and frequency of collecting these records needs to be fully explained to ensure they are up-to-date. Finally, the reason for collecting hours and how this information will be used also needs to be fully explained. Similar efforts are needed for the remaining project metrics in order to improve compliance by the project staff.

e. The Project Team Was Not Well Informed With a Summary of Senior Management's Comments and Directives

Provide feedback to the project staff on the results of the Senior Management Reviews (SMRs). The SMRs were effective in presenting the status of the project to the Associate Director (AD) and getting his directives for resolving management issues. However, only functional area leads attended the SMRs. The remaining project staff should have the option to attend. In addition, while the slides presented at the SMR were made available to all, SMR minutes were not published. This missed the opportunity to keep the project staff informed with a summary of senior management comments and directives.

f. Individual Project Team Members Did Not Apply Their Own Experience to Help in Identifying, Assessing, Prioritizing, Mitigating, and Tracking Risks

All members of the project team need training in risk management. Everyone needs to be involved in identifying, assessing, prioritizing, mitigating, and tracking risks and in preparing contingency plans in case a particular risk is realized. Each member should be capable of applying their own experience to assist the Project Lead in identifying and managing risks. This will help ensure that all risks that could significantly impact a project are identified.

g. Project Risks Were Not Presented as Effectively as They Could Have Been

The format for presenting the highest priority risks at Senior Management Reviews should effectively identify issues for senior management consideration. Various formats were tried.

h. SCM Was Not Viewed as a Continuous Process Involving Participation by the Entire Project Staff

SCM is not just a repository for project work products but a continuous process involving participation by the entire project staff. Such participation should lead to improvements in the process as staff members generate Process Change Requests (PCRs) to resolve issues.

i. Some Metrics, Such As Effort Data, Were Difficult To Collect Manually and Presented Problems in the Staff Not Understanding the Benefit of Their Use

Select project metrics for the information they provide and ensure their ease of collection. The project staff was not always aware of what metrics were collected and what they would be used for. Some metrics, such as effort data, was difficult to collect manually. In addition, it was difficult to get all project team members to record data. Perhaps this was because they did not understand the benefits of collecting this data.

C. CASE 2 ANALYSIS

1. Analysis of Evaluation Results

The following observations were made based on process evaluation ratings given:

- 100% of the practices were performed to some degree (all were rated either “Not Performed Adequately”, or “Performed Adequately” – none were rated “Not Performed”). All practices are being performed to some extent.
- Overall, 12/22 or 55% of the practices were rated “Performed Adequately”. This describes the success of most practices associated with each of the three goals in this Process Area indicating that the improvements will not need to be concentrated on one particular goal, rather, a few practices in each area will need to be improved.

2. Lessons Learned Reported

a. Schedules and Key Project Artifacts Were Not Kept Up to Date and Visible

Schedules and key project artifacts were not presented at every meeting, nor were responsibilities for maintenance assigned. In addition, there were no defined standard access rules for these artifacts.

b. Elements of the Plan Were Not Performed

Project meetings, senior management review meetings, and risk management activities were not executed. Plans were not coordinated and

action items were not recorded or tracked to closure. The project lacked a full time project engineer (manager) to lead these efforts.

c. Project Metrics Not Accurate and are Not Being Used

Essential project data was not defined and did not have spreadsheets to manipulate and store the data, did not have built-in reporting requirements for project meetings and senior management reviews. The data collection process needs to be reviewed and refined for ease and efficiency.

d. An Overall Project Schedule Was Non-Existent

The lack of a project schedule resulted in differing milestones between the developers, testers, CM, SQA, and the industry partner.

e. Lack of Project Manager

The lack of a project lead caused much frustration due to the lack of coordination, both internal and external.

f. Lack of Commitment to Effort Recording/Reporting

There were a variety of problems with actual effort data recorded. There was much missing data, and estimates made well past actual work done were likely less accurate. In addition, QA audits sometimes (mistakenly) included team members who were no longer working on the project, and team member response did not seem to greatly improve over time. It is now impossible to compare final estimates to actual time spent.

g. There Was a Lot of Missing Data and Much Data is Recorded a Considerable Amount of Time After Actual Time is Spent

There appeared to be a lot of missing data, and much data is recorded a considerable amount of time after actual time is spent. Either data is lost or, when finally recorded, may be less accurate than it could have been if recorded on a more regular basis. Only 33% of the Case 2 project team has updated their worksheets within the last month.

h. It Has Been Difficult to Determine if Worksheets are Current (and "Zero" Time Has Been Put Towards the Project) or if Data Entry is Lagging

For audit purposes, the latter was assumed. If correct information is not communicated to the auditor, audit results may be skewed.

i. There is Not a Consistent Naming Convention Used to Identify the Effort Record Worksheets

QA worksheets use fiscal year and team member identification in the file names. Test group worksheets use only name for Case 2 worksheets and name and project identification for Case 2 worksheets in the file names. Development and lab worksheets use only name identification in the file names. Once archived, it would be difficult to determine what project the data was recorded for with out opening each file.

