NOTE

CMM Level 3 Appraisal

CMM (Capability Maturity Model for Software) is a trademark of the Software Engineering Institute of Carnegie Mellon University, USA.

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1 Introduction

In recent years, as systems such as information/control devices have increased in complexity, the increase in the scale of embedded software has become problematic. This has made it difficult to offer software with a stable level of quality when dealing with conventional methods that rely on the skill of the individual developer.

This situation has caused more companies and organizations to place emphasis on the software development process. As a result of improvements to the software development process at Fujitsu Ten, Ltd., the Automotive Electronics Department received a CMM Level 3 appraisal on October 30th, 2002., becoming the first domestic automotive electronics manufacturer to do so. This document describes the efforts and improvements implemented at Fujitsu Ten, Ltd. that led to the acquisition of CMM Level 3.

2 CMM: An Explanation

CMM is a model researched and developed by the Software Engineering Institute (SEI) of Carnegie Mellon University (USA) at the request of the U.S. Government in order to evaluate of the maturity of software processes at companies in the software industry. (Table 1) CMM is notable because it specifies the structure of processes (procedures) for quality improvements needed to achieve each level of a 5-step maturity scale. As improvement proceeds, processes become visible (Fig. 1) and evolve (Fig. 2). For this reason, CMM is becoming the standard for assessing and improving software development in the public and private centers in the United States and beyond.

The level 3 accreditation acquired by Fujitsu Ten Ltd. signifies that development objectives and management procedures have been systematically defined and that organized activities for continuous improvement have been established. Very few companies in Japan have received this evaluation.

Table 1 Capability Maturity Model (CMM)

Level	Focus	Key Process Area (KPA) ※
⑤Optimizing	Continuous process improvement	・Defect Prevention (DP) ・Technology Change Management (TCM) ・Process Change Management (PCM)
④Managed	Product and process quality	・Quantitative Process Management (QPM) ・Software Quality Management (SQM)
③Defined	Engineering processes and organizational support	・Organization Process Focus (OPF) ・Organization Process Definition (OPD) ・Training Program (TP) ・Integrated Software Management (ISM) ・Software Product Engineering (SPE) ・Intergroup Coordination (IC) ・Peer Reviews (PR)
②Repeatable	Project management processse	・Requirements Management (RM) ・Software Project Planning (SPP) ・Software Project Tracking and Oversight (SPTO) ・Software Subcontract Management (SSM) ・Software Quality Assurance (SQA) ・Software Configuration Management (SCM)
①Initial	Competent people and heroics	

※Key Process Area (KPA):Area on which organization should focus process improvements

