CMMI Level 4 and 5 Implementation

7

Key Topics

- Process Performance Objectives and Measures
- Goal Question Metric
- Statistical Techniques
- Problem Solving
- Process Performance Models

7.1 Introduction

A level 4 organization sets quantitative goals for the performance of key processes, and the processes are controlled using statistical techniques to meet the needs of the stakeholders. Software process and product quality goals are set and managed, and processes are stable and perform within narrowly defined limits. A level 4 organization has predictable process performance, with variation in performance identified and the causes determined and corrected.

There are two process areas that need to be implemented for CMMI level 4. These are

– Organization process performance
– Quantitative project management

A level 5 organization builds upon the level 4 foundation and has a continuous process improvement culture in place. Processes are improved based on a quantitative understanding of variation, and defect prevention activities are an integral part of the development life cycle. The causes of defects are systematically determined and corrected,

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and new technologies are evaluated to improve process performance. New technology is introduced in a controlled manner into the organization after successful evaluations. Processes may be improved incrementally or through innovative process and technology improvements.

There are two process areas that need to be implemented for CMMI level 5. These are

- Organization innovation and deployment
- Causal analysis and resolution

7.2 Organization Process Performance

This process area is concerned with obtaining a quantitative understanding of the performance of selected processes in order to quantitatively manage projects in the organization. It involves establishing and maintaining a quantitative understanding of the organization's set of standard processes in order to support the organization in quality and process improvement. This allows the organization to baseline its process performance and to compare it with actual project performance. This information is then used to quantitatively manage its projects, and each quantitatively managed project provides performance results that become part of the baseline data for the organization process assets.

Process performance is a measure of the actual results achieved by following the process for a particular project. It includes process measures such as effort and schedule variance, and product measures such as quality, reliability, and defect density. The specific goals and practices for this process area are given in Table 7.1.

This will enable the organization to

- Determine whether the processes are behaving consistently (i.e. predictable)
- Identify processes with unpredictable behaviour
- Establish criteria for identifying whether a process or process element should be statistically managed and determine measures
- Identify processes that can be improved

Table 7.1 CMMI requirements for organization process performance

Specific goal	Specific practice	Description of specific practice/goal
SG 1		*Establish performance baselines/models*
	SP 1.1	Select processes
	SP 1.2	Establish process performance measures
	SP 1.3	Establish quality and process performance objectives
	SP 1.4	Establish process performance baselines
	SP 1.5	Establish process performance models

The first step is to determine which processes will be measured. Next the quality and process performance objectives for those processes are determined and appropriate measures chosen to give insight into quality and process performance.

One useful approach to selecting measures is Goal, Question, Metric (GQM) developed by Basili and Rombach [Bas:88]. This is a rigorous approach to measurement in which goals and measures are closely linked. The business goals are first determined. This leads to questions that relate to the extent of achievement of the business goal. Metrics are then chosen to give an objective answer to these questions:

- Define *Goals* specific to needs
- Refine the goals into *Questions*
- Deduce the *Metrics* and data to be collected to answer the questions

GQM is discussed in more detail in [ORg:02]. Process performance baselines are established and maintained of the organization set of standard processes. This involves collecting measurements from the organization's projects. Process performance models for the organization set of standard processes are established and maintained. They are used to represent past and current process performance and to predict future process performance. These performance models may be used to

- Estimate potential return on investment for process improvement activities
- Estimate and predict process performance for the project's defined software processes

7.3 Quantitative Project Management

This process area is concerned with quantitatively managing the project's defined process to achieve the project's quality and performance objectives. It involves

- Establishing and maintaining the project's quality and process performance objectives
- Selecting subprocesses in the project's defined software process to be statistically managed
- Monitoring the project to determine whether quality and process objectives are being achieved and taking corrective action
- Monitoring the performance of the selected subprocesses and taking corrective action
- Recording statistical data in the organization's measurement repository

The project's quality and process performance objectives will need to be realistic and based on an understanding of current process performance for the organization set of standard processes.[1] Quality objectives for quality attributes such as the mean time to

[1] The project's defined software process is derived from the organization set of standard processes by tailoring, and so its capability will be closely related to the capability of the organization's set of standard processes.

Table 7.2 CMMI requirements for quantitative project management

Specific goal	Specific practice	Description of specific practice/goal
SG 1		*Quantitatively manage the project*
	SP 1.1	Establish the project's objectives
	SP 1.2	Compose the defined process
	SP 1.3	Select the subprocesses that will be statistically managed
	SP 1.4	Manage project performance
SG 2		*Statistically manage subprocess performance*
	SP 2.1	Select measures and analytic techniques
	SP 2.2	Apply statistical techniques to understand variation
	SP 2.3	Monitor performance of selected subprocesses
	SP 2.4	Record statistical management data

failure and the number and severity of defects in the released product may be set. Process performance objectives for attributes such as percentage of defects found in software inspections and peer review activities may be set. Process performance models[2] may be employed to predict the number of defects in the released software based on the defects identified during the peer reviews and testing activities.

The specific goals and practices for the quantitative project management process area are given in Table 7.2.

Subprocesses are components of a larger defined process. The subprocesses may be further decomposed into other subprocesses and process elements. The subprocesses that will be statistically managed are chosen based on the project's needs for predictable performance.