D. COMPARISON OF CASE 1 TO CASE 2

1. Goals

The goals associated with the PMC PA are as follows:

- Specific Goal (SG) 1 - Specific Goal (SG) 1 – "Actual performance and progress of the project are monitored against the project plan."
- Specific Goal (SG) 2 – "Corrective actions are managed to closure when the project's performance or results deviate significantly from the plan."
- Generic Goal (GG) 2 – "The process is institutionalized as a managed process."
- Generic Goal (GG) 3 – "The process is institutionalized a defined process."

The achievement by Case 1 and Case 2 in terms of goal success can be described by a comparison of the number of practices given the "Performed Adequately" rating to the total number of practices for that goal. The results of this analysis follow:

Case 1 – SG 1 – 7/7 or 100%
SG 2 – 3/3 or 100%
GG 2 – 7/10 or 70%
GG 3 – 1/2 or 50%
Case 2 – SG 1 - 6/7 or 86%
SG 2 – 3/3 or 100%
GG 2 – 2/10 or 20%
GG 3 – 1/2 or 50%

No overall goal improvements can be demonstrated by this data, only digression for SG 1, and GG 2.

2. Practices

Practice	Case 1		Case 2	
	Not Performed Adequately	Performed Adequately	Not Performed Adequately	Performed Adequately
SP 1.1		X		X
SP 1.2		X		X
SP 1.3		X	X	
SP 1.4		X		X
SP 1.5		X		X
SP 1.6		X		X
SP 1.7		X		X
SP 2.1		X		X
SP 2.2		X		X
SP 2.3		X		X
GP 2.1		X		X
GP 2.2		X	X	
GP 2.3		X	X	
GP 2.4		X	X	
GP 2.5		X		X
GP 2.6	X		X	
GP 2.7		X	X	
GP 2.8	X		X	
GP 2.9	X		X	
GP 2.10		X	X	
GP 3.1		X		X
GP 3.2	X		X	

Table 3 Summary of Project Monitoring and Control Evaluation Results

The results do not demonstrate improvement from Case 1 to Case 2 in any project monitoring and control practice evaluated. They do show digression in the following practices (highlighted rows):

- SP1.3 – Monitor risks against those identified in the project plan."
- GP2.2 – Establish and maintain the plan for performing the Project Monitoring and Control process.
- GP2.3 – Provide adequate resources for performing the Project Monitoring and Control process, developing the work products, and providing the services of the process.
- GP2.4 – Assign responsibility and authority for performing the process, developing the work products, and providing the services of the Project Monitoring and Control process.
- GP 2.7 – Identify and involve the relevant stakeholders of the Project Monitoring and Control process.
- GP 2.10 – Review the activities, status, and results of the Project Monitoring and Control process with higher-level management and resolve issues.

In addition, results indicate that for both projects, the following practices were "***Not Performed Adequately:***"

- GP2.6 – Place designated work products of the Project Monitoring and Control process under appropriate levels of configuration management.
- GP2.8 – Monitor and control the Project Monitoring and Control process against the plan for performing the process and take appropriate corrective action.
- GP2.9 – Objectively evaluate adherence of the Project Monitoring and Control process against its process description, standards, and procedures, and address noncompliance.

- GP 3.2 – Collect work products, measures, measurement results, and improvement information derived from planning and performing the Requirements Management process to support the future use and improvement of the organization's processes and process assets.

3. Comparison of Evaluation Results to Lessons Learned

Examination of the comments from the evaluation results for which both projects had "Not Performed Adequately" rating show that designated work products were not put under appropriate levels of configuration management, the PMC process was not monitored, and corrective action was not taken when it was needed. Similar to other process areas evaluated, some metrics were collected, some artifacts were stored, and some lessons learned were collected. However, those activities were also conducted informally, without process improvement necessarily in mind.