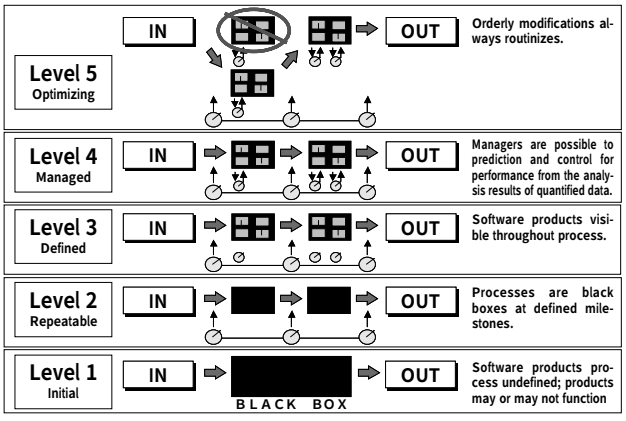

Fig.1 Management View of Process

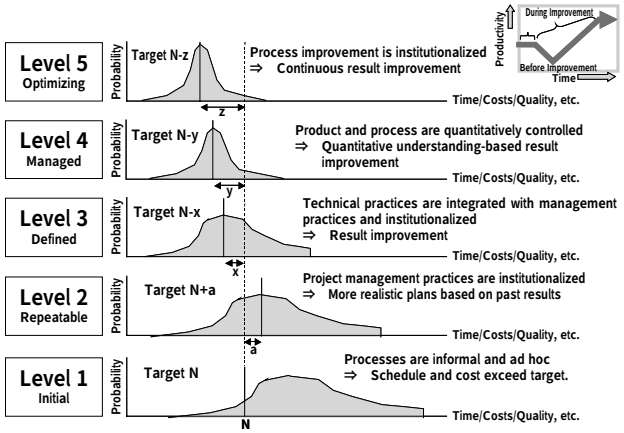

Fig.2 Evolution of Process Capability

3 Organization-wide Activities

3.1 Improvement Progress

Fujitsu Ten, Ltd.'s commitment to putting customers first and attaining the highest possible quality has led us to continue to improve our quality system, resulting in the acquisition of ISO 9001 and QS 9000 approval in August, 1996 and August, 1998, respectively. In order to improve quality even further, focus has been placed on improving software quality and efficiency (emphasis is being shifted from temporary efficiency to quality/continuous efficiency and effects) as well as the advantages of CMM. (Refer to Table 2.) Software development process improvements based on CMM guidelines have been continuously implemented since December 1999. (Refer to Figure 3.)

Table 2 CMM Merits

【CMM Merits】	
①Justness of Targets	CMM is the software standard development process in the U.S.
②Visibility of Achievement Status	CMM make the unerring judgment is performed by the assessment.
③Evaluation when Achieving	CMM is publicly admitted enough.

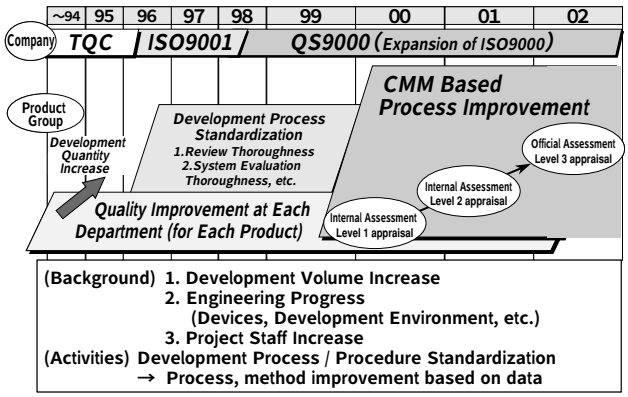

Fig.3 Software Quality Improvement Progress

3.2 Present Organization Status

To advance actual improvements, the present state of the organization is perceived from the perspective that CMM assessment is an indicator of actual status. The IDEAL model (Fig. 4), a model of improvements, is used to clarify the organizational mission. Following clarification, workers should find solutions themselves and make the improvements with which they feel comfortable, rather than having everything suggested to them by supporters and managers. Adequate time was spent achieving the consensus necessary to make this possible.

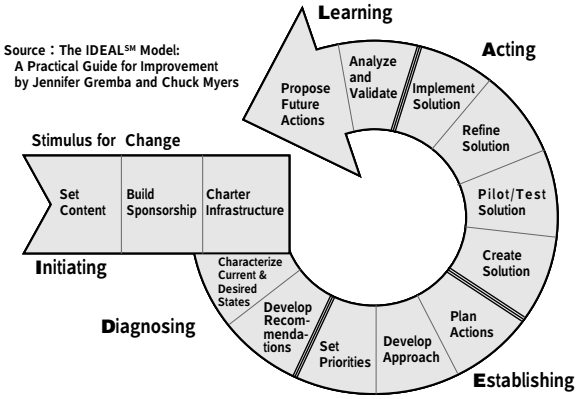

Fig.4 The IDEAL℠ Framework

Next, assessment results confirm a subject, on which only necessary process improvements are implemented. For example, even modifications to areas for which improvements are preferable will be deemed unnecessary if present methods pose no major problems and business objectives are being met. In such cases, these areas are removed from the scope of improvements.

Emphasis for promoting process improvements has been placed on the following 2 points:

①Compose Quality-focused Work Methods

・The concept that focusing on quality requires onerous development was replaced by the concept that conformity with each site requires relaxed development. As a result, ideas for improvement were extracted.

