The Path to CMM Level 2 – an Integrated Approach

Increasing comfort demands and the postulation of reduced environmental impacts lead to an ever growing complexity of software intensive mechatronic and electronic systems in the vehicle. The resulting challenge for automotive development: reduction of quality problems and their connected costs. Considering the development of systems for the electric energy management in vehicles as example, this joint article of Robert Bosch GmbH and Vector Consulting GmbH describes the experiences made during a process improvement project for systems engineering according to the capability maturity model CMM.

1 Introduction

One of the most urgent challenges in automobile development is the reduction of quality problems and the significant costs associated with them. A look at the official recall statistics shows a clear increase in the last decade. An increasing portion of the recalls is due to problems in the electronics and software area. ADAC (the German automobile club) reports that one-third of all automobile accidents are due to problems with electronics 0. On the other hand, increasing demands for comfort and reliability and the desire for less environmental impact in turn cause constant increases in the complexity of software-intensive mechatronic and electronic systems in automobiles. Thus the development of these systems is accompanied by consistently increasing demands for speed, reliability, and efficiency. The effective resolution of these conflicting objectives

necessarily requires a networked and well-structured cooperation among all participants in the production process; that is, a secure mastery of automotive systems engineering 0. For a systematic implementation of automotive systems engineering, it is necessary to select an appropriate stage of maturation model that can serve as a guideline.
Using the example of the development of systems for electrical energy management in automobiles, this article will present and discuss experiences gained during the execution of a process improvement project for systems engineering based on the Capability Maturity Model (CMM).

2 Initial situation

In its Energy Systems business division, Robert Bosch GmbH develops innovative systems for electrical energy supply. Emphases of development are Electrical Energy Management (EEM) and battery condition recognition. The complexity of such systems is comparable with that of an ABS system.

2.1 Challenges

The challenges presented to the development of systems embedded in automobiles apply especially to EEM systems:

- Speed: The advantages of an EEM system are often recognized relatively late in the development of new automobiles, even though these vehicles make increased demands on the electrical energy supply system due to the introduction of new systems. Therefore, available development times are usually short; only 18 to 24 months.
- Reliability: Since the availability of all electrical systems in automobiles depends directly on the EEM

system, very high demands are made on its availability.

- Efficiency: Electrical energy supply is an important prerequisite for the functioning of all electrical systems, but with few exceptions, it presents no direct customer benefit, as does, e.g., the display of battery charge condition. Despite the high complexity of an EEM system, a connection is pulled to the body electronics. The cost pressure that arises thus requires high-efficiency development.

The solutions to these challenges are:

- Concentration on one's own core competencies and cooperation with competent development partners.
- Use of a product line approach with a platform architecture and reusable system components.
- Mastery of the automotive systems engineering process with a consistent tool chain and high degree of automation.

A secure mastery of the development process is thus extremely important. For software development, the Capability Maturity Model has established itself as a strategy for improving the development process.

2.2 Status at the Beginning

In the example of the EEM system presented here, software development is an integral part of the development of a mechatronic system. Software development works together with system development, hardware development, construction, and application. To exploit optimally the potential speed advantage and efficiency gain due to simultaneous engineering, the development processes of partial areas must be attuned optimally to one another. At the beginning

the basic process elements for this were established. The participating executives were informed in the course of several workshops about the main features of the Capability Maturity Model and the six Key Process Areas (KPA) of level 2 and about the V model.

3 Objective

At the beginning of the project, the objectives for the optimization of the total development process were established. The concern was to find an answer to the challenges for development discussed in section 2. Through suitable development processes, development quality was supposed to be assured and the complexity of products and very dynamic customer demands mastered.

For this, CMM level 2-compliant development processes for system, hardware, and software development and application were supposed to be defined and implemented. For the areas of system development, hardware, and application, the KPAs of CMM level 2 were interpreted accordingly.

Target timeframes for the achievement of CMM level 2 were 15 months for software development and 18 months for system development, hardware development, and application.

4 Strategy

Great emphasis was placed on developing and implementing the processes in small, manageable groups. Thus "mammoth projects" that would give each individual only a partial and unclear responsibility were avoided. Each group was supposed to have the greatest possible freedom to design its processes. Coordination with the other groups was voluntary apart from agreement about the process interfaces.

In each participating development group, an improvement project with a project leader was set in motion. For each project, a project agreement was created, which was also signed by the management of the business division. For project coordination, a Management Steering Group (MSG) was established, which coordinated the individual projects. The project leaders themselves coordinated their activities regularly in a Systems Engineering Process Group (SEPG). For the handling of individual KPAs, Technical Working Groups (TWG) were established.

The line responsibility for the definition and implementation of processes lay with the relevant executives (group leaders) and was coordinated in an objective agreement discussion.

The improvement projects were supported competently by internal and external consultants. Project progress, that is, the state of process ripeness achieved, was communicated through regular evaluations based on the CMM list of questions.

5 Implementation

In order to achieve the objective of the process improvement project, various methods, which were coordinated with one another, were used.

- All relevant employees were first sufficiently familiarized with CMM topics and the development process through appropriate trainings.
- The individual partial processes were defined in the TWGs, which were composed of the project leaders named for the KPAs, selected employees with production experience, and external consultants. Each partial process was reproduced as a workflow and docu-

ments belonging to each activity, such as templates, checklists, assignment matrix, etc. were created. The SEPG subjected the documents to a review, the MSG then made them binding after successful review.

- The defined partial processes and the associated documents were introduced across the company with the help of workshops.
- To ease the application of the defined systems engineering processes and assure the sustainability of process optimization, pilot projects were selected. External consultants supported the project teams with coaching during their operative work. For coaching, objectives and content were agreed upon and the achievement of the objectives was tracked consistently.
- For each pilot project, evaluations based on the CMM list of questions were undertaken regularly in order to ascertain project progress and the success of the coaching. The ideas for improvement thus identified served as the basis for optimizing the individual partial processes.
- To ease the application of the systems engineering process in daily work, practical software tools were identified and introduced. The introduction was supported by the tools' manufacturers and consultants.

6 Achievement of Objectives

6.1 Duration of the improvement project

The project objective in individual departments was achieved with only minimal delay. The greatest deviation from the objective deadlines set was two months. In system and hardware development and application, the achievement

of the objectives was demonstrated by moderated self-assessments by external consultants. For software development, a CMM assessment was made by a certified CMM assessor, who verified the achievement of the objectives.

6.2 Survey

On conclusion of the improvement project, the participating executives and project leaders were presented with feedback acquired by means of an anonymous survey. The objective was to identify in retrospect the success factors and the barriers to achieving CMM level 2, to evaluate these, and to put this experience to use for similar projects.

6.2.1 Success factors

Those people surveyed identified a number of different issues, which in their opinion were conducive to the success of the project. The success factors are presented below, organized according to theme, structure, culture, strategy, and employees:

- Theme: Innovative culture with open-minded employees who show a willingness to make changes. Freedom in the design and mastery of tasks.
- Structure: Sufficient personnel and means, also for external consultants.
- Culture: Open culture and credibility even with the business management. Clear management commitment and support of the improvement project by the executives. Clear orientation to objectives, which is documented for the executives with corresponding objective agreements.
- Strategy: Benefit of project experience and fulfillment of the formal CMM level 2 concerns. Consultants

who were ready to "dig in." Support of operative application by executives and consultants. Trainings on CMM and the development process for all participants. Regular measurement of project progress and visualization of the current status at any point in time. Direct implementation in projects.

- Employees: At least a few enthusiastic employees with extensive knowledge.

6.2.2 Barriers

In addition to the success factors, those surveyed also identified issues that hindered the project or that had no great benefit, and they made suggestions for improvement:

- The group-wise execution of the improvement project hindered the implementation of the optimized partial processes in the production projects. Work was done twice due to failed coordination.
- In critical project situations, customer acceptance of the CMM improvement project was lacking.
- Due to the short time span for the achievement of objectives, time was lacking for becoming acquainted with the topic and dealing with it intensively.
- Due to the sometimes tense capacity situation in the production projects, acceptance of the improvement project was impaired.
- Among some employees, there was a basic resistance to process improvement measures, which was founded on concerns about additional bureaucracy.

6.2.3 What is the use of working according to CMM level 2?

The employees surveyed see an immediate benefit in the application of the processes they themselves have developed. The following issues were emphasized particularly:

- Defined processes and interfaces ease the execution of development projects.
- Transparent mode of operation on the interface to the customer.
- Development of high quality even in "highly-dynamic" projects.
- Common understanding of processes, activities, task profiles, and interfaces.
- Mastery of complex project situations and availability of a current project overview.
- With development that follows quality guidelines, recursions can be avoided and time saved as a result.
- Transfer of expertise within the organization due to consistent and coherent documentation.
- Effective and efficient incorporation of new project team members.

The opinion was also expressed, however, that in certain situations, defined processes can sooner hinder rather than advance the work. The associated issues are the following:

- Increased expenditure of time (filling out of metrics/databases with estimation data), possible gain only in later projects.
- For smaller projects, there is the danger of bureaucratization.
- Quick reaction to customer desires, if necessary “quick and dirty, is no longer possible.

In order to accommodate these objections, processes must be further optimized and awareness training for customers, employees, and managers must be undertaken. This applies especially for work in critical project situations.

7 Further work

With the achievement of the objective of the improvement project, a process and quality group was introduced, as was subsequently a uniform quality assurance system. The objective of these measures is to effectively stabilize the degree of ripeness according to CMM level 2 across all projects and to support verification by management.

The capacity to work in compliance with CMM level 2 should be expanded to include other processes, e.g. the sales process.

Measures have also been implemented for the improvement of the interface to the customer. Requirements management, which on the customer side was initially relatively indistinct in some cases, will be supported with the cooperative development of requirements, e.g. in moderated workshops 0. For the coverage of requirements, a rapid prototyping was introduced in hardware and software development. In regular project team meetings with the customer, cooperative project management will be established. For this, the role of the project leaders in their own organization was strengthened.

8 Results and Conclusion

With the processes developed, the necessary high development speed could be realized in hardware, software, and system development and application. The first two projects completed according to the systems engineering process have

achieved production successfully and on deadline. Above all, the usually complex and hectic situation in the time span of two to three months before the start of production could be managed steadily. The client appreciated the high quality level. The development efficiency was increased so that even in 2002, the development budget could be reduced by 8%.

The participating employees have become demanding due to the process improvements developed and they provide their boss with critical feedback with respect to their "process capability." Therefore, a cooperative improvement of all processes, not just the development process, and cooperation across all levels is extremely important for lasting success. Therefore, we can only recommend expanding the process capability of CMM level 2 analogously to other company processes in upper management.

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