The Case 1 project team noted negative impacts to the fact that the initial set of identified risks were not effectively tracked, individual project team members did not apply their own experience to help in identifying, assessing, prioritizing, mitigating, and tracking risks, project risks were not presented as effectively as they could have been. The team also recognized that more complicated problems were being resolved but the effort audits didn't show how much effort was expended on each problem. In addition, there was a significant lack of compliance in recording effort data, and some metrics, such as effort data, was difficult to collect manually and presented problems in the staff not understanding the benefit of their use. In general, the project team acknowledged that they did not think they were well informed of senior management's comments and directives, and that the large all-encompassing schedule became too complex and unwieldy. At first glance this list seems long compared to the evaluation results reported, but the fact that there was not enough corrective action taken to correct process execution supports the entire list.

The Case 2 project had additional practices that received the “Not Performed Adequately” rating (noted above). The ratings were a direct result of inadequate risk monitoring, not maintaining the plan for the PMC process, not providing adequate resources and assigning responsibility and authority for executing the PMC process, inadequate stakeholder involvement, and not reviewing issues with senior management or using them to help solve problems.

The Case 2 lessons learned was a long list including the fact that schedules and key project artifacts were not kept up to date and visible, elements of the plan were not done, project metrics not accurate and were not being used, an overall project schedule was non-existent, lack of project manager, and a lack of commitment to effort recording/reporting (much missing data and inaccurate data, and inconsistent worksheet organization). These are the symptoms noticed by the project team as a result of confusion over the project plan, and lack of direction from a dedicated project engineer (manager).

Again, it is interesting to note that one characteristic of a CMMI Level 1 organization is that people create their own processes to do the work, creating the potential for duplication, and even conflict later on in the project. The migration in effort recording activities demonstrated this characteristic.

While the organization did not have outstanding performance on all practices, it was demonstrated that something was being done by the project team in every area. The transition from simply managing requirements to actually managing plans takes place as the organization advances from Level 2 to Level 3. It appears that the source of risk lied with maintaining a dedicated resource for a project engineer and keeping senior management involved to help enforce the discipline needed to make sure corrective action was identified and followed through with.

This information can be used to identify a business goal on which to base targeted process improvement, such as “to improve the project monitoring and control process.”

E. SUGGESTED IMPROVEMENTS

As a result of the above Case 1 and Case 2 analysis the following list of improvement suggestions was compiled. Some suggestions are a direct reflection of the lessons learned reported, some are specific to CMMI practice requirements that need to be fulfilled, and some are more general and would contribute indirectly to all reported deficiencies. It can be used to improve the project performance by targeting process improvement in these areas.

- Make sure a dedicated resource is assigned to perform the project engineer (manager) role (to follow up on project plan peer review and approval process, project and senior management review meetings, risk management, the change control process, etc.).
- Schedules, plans, scope documents, and other and key project artifacts need to be kept up to date and visible, presented at every meeting. Responsibilities for maintenance of these products must be clearly assigned. Use “baselining” (accomplished at the organization by completing the senior management approval process) to keep a record of current agreements made for the duration of the project.
- Training in the risk management process should be provided to ensure that true risks to project completion are identified, assessed, prioritized, mitigated, and that contingency plans are in place should a risk be realized. The current set of risks should be available to all project staff in a shared repository. A standard format for presenting the highest priority risks at Senior Management Reviews should be developed.
- There should be more detail recorded in planning and estimating resource requirements. The project should be tracked at two levels – project and functional. All of the schedules should be posted on a shared repository so that all project staff are aware of key dates.
- Select project metrics for the information they provide and ensure their ease of collection. More feedback on definition, collection, and use of

metrics should be provided to project team members. The categories, method, frequency of collecting these records, and the reason for collecting hours and how this information will be used also needs to be well defined and fully explained. Similar efforts are needed for the remaining project metrics in order to improve compliance by the project staff.

- Provide more feedback to the project staff on the results of the Senior Management Reviews (SMRs).
- Review and renew the commitment to record and collect effort data to demonstrate that this is a valuable and necessary activity. Develop standard naming conventions for effort worksheet file names and effort categories, a way to indicate when the worksheet was last updated, and a standard way to add/delete team members from the audit roster.
- Develop questions and metrics to measure accomplishments in response to the business goal to “improve the project monitoring and control process.”
- Archive all project planning work products using the organization’s designated CM tool (ClearCase). SCM needs to become a continuous process involving participation by the entire project staff (rather than just a repository for work products). Staff members should generate Process Change Requests (PCRs) to resolve issues.
- Conduct a formal audit on the project monitoring and control process at least once during project execution.
- Update policy, process, and procedure documentation to reflect additional activities.

