Controlling software acquisition: is supplier's software process capability determination enough?

Fabrizio Fabbrini, Mario Fusani, Giuseppe Lami

Abstract

Innovation in automotive is principally due to the market-driven demand of electronic devices on the vehicles. Car manufacturers usually acquire software-intensive components from different suppliers, and they need to carefully manage such acquisitions to avoid losses in terms of time and quality of the final product. In the last decade, in Europe, many car manufacturers adopted Automotive SPICE-based mechanisms to face such a situation. In this paper we discuss the results achieved by adopting such approaches, and we show that the overall software supplier management would be improved by means of a better usage of the information Automotive SPICE assessments are able to provide.

1. Introduction

Modern vehicles are definitely "software-intensive" systems (someone says "computers with wheels"). Software is now implementing and/or controlling a growing number of traditional functions as well as new innovative functions, made possible only by software. Moreover, increasing competition among car manufacturers is demanding for more and more basic and sophisticated functions, ranging from car control and passenger comfort to continuous information exchange between vehicles and their echo-environment. This has led the software to play a key role in the whole car design, now scoring an 80% of the whole project. [1, 2]

Although Software Engineering as a discipline may now be sufficiently mature to guarantee the trustworthiness of software-controlled systems, what is not guaranteed is that ECU manufacturers are actually adopting the most suitable techniques and practices.

Consequently the software acquisition process became a critical activity for car manufacturers. In fact, because the high importance of the supplied software-intensive systems, they need to track and control the software development of their suppliers in order to avoid losses in terms of time and quality of the final product. This paper focuses on a widely adopted technique aiming at allowing car manufacturers to control and understand the supplier's way to produce software: supplier's software process assessment. Many European car manufacturers use the software process assessment as a principal way to qualify software suppliers on the basis of the rating, in terms of process capability, they obtain according to the Automotive SPICE assessment approach [14]. The aim of this paper is to light-up some drawbacks of the massive usage of process assessments for supplier's qualification purposes made in the last years and, at the same time, show that the amount of information potentially available with an Automotive SPICE [7] assessment may represent a resource to improve the car manufacturer's acquisition process of software-intensive components.

This paper is structured as follows: in section 2 we provide a view of the state-of-the-practice in the software-intensive components acquisition in automotive. In section 3 we discuss the results the automotive industry obtained in the last years applying Automotive SPICE-based methods. In section 4 we show how Automotive SPICE assessments can be used also to support the tracking and control of software suppliers. Finally, in section 5, conclusions are provided..

2. Software-Intensive Components Acquisition in Automotive

The increasing importance of the electronics in automobiles made acquisition a key process for car manufacturers. The time-to-market as well the overall functionality of the vehicle may depend on the car manufacturers' ability to interact effectively with its own software suppliers.

In the recent past a huge amount of resources have been lost because an insufficient management of the technical aspects of the acquisition processes. That caused late releases and after-market problems.

Achieving a formal agreement on single requirement baselines can be insufficient if not accompanied by a continuous communication all over the development of the supply. Customers should improve their ability of assisting and monitoring the software development of their suppliers and suppliers should be more open to customer involvement.

To face this challenge, in practice, car manufacturers adopt different techniques (often not in isolation) as joint reviews [4, 17] with their software suppliers as well as process-evaluation-oriented approaches from the "traditional" ISO 9001 to CMMI and SPICE [5, 6, 8, 9, 10, 11].

While different car makers set up their own improvement program, a policy commonly adopted by the European automotive industry is the choice of the SPICE model as the principal mean [7] to assess the capability of the suppliers' software process. This choice has been supported by some large-scale awakening effort: in year 2001 an initiative was launched by the Procurement Forum [12] with the principal European Car Makers, their assessors and representative bodies to address the problems related to software assessments in automotive. In the framework of this initiative, a Special Interest Group (SIG) has been founded with the aim to design a special version of the SPICE model (called Automotive-SPICE) tailored on the needs and peculiarities of the automotive business area [13]. The initiative aimed at creating consensus on commonality of approach in order to avoid that suppliers face multiple assessments from multiple manufacturers using different models and criteria and consume resources that put additional pressure on delivery times.

The focus on software capability determination by means of software process assessment has determined in the last years a common trend among the European Car manufacturers in using Automotive SPICE as a mean for determining a qualification mechanism for suppliers of software-intensive components. Such a qualification mechanism is based on the definition by the car manufacturer of a target capability profile that the suppliers shall reach to be admitted in the supply selection. [14, 15,16]. The process assessment-based approach requires significant investments both by the car manufacturer and the software suppliers.

3. Automotive SPICE-based Initiatives in Europe: Are Them Really Successful?

European car manufacturers have promoted in the last years hundreds of software process assessments of their software suppliers. Today it's time to evaluate the outcomes obtained and the effects produced by such an approach in order to understand what are possible improvement directions for the next years.

To contribute in such an evaluation we start from the statement of the expectations the adoption of the Automotive SPICE-based initiatives generated at the beginning and then we compare them with the actual situation in order to understand at what extent these expectations have been satisfied.

To do that we take advantage from the experience gained since year 2001 with the co-operation between Fiat Group Automobiles and the System and Software Evaluation Centre of the CNR-ISTI (SSEC). Fiat Group Automobiles defined an Automotive SPICE-based

capability profile to be used as a software suppliers' qualification criterion. During this time, SSEC performed several software process assessments on behalf of Fiat Group Automobiles [14].

While the initial general objective of the Automotive SPICE-based qualification initiatives was to achieve an increased degree of satisfaction for the quality of the acquired software products, other expectations by European car manufacturers can be summarized as:
1. better supplier selection (only supplier having a high capability profile can be selected);
2. better project monitoring (customer can identify the principal phases and work products to be controlled during the supplier's software development process);
3. better relationship with own suppliers (clearer than before, because based on a deeper knowledge of the suppliers organization and processes and on a common technical language);
4. identification of internal improvement areas (both for customer and suppliers) addressing specific processes (e.g. Requirement Management, Testing Management, etc.) and work products.

3.1. Benefits for Car Manufacturers