The statistical techniques employed may include trend charts, histograms, bar charts, control charts, confidence intervals, and tests of hypotheses.

The collection and analysis of process and product measures allows special causes of variation to be identified and addressed. A special cause of process variation is characterized by an unexpected change in process performance. These causes can be investigated, analysed, and addressed to prevent future occurrence. Statistical techniques are applied to identify and understand variation in process performance.

The project will be monitored to determine whether its objectives for quality and process performance will be satisfied. Statistical techniques help the project predict whether it will be able to achieve its quality and process performance objectives, and corrective action is taken where appropriate.

[2]It is essential that these models be validated to ensure that they are sound. The models should be based on good empirical data and rigorously tested to ensure their validity. There is a well-known saying "All models are wrong: some are useful".

Statistical and quality management data are recorded in the organization's measurement repository.

7.4 Organization Innovation and Deployment

The purpose of this process area is to select and deploy incremental and innovative improvements that measurably improve the organization's processes and technologies. The improvements support the organization's quality and process performance objectives as derived from the organization's business objectives.

It enables the organization to select and deploy improvements to enhance its ability to meet its quality and process performance objectives. The successful implementation of this process area leads to an innovative organization that actively encourages its staff to propose potential improvements to its processes.

Improvement proposals will be collected and analysed. The improvement proposals may come from various sources including process appraisals; benchmarking; analysis of data on causes of defects; quality and process performance objectives; and improvement suggestions from staff. The analysis of the improvement proposals will consider the return on investment (ROI) from the implementation of the improvement versus the cost involved.

This process area is also concerned with identifying and searching for innovative proposals to improve processes and technology. The organization's set of standard processes are analysed to determine areas where innovative improvements would be most helpful. These are identified in various ways such as proposals from projects and the organization; examining innovations in other organizations; considering innovations documented in research literature; and maintaining awareness of technology trends.

The selected improvements are piloted prior to their deployment. This will ensure their fitness for purpose in the organization as well as any barriers and risks to their deployment.

Table 7.3 CMMI requirements for organization innovation and deployment

Specific goal	Specific practice	Description of specific practice/goal
SG 1		*Select improvements*
	SP 1.1	Collect and analyse improvement proposals
	SP 1.2	Identify and analyse innovations
	SP 1.3	Pilot improvements
	SP 1.4	Select improvements for deployment
SG 2		*Deploy improvements*
	SP 2.1	Plan the deployment
	SP 2.2	Manage the deployment
	SP 2.3	Measure the improvement effects

The actual improvements to be deployed are then selected and the improvements incorporated into the organization set of standard processes. The deployment is planned and appropriate changes made to process definitions, procedures, and standards. All affected staff are trained on the new processes and standards.

Finally, the actual return on investment is determined. This involves determining the cost of deploying the new or enhanced processes versus the monetary business benefit gained from the deployment. The specific goals and practices for organization innovation and deployment are given in Table 7.3.

7.5 Causal Analysis and Resolution

The purpose of the causal analysis and resolution process area is to identify causes of defects and to take corrective action to prevent future re-occurrence. It may include the examination of defects identified during peer reviews and testing activities as well as defects identified by the customer.

The successful implementation of causal analysis and resolution helps to improve quality and productivity, and it helps to prevent the introduction of defects into a product. It is much more cost effective to prevent defects from being introduced than to detect and correct defects later in the software development life cycle.

Several methods such as Pareto analysis, histograms, and process capability analysis are used to select defects to be analysed. Causal analysis of the selected defects is then performed with people who have an understanding of the defects. The types of defects found are analysed to identify any trends, and the root causes of the defects determined. The actions required to address the root causes are identified. There are various tools to assist in finding root causes such as cause and effect (fishbone) diagrams. Actions to address the root causes are identified and implemented.

The impact of the changes made to prevent defects is reviewed to ensure its effectiveness. The specific goals and practices for the causal analysis and resolution process area are given in Table 7.4.

Table 7.4 CMMI requirements for causal analysis and resolution

Specific goal	Specific practice	Description of specific practice/goal
SG 1		*Determine causes of defect*
	SP 1.1	Select defect data for analysis
	SP 1.2	Analyse causes
SG 2		*Address causes of defects*
	SP 2.1	Implement the action proposals
	SP 2.2	Evaluate the effect of change
	SP 2.3	Record data

7.6 Review Questions

1. Describe the Goal, Question, Metric approach developed by Basili.
2. Discuss process performance models and how they may be used for prediction. Describe how they may be validated.
3. Describe various problem tools such as Pareto analysis, trend graphs, bar charts, and histograms and describe how they may be used in problem solving
4. Describe the level 4 process areas.
5. Describe the level 5 process areas.

7.7 Summary

A level 4 organization sets quantitative goals for the performance of key processes, and the processes are controlled using quantitative techniques to meet the needs of the various stakeholders. A level 4 organization has predictable process performance with variation in process performance identified and the causes of variation determined and corrected. Software process and product quality goals are set and managed, and the processes are stable and performing within narrowly defined limits.

A level 5 organization has a continuous process improvement culture in place, and processes are improved based on a quantitative understanding of variation. Defect prevention activities are an integral part of the development life cycle. New technologies are evaluated and if successful are introduced into the organization. Processes may be improved incrementally or through innovative process and technology improvements.