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VII. CONCLUSIONS

This study showed that while the organization is performing to some extent in every area of the project management practices evaluated, there is still much room for improvement. The evaluation results did not demonstrate improvement of any one practice, there were many practices for which both projects were rated "Not Performed Adequately," and there were many cases for which the more recent project (Case 2) got a lower rating than the less recent project (Case1), i.e., evaluation results showed some digression from one project to the next. This conclusion was reached by consensus of a small group of project team members who participated in reviewing the results. It matched the general perception held by the team, and management.

Given that the project team was highly successful at delivering planned scope, within planned schedule and fixed cost, these results are surprising since team members have remarked about how much more organized and consistent the process seems to be than ever before (albeit they would be referring to all processes used, not just project management processes). Why then doesn't this show up in the evaluation results?

The project team is small (less than 20 people), and most of the same people fulfilled the same duties on both projects studied. The projects were similar (unique iterations of software maintenance efforts), and the staff were experienced (from previous iterations of the same type of projects). The advantage of the circumstances implies that the team was able to rely on experienced staff to do whatever needed to be done to make the delivery on time, in spite of process digression.

So why should the organization even do process improvement since achieving a certain CMMI level cannot improve on the already great record? One valid reason might be to satisfy a bidding requirement to gain more government contracts, to in effect "keep up with industry trends" by advertising

the organization's achievement. But what is the internal value for this pursuit? Does the organization need to improve its effectiveness and efficiency?

One way to answer this question is to look closer at one aspect of this evaluation –recording, collection, analysis, and reporting of effort data. The project team may ask themselves if they even know how effectively and efficiently they perform various tasks? There were many problems related to these activities (determining estimates versus actual time spent on categories of tasks). Improving this process would help the team to gather more accurate data, which would enable the team to discover what the measurements mean in terms of productivity. Once understood quantitatively, process improvements could be targeted for certain processes that affect effectiveness and efficiency. More important, the organization will have the capability to demonstrate these skills to customers with data, instead of opinions. This could be used as a valuable marketing tool.

Further, as processes become more consistent, individual frustrations with ad hoc methods will begin to disappear. When the team begins to demonstrate enough discipline to learn, perform, and improve the same processes, the team will come together to do more of the same work (instead of each person improving their own way of doing things, which is likely different that the way another person performs the same task).

One test of process improvement is whether or not it can withstand changes in business and personnel. The right combination of striving for consistency and then accepting more change will provide a successful balance. The organization just needs to know where to start.

It sometimes seems that examination and acknowledgement of the reasons previous process improvement efforts did not take hold is too often glossed over, and the information not used. Getting comfortable with exposing barriers could be the very key to making a change stick, or at least help to prevent doing the same thing, and getting the same (not as good as we want)

results. Even though the barriers do not usually turn out to be rocket science, it is often difficult to uncover and overcome them, especially in an organization where things have been done in the same ways, and by the same people, for years. Add that to the fact that making even minor changes for most of us is at best challenging. “Starting over" has to be a way of life to get different results. And there has to be some strong motivation, even for simple changes. If the organization is committed to preparation for expanding the ability to grow the SOW it must be strongly emphasized.

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VIII. POTENTIAL BENEFITS

The following list outlines some predicted benefits that should take place after implementation of the suggested process improvements discussed in this paper. Some benefits of this study have already been realized, as all of the work done by this organization in the last few years have planted seeds that are now presenting opportunities. Conducting this study has served as a training tool among the participants and stirred many very good additional questions.

A. INTERNAL TO THE ORGANIZATION

The primary benefits internal to the organization include:

- Increased Awareness of the current organization processes, how they compare to CMMI practices, and specific ideas for valuable improvements
- A better understanding of the value of collecting and using lessons learned
- An improved problem solving environment (better communication leads to greater understanding, which translates into acknowledgement, then comfort)
- Opening and strengthening communication between the project team and senior management will help to uncover and prevent further misunderstanding about current processes as they work together to devise the best process solutions
- Improvement suggestions that are related to low level business goals (i.e., “improve the requirements management process” is easier to measure than to “improve productivity”) can be prioritized according to management needs
- The organization will learn to plan to prevent problems, instead of just reacting to problems.
- Improved basic project management skills (planning, tracking, and reporting)

- Improved mid-course decision making to help manage risks
- Increased ability to provide more accurate estimate and progress information to the project team, management, industry partners, and customers.
- The team will become more enthusiastic as success is realized by owning the culture shift from relying on previous experience to currently defined process discipline.
- The data needed to do earned value progress reporting will be available (a method of relating the scope of work to the project schedule and budget).
- Increased productivity when goals between project teams and senior management are realigned and decisions made to enforce organization level consistency in implementation, so the team would be able to finish the project sooner, or take on more scope.
- CMMI achievement award of as a result of a SCAMPI or official licensed CMMI appraisal.