②Compose Work Methods Suited to Organizational Culture (More Relaxed)

・To ensure proper consideration for organizational culture, particulars regarding how to bring improvements fruition were left up to individual sites as long as the direction of the improvements in question was correct.

Particular pains were taken on the following CMM-based process improvements.

①Documentation Quantity

・As the result of repeated discussions with <those involved> regarding necessity of documentation, it was decided that quantity (effectiveness) would be emphasized over quantity.

②Make CMM expressions vague so that they apply to all development processes

・In contrast, creative processes were established.

③ Secure activity supporters (SEPG/Software Engineering Process Group): Is responsible for development and maintenance of organizational processes, directs adjustment of process improvements in conjunction with on-site personnel.)

・Multiple personnel selected in order to enable them to attend meetings in shifts.

④Improvement Promotion (Fig. 5)

・SQA (Software Quality Assurance: Process in which products are reviewed/audited and results are reported to management in order to verify compliance with procedures and standards.)internal assessments were repeated multiple times.

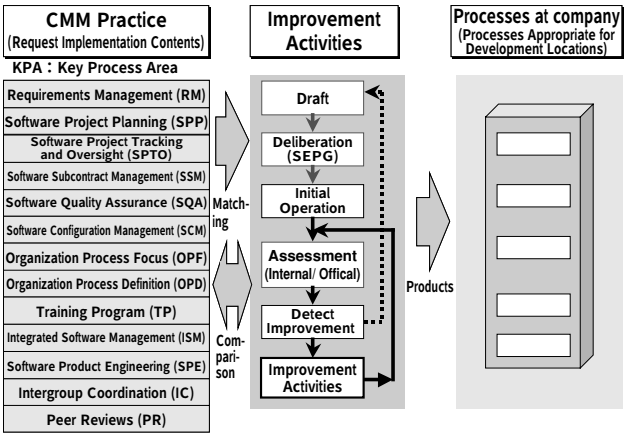

Fig.5 CMM-Based Process Improvement Activity Promotion

3.3 Process Improvement Activity Contents

Detailed information regarding the process improvements that led to acquisition of Level 3 accreditation is shown below. (Fig. 6, 7)

■"Main Content of Level 2 Activities"

・Requirements Management (RM):
Specification sheet receipt status confirmation/ review

・Software Project Planning (SPP):
Creation of written proposal based on estimate

・Software Project Tracking and Oversight (SPTO):
Progress confirmation, management in accordance with plan

・Software Configuration Management (SCM):
Record of modifications (to specifications, software) made in accordance with plan

・Software Quality Assurance (SQA):
Implementation status of the aforementioned checked by independent SQA group.

■"Main Contents of Level 3 Activities"

・Organization Process Focus (OPF):
SPEG Group creation/improvement of Product Group standards

・Organization Process Definition (OPD):
Software development in accordance with Product Group standards

・Training Program (TP):
Implementation of skill-increasing education

・Integrated Software Management (ISM):
Application of division standards (modified head office standards)

・Software Product Engineering (SPE):
Software development / product activities according to standards of each operation division

・Intergroup Coordination (IC):
Implementation of regular meetings with related

・Peer Review (PR):
Comprehensive review implementation and records thereof

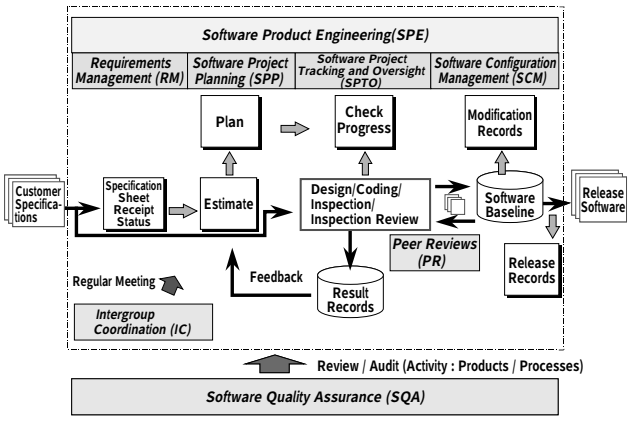

Fig.6 Process Improvement Activities 1

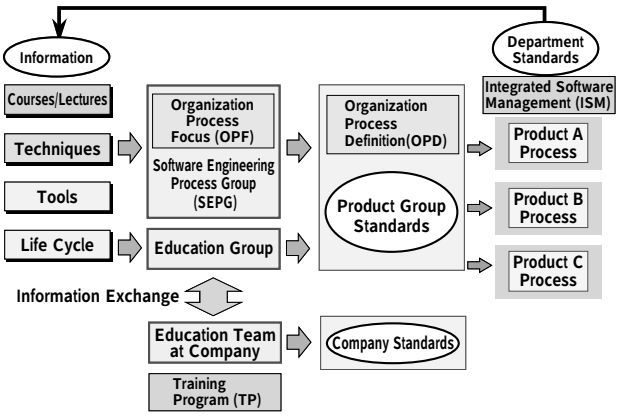

Fig.7 Process Improvement Activities 2

4 Solution Business Division Activities

4.1 Solution Business Division Overview

Solution Business Division is a division focused on the development of software for electronic automotive control systems. This division implemented software product improvements pursuant to CMM acquisition in

line with organizational trends.

4.2 CMM Accreditation Acquisition Effort Details

The results of ISO9001, QS9000, and quality improvements were recorded on a checksheet called a "software design procedure document", enabling oversight of necessary output at each point of design during the progression from specification receipt to shipping.

Improvements were conducted based on the aforementioned checksheet in order to satisfy CMM oversight criteria. Areas of improvement are listed below:

An examination of each CMM Key Process Area (KPA) was conducted to determine whether or not its requirements were being met. As a result, improvements to the following KPAs were deemed necessary.

(Level 2 Requirements)

①Specification Sheet Receipt Status (Requirements Management)

② Scale/Man-hour Estimate (Software Project Planning)

③Work Progress Status (Software Project Tracking and Oversight)

(Level 3 Requirements)

④Review Records(Peer Review)

⑤Educational Structure (Training Program)

⑥Coordination with Related Departments (Intergroup Coordination)

Details of improvements made to ameliorate this problem are listed below:

①A "Program Management Table" showing the specification sheet receipt status for each individual part was generated.

②A procedure document for estimating man-hours for design/evaluation resulting from specification changes was generated and adopted as a division standard.

Table 3 Organized Documents & Tools

	Content	Improved Items
Software Design Procedure Check Sheet	As the main check sheet, checks each software development task. Meet the following KPA: Requirements Management, Software Project Planning, Software Project Tracking and Oversight, Peer Review, and Software Configuration Management.	① ② ③ ④
ADLib	Tools for integrated management of products in each step of design (proprietary tools developed by Fujitsu Ten, Ltd.). Meet the following KPAs: Requirements Management… "Specification Modification Status List" Impact of Modifications for Each Part, Specification Sheet Receipt Rate Software Project Planning… "Estimate Table" Functions Software Project Tracking and Oversight… "Progress Management Table" ←Track Each Process "Program Management Table"	① ② ③

③Altered to visually represent the status of each design process (design, design review, debugging).

④Reviewed items/implementation methods unified; records left as basic data for review improvement.

⑤Separate software designer curricula prepared for new employees and mid-level employees; annual schedule determined; education implemented.

⑥An SEPG manager was designated internally to coordinate with other department (Safety System Division). Joint discussions were held between departments regarding CMM requirements with other departments. At this department, division of labor from a management perspective was implemented in response to engine control function diversification, enabling management with respect to the entire unit and each individual domain. It was determined that total DR would be implemented twice, enabling all designers to debate their concerns.

Representative examples of documents and tools used to implement improvements have been compiled into Table 3. These documents and tools were used effectively, enabling satisfaction of CMM requirements.

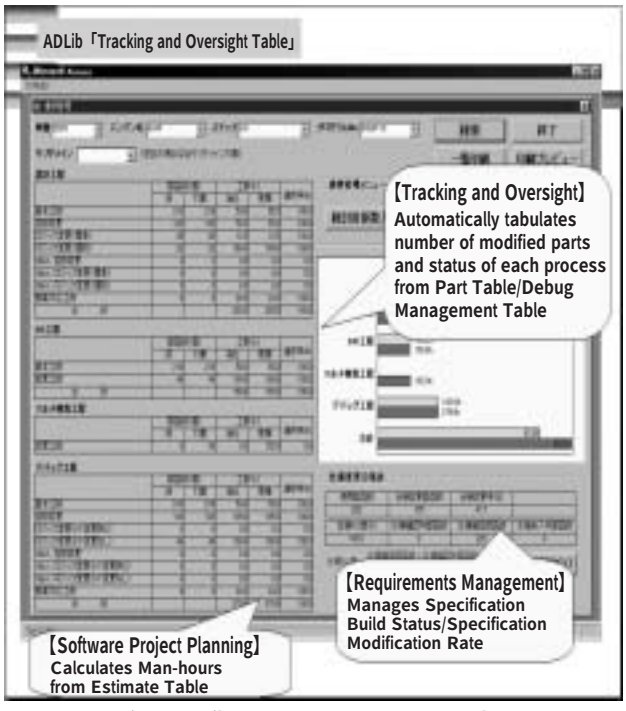

Fig.8 ADLib Progress Management Table

"Progress Management Table", one of the functions ADLib, is shown in Fig. 8.

The table on the left-hand side of Fig. 8 shows the current status of each work process (design, DR, and debugging). For example, it is possible to display the number of parts in the current step that have been modified and the current rate of progress of individual processes on a percentage basis. The progression rates of four categories (design, DR, multiple inspection, and

debugging) are displayed on the right hand side in a graph so that the status of each can be ascertained at a glance. (Software Project Tracking and Oversight)

A table showing man-hour estimates for each task is provided, enabling calculation of estimated man-hours for each change part. (Software Project Planning)

The total number of modified parts and the establishment status of the specifications can be displayed. (Requirements Management)

As explained above, using ADLib clarified workflow.

4.3 Effects

The following three items are provided to illustrate the qualitative effects of CMM activities:

①Visible Management

- Business operation thoroughness according to "Software Design Procedure Check Sheet"
- Each process is checked to see if it is according to plan; lag reduced

②Improved Attitude Towards Managerial Duties

- Compliance with "Software Design Procedure Check Sheet"
- Measurement (estimate, etc.) necessity

③Educational Content Clarification

Past: OJT (Instructors Exhibited Individual Differences)
Present: Internal Education (Identical Instructors Used; No Individual Differences)

5 Safety System Division Activities

5.1 Safety System Division Overview

This division, which is responsible for providing automotive safety and peace of mind, was created when the air bag and structural integrity departments merged. The division's System Software Team assumed responsibility for the software business and implemented software quality improvements pursuant to CMM accreditation.

5.2 CMM Accreditation Acquisition Effort Details

As in past methods, Software Design Procedure Documents are generated and used. The following information is recorded in these documents: scheduled/actual period from specification sheet until shipment, procedures, and regulations related to forms necessary for output as well as the publication numbers thereof.

Based on these procedure documents, forms relevant to Table 4 were stipulated, generated, and revised to fulfill CMM oversight requirements. To enable their use by all system software team personnel, these forms were registered as a team standard. These forms are used at each step of shipment for every model.

In fiscal year 2001, configuration management tools were introduced at this department as a means of software base reexamination.

Table 4 Relevant Form Types

Basic Documents	Contents	Level 2	Level 3
Software Design Procedure Document	List which clarifies the procedure from specification acquisition to shipment, manages scheduled/actual oversight and input/output for each process, and manages each task in its entirety.	○	
	The Details of coordination with related sections are added and managed.		○
Software Traceability Oversight Table	Based on data from the specification sheet list, receipt status and modification/addition scale are managed, man day estimates, such as design, evaluation, and DR, are performed, and progress is managed.	○	
Software Version Management Table	Base, management of each software version, modification details of each version, uses, ROM/RAM capacity and tools are specified. History of each software version is clarified.	○	
Man-hour Estimate Regulation Document	Method for calculating man-day estimates for design and evaluation is specified based on specification modification details. Corrections periodically implemented based on past data.	○	
Review Definition Document	Result review procedure, contents of records at time of review defined. Also uses basic data to improve review methods.		○
Education Plan/Result Management Table	Separate education content for new, mid-level employees clarified; education program implemented systematically.		○

