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Diagnosis platform development of partial discharge data based on CMMI model

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Abstract. Capability Maturity Model Integration (CMMI) model is an international standard in software development process and quality management. It integrates the idea of project management body of knowledge and total quality management. Through continuous process improvement for CMMI model, a flexible, regular and progressive capability model framework is established to increase the transparency and controllability of project management and improve the overall effectiveness of software development, which not only ensures software quality, but also solves the bottleneck of traditional project management applied in information technology (IT) industry. This paper presents the analysis and application of CMMI in partial discharge data diagnosis platform, which illustrates its outstanding capability of IT project management. CMMI model make the process manageable and measurable so that the main factors that lead to poor quality and low productivity can be controlled or eliminated.

1. Introduction

According to *condition-based maintenance based on power-on state* from operation and maintenance (OM) department of state grid, information, automation and intelligence of live detection need to be further enhanced[1]. However, the uncontrollable OM process, OM data, test result and personnel allotment limit its development. To realize intelligent OM system, professional OM management, excellent OM benefit and reliable equipment operation, a comprehensive solution was proposed by Tianjin Electric Power Corporation through their years of experiences and achievements in OM. That is the project for diagnosis platform of partial discharge data. To ensure it stable and controllable during the process of project implementation, Capability Maturity Model Integration (CMMI) is used to optimize software improvement and make the development process analysable, predictable and controllable.

CMMI was developed by the software engineering institute of Carnegie Mellon University in the United State with the participation of experts in software process improvement, software development and project management all over the world[2]. It is a assessment standard of capability maturity that has been popularized and implemented widely[3-5]. It is mainly used to guide improvement of software development process and evaluation of software development capability. CMMI framework contains many information guides and behavior references that help enterprises promote their process improvement. For example, at the beginning of a project, the project team should create and maintain a planning process to track and manage the work, and ensure that all members understand and follow the process to carry out project activities. It should be strictly determined how to develop and maintain cost, schedule and product estimates in this plan[6,7]. Implementation effects should be judged by collecting and measuring variances from the plan during the process of project, and corresponding corrective methods have to be taken to ensure the activities be implemented as planned according to the cause of the variances. Besides project planning, tracking and monitoring activities, CMMI also involves project risk management, team building, integrated project management and other related activities.

2. Applications of CMMI in the project

2.1. Project estimation

At the beginning of the project for diagnosis platform of partial discharge data, function point estimation method has been implemented based on the work breakdown structure (WBS) of this development. Function points of this development are figured out with comprehensive consideration of technical, environmental and functional complexity. Calculations of technical, environmental complexity are shown in table 1-2, and statistics for functional complexity of modules are shown in figure 1.

Table 1 Calculations of technical complexity factors.

Technical factor	Instruction	Weight	Complexity
TF1	Distribution level	2	0
TF2	Performance requirement	1	2
TF3	User efficiency requirements	1	2
TF4	Internal processing complexity	1	2
TF5	Reuse level	1	1
TF6	Easy-to-install requirements	0.5	1
TF7	Easy-to-use level	0.5	2
TF8	Portability	2	2
TF9	Easy-to-modify level	1	2
TF10	Concurrency requirements	1	9
TF11	Requirements on special safety features	1	5
TF12	Third-party access	1	0
TF13	Special user training facilities requirements	1	0

Table 2 Calculations of environmental complexity factors.

Environmental factor	Instruction	Weight	Effect
EF1	UML Proficiency	1.5	0
EF2	Application experience	0.5	3
EF3	Object-oriented experience	1	3

EF4	Analyst Capabilities	0.5	3
EF5	Team morale	1	3
EF6	Requirement stability	2	1
EF7	Proportion of part-time workers	-1	0
EF8	Difficulty of programming language	-1	0

UC ID	UC Name	Type	Complexity	UCP
UC001	Supervision and Management of Live Detection	UseCase	Complex	15.0
UC002	Standardized Operation of Live Detection	UseCase	Simple / Average / Complex	).0
UC003	Business Process Control of Live Detection	UseCase	Average	10.0
UC004	Intelligent Control of Live Detection Implementation	UseCase	Simple	5.0
UC005	Intelligent Diagnosis of Live Detection Data	UseCase	Simple	5.0
UC006	Expert database of live detection data	UseCase	Simple	5.0
UC007	Intelligent State Assessment of Electric Power Equipment	UseCase	Complex	15.0
UC008	Supervision and Management of Abnormal State of Electric Power Equipment	UseCase	Simple	5.0
UC009	Portable management of diagnostic module	UseCase	Average	10.0
UC010	Pilot application of new technology	UseCase	Average	10.0

Figure 1. Statistics for functional complexity of modules.

Accurate workload data are obtained based on accumulated productivity data and estimated results of functional points to provide a reference for cost and schedule estimation. Estimated data of workload and period are shown in figure 2.

1. Project Productivity:

	Productivity	Unit
Average productivity:	7.00	Person-hou/UCP

2. Project Overall Estimation: ◎ 1 Person-months=22 Person-day , 1 Person-day=8 Person-hour

Change rate of requirement(RV%)	productivity	UCP	UCP×(1+RV%)	Person-hour	Person-day	Person-months
10%	7.00	463	509	3565	446	20

Workload type	Project R&D	PM	QA	CM	Other	Total
Proportion of R&D		10%	5%	3%	5%	
Workload(Person-day)	446	45	22	13	22	548

3. Estimation of project schedule:

Phase	Requirement Development	High-Level Design	Detailed design	Coding and testing	Integration testing	System Testing	Confirmation and acceptance	Total
Reference upper limit	25%	5%	25%	50%	5%	10%	2%	
Reference Average	20%	3%	20%	40%	5%	5%	2%	
Reference Lower Limit	15%	0%	20%	35%	0%	5%	2%	
Proportion of this project	25%	0%	16%	40%	2%	12%	5%	100%
Workload(Person-day)	137	0	88	219	11	66	27	548
Number of personnel	3	0	4	5	3	4	3	22
Time limit for a project(Day)	46	0	22	44	4	16	9	141

Figure 2. Statistics for functional complexity of modules.

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2.2. *Project plan*

Project schedule, key milestones and other related sub-plans such as communications, project tracking and monitoring, data collection and analysis plan of project and review plan are developed based on estimated workload data. Moreover, this plan need to be reviewed and confirmed by related personnel. Gantt chart of the plan is shown in figure 3.

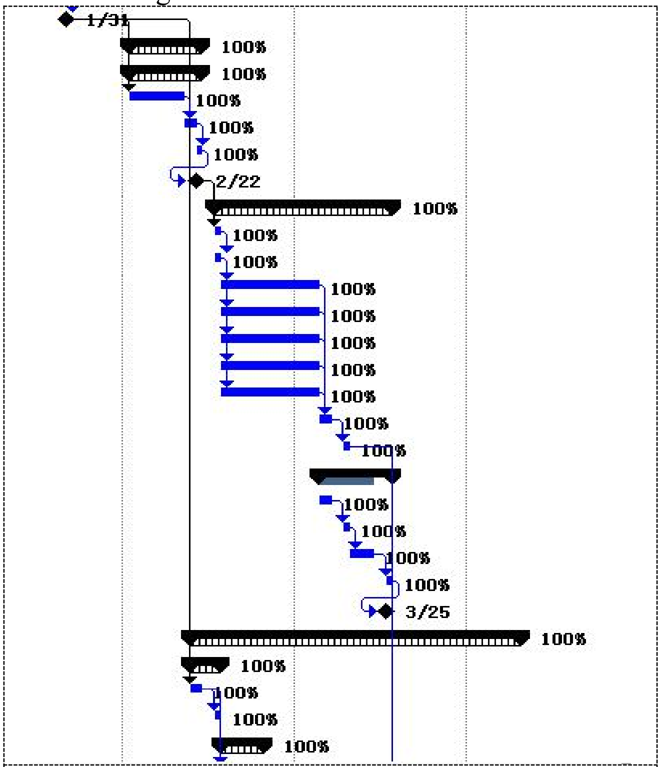

Figure 3. Gantt chart of the plan.

Besides schedule plan, the project plans contain composition and human resource plan (including training plan), project tracking and monitoring plan, measurement and analysis plan, stakeholder participation plan and other plans.

2.3. *Tracking and monitoring*

The project is tracked and monitored by weekly and milestone ways. Earned value analysis (EVA) method is used to track progress and cost implementation of the project during the milestone period.

In tracking and monitoring activities of the project, manager would compare the progress with the plan so that corrective measures would be taken to avoid problems and risks. Earned value (EV) tracking data in the milestone period are shown in figure 4, and the risk tracking data are shown in figure 5.

1. Analysis of Project Progress — Earned Value Analysis

Current progress of the project	Milestone phase	Accumulate to the present	Target Control Scope		Analysis results	Milestone phase	Accumulate to the present
			lower limit	Upper limit			
Planed Value(PV)	617	1716.0	–	–	Schedule	normal	normal
Earned Value(EV)	620	1727.0	–	–			
Actual Cost(AC)	622	1749.0	–	–			
Schedule Performed Index(SPI)	1.00	1.01	0.80	1.08	Cost	normal	normal
Cost Performed Index(CPI)	1.00	0.99	0.80	1.08			
Schedule Variance rate(SV%)	0%	1%	-10%	10%			
Cost Variance rate(CV%)	0%	-1%	-10%	10%			

Projects Progress Forecast	Schedule(day)			Effort(Person-hour)			Result analysis
	Plan	predicted value	Time deviation	Plan	predicted value	Effort deviation	
Next Milestone phase	55	55	0	1734	1740	-6	The cost will exceed 6 Person-hour
total	120	119	1	1822	1845	-23	The total cost will exceed 32 Person-hour

Figure 4. EV tracking data of the milestone period.

2. Project risk

Risks and Countermeasures	Risk description	Possibility	Seriousness	Risk coefficient	Risks and Countermeasures
Risks that have occurred	System analysis and design work because of the tight project duration, resulting in simple design, not rigorous analysis and overall consideration, to the late code implementation brings the risk of rework.	4	4	16	The project team strengthens the supervision and evaluation of design, and enables developers to fully understand the importance of pre-design work.
Possible follow-up risks	With the development of the project, the implementation of system functions lags behind schedule	4	4	16	Do a good job of detailed project work decomposition, strengthen the monitoring of work results, to ensure that the system functions are completed on time and in good quality.

Figure 5. Risk tracking data.

At the end of each milestone, process and product audit of quality assurance (QA) is carried out to verify whether the project is implemented following CMMI. When there were variances found by QA, its solving process would be tracked to ensure consistency between process and product[8]. Audit checklist for monitoring process is shown in figure 6.

Project Monitoring and control (PMC)					
Project name	Large Data Diagnosis Platform for Partial Discharge				
Check name	Zhidong Liang				

ID	Checkpoints	YES	NO	not applicable	Notes
1	Project status tracking				
1.1	Whether project members finish their tasks in accordance with the Project Plan?	√			
1.2	Do project members fill in their personal logs?	√			
1.3	Does the Project Manager Verify the Data in the Personal Log of Project Team Members?	√			
1.4	Does the project manager form Project Weekly after the weekly personal log and before the weekly meeting?	√			
1.5	Does the project manager track weekly non-conformities, defects, and other issues?	√			
1.6	Does the project manager follow up the implementation of the project plan by project members and consult QA Weekly and CM Weekly?	√			
1.7	Does the project manager complete the collection of relevant metrics data and store the collected data in the Project Metrics Database?	√			
1.8	Does the Project Manager Generate the Milestone Report Based on the Analysis and Summary of Data in the Project Metrics Database?	√			

Figure 6. Audit checklist for monitoring process.

2.4. Risk management
Risk management of CMMI has several steps as follows:
- Preparing risk management
- Identifying and analyzing risks
- Reducing or transferring risks

2.4.1. Preparing risk management. The source of risk must be cleared in advance, such as external and internal risks, then the risk coefficient should be determined based on the probability of risk and the severity of the impact. Different management strategies need to be taken according to the risk coefficient[9]. For example, detailed risk management and avoidance plan are required if risk coefficient is high. Proper corrective measures are required if risk coefficient is medium. Tracking with no actions is required if risk coefficient is low.

2.4.2. Identifying and analyzing risks. Possible risk factors of the project should be identified at the start-up stage based on the collected project information, quality and product requirements. Furthermore, the risk, its coefficient and influence scope also need to be evaluated and analyzed.

2.4.3. Reducing or transferring risks. According to the risk management strategy, corresponding risk solutions should be implemented. The impact of risks is tracked weekly to ensure that all risks have been identified and controlled to avoid the impact of risks on the project.

2.5. Peer review
Strict peer review mechanism is adopted in requirement, design and development stage of the project to ensure product quality. For example, firstly, the review experts have received and previewed the software specifications a week before the review. Secondly, deep and intense discussions were conducted among industry experts during the review, and the consensus and problems are recorded. Finally, requirement changes have been decreased due to rigorous and adequate peer review during development process of diagnosis platform.

2.6. Software test
Software testing is a process used to promote and verify the correctness, integrity, security and quality of software products[10]. A detailed software test management plan which covers the requirements of test scope, test strategy, test method, test access conditions and exit conditions, has been formulated in the project planning stage. Test plans and cases must be reviewed before they are implemented.

Besides software test, requirement tracking matrix (RTM) is also used in requirement management activities. The implementation of each requirement can be tracked by RTM, and several specific examples are as follows:
- Whether the corresponding requirement function points are designed, developed and tested
- The impact of requirement change on related products
- Scope of impact on planning, design and other activities.

3. Conclusion
The project for diagnosis platform of partial discharge data is implemented and launched successfully because of the adoption of CMMI module. Corresponding measures can be taken in advance, and the whole process of the project can be clearly guided and supported. This project has accumulated good implementation experience and best practice cases, which can provide reference for the development of similar platforms.

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