B. EXTERNAL TO THE ORGANIZATION

Aside from some of the same benefits noted above being noticed by stakeholders who interact with the organization, some additional benefits that may be realized include the following.

- Demonstrated contribution to the ARMY process improvement initiative
- A new credibility that is recognized in the industry, and can be used as a strong marketing tool for the organization, and for the Army

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APPENDIX – SAMPLE PROCESS AREA EVALUATION CHECKLIST

Evaluator: SQA Engineer

Assessment Date: 1/24/06 – 3/10/06

Project Audited: Case 1 and Case 2 - Evaluating both projects was recommended by the SEPG since it will demonstrate continuous use of processes and artifacts. In addition, it will expose improvements, or regressions, from capabilities demonstrated during the project to capabilities demonstrated during the Case 2 project.

Support/Review Team: Project manager, Software Development Lead, Test Lead, SEPG Lead, SQA Engineer, Project Manager, and CM Lead.

Specific Practice (SP) [Comments regarding interpretation of practices as applicable to this project were inserted as needed.]	**Requirements Management – SP Rating** NP – Not Performed, NPA – Not Performed Adequately, PA – Performed Adequately or Better			
	NP	**NPA**	**PA**	**Basis for Rating**
Specific Goal (SG) 1 Requirements are managed and inconsistencies with project plans and work products are identified.				
SP1.1 Develop an understanding with the requirements providers on the meaning of the requirements [budget, schedule, and delivery constraints].			Case 1 Case 2	**** Note that all comments in this column were removed for presentation of results in this paper to maintain project anonymity.*

SP1.2 Obtain Commitment to the requirements from the project participants. This practice refers to the "initial" commitment (not changes) to a specific set of requirements.		Case 2	*Case 1*	
SP1.3 Manage changes to the requirements as they evolve during the project. This practice refers only to changes made to the initial baseline to a specific set of requirements.		Case 1 Case 2		
SP1.4 Maintain bidirectional traceability among the requirements and the project plans and the work products. This is interpreted as referring to both the initial and changes made to the requirements. For the purposes of this study, it was interpreted as traceability between the external Statement of Work (SOW) to the organizations internal SOW, and to the organizations Case 1 and Case 2 project plans. In both cases, the organization's internal schedule was considered part of the plans.		Case 1 Case 2		
SP1.5 Identify inconsistencies between the project plans and work products and the requirements. This is interpreted as comparison between the (project plans and/or the work products) and the requirements.		Case 2	*Case 1*	

Generic Practice (GP)	Requirements Management – GP Rating			
	NP	**NPA**	**PA**	**Basis for Rating** *Note that the comments in this column were removed for*

				presentation of results in this paper to maintain project anonymity.
Generic Goal (GG) 2 – The process is institutionalized as a managed process.				
GP2.1 - Establish and maintain an organizational policy for planning and performing the Requirements Management process.			*Case 1* *Case 2*	
GP2.2 - Establish and maintain the plan for performing the Requirements Management process.			Case 1 Case 2	
GP2.3 - Provide adequate resources for performing the Requirements Management process, developing the work products, and providing the services of the process.			Case 1 Case 2	
GP2.4 - Assign responsibility and authority for performing the process, developing the work products, and providing the services of the Requirements Management process.			Case 1 Case 2	
GP2.5 - Train the people performing or supporting the Requirements Management process as needed.			*Case 1* *Case 2*	
GP2.6 - Place designated work products of the Requirements Management process under appropriate levels of configuration.		*Case 1* *Case 2*		
GP 2.7 - Identify and involve the relevant stakeholders of the Requirements Management process as planned.			*Case 1* *Case 2*	

GP2.8 - Monitor and control the Requirements Management process against the plan for performing the process and take appropriate corrective action.		*Case 2*	*Case 1*	
GP2.9 - Objectively evaluate adherence of the Requirements Management process against its process description, standards, and procedures, and address noncompliance.		*Case 1* *Case 2*		
GP2.10 - Review the activities, status, and results of the Requirements Management process with higher level management and resolve issues.		Case 2	Case 1	
GG3 – The process is institutionalized a defined process.				
GP 3.1 Establish and maintain the description of a defined Requirements Management process.			Case 1 Case 2	
GP 3.2 Collect work products, measures, measurement results, and improvement information derived from planning and performing the Requirements Management process to support the future use and improvement of the organization's processes and process assets.		Case 1 Case 2		

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