The conventional method posed the risk of errors being made to the base because of clerical errors or emissions due to the fact that designers corrected source code based on version management tables, which were base management tables generated manually. Design assistants could not ascertain file update period or update contents. The conventional method also presented a risk of redesign and/or reevaluation due to

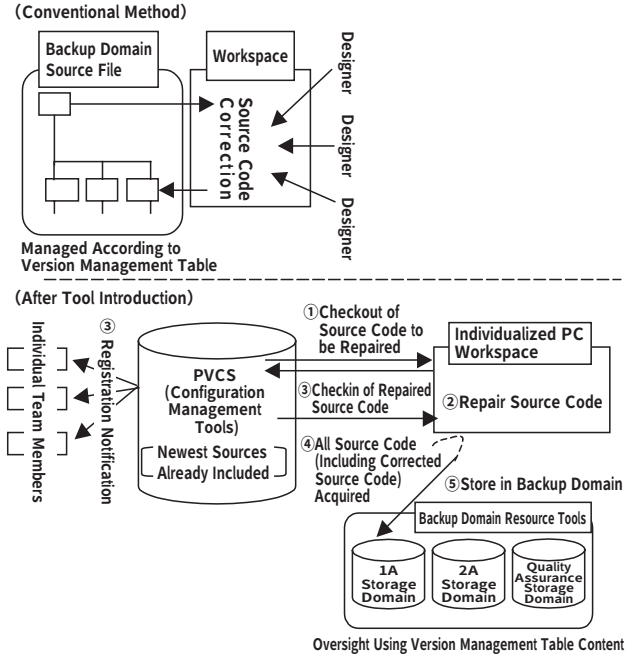

Fig.9 Configuration Management Using Tools

interface incompatibility, and/or missing data.

The newly introduced tools constantly store the newest source files. In addition, revisions are attached to corrected files and automatically managed, eliminating base errors.

Furthermore, design modifications are transmitted via E-mail, making information sharable (Fig. 9).

5.3 Effects

The following three items are provided to illustrate the qualitative effects of CMM activities: undertaken this time

①"Software Design Procedure Document" Defined

・Operations can be fulfilled through implementation of indicated content.

②Educational Content Clarification

・Extremely beneficial due to the current increase in software designers.

③Estimate/Measurement Promotion

・Development status made easier to ascertain through digitalization.

6 Conclusion

Improvements suitable for the type of development favored by each department were implemented in accordance with organization-wide software development processes, thus enabling improvements to advance without radically changing to previously employed processes. Improvement advancement in accordance with CMM also provided the following advantages: procedure clarification, educational content homogenization, facile ascertainment of software design progress, and man-hour estimation. Since the improvements being implemented are inter-departmental, more effective improvements to development processes and forms are enabled by integrating the good/bad points of other departments in our department. Though this will not necessarily result in an improvement in software quality, it will undoubtedly result in an environment conducive to quality improvement.

Though the acquisition of Level 3 accreditation confirmed that an organized software development process was in place, Fujitsu Ten, Ltd. was able to obtain Level 3 accreditation in 3 years. This is the result of having already received ISO 9001 and QS-9000, development processes for all products having already been established, and because all personnel involved in software development devoted themselves to improvement.

Fujitsu Ten, Ltd. will work towards increased software quality through continuous improvement of the software development process in accordance with higher CMMS level and other systems.

Reference Materials

・Software Engineers Association: Capability Maturity Model for Software, Version 1.1 (CMU/SEI-93-TR-24 Official Japanese Version)
・Software Engineers Association: Key Processes of the Capability Maturity Model, Version 1.1 (CMU/SEI-93-TR-25 Official Japanese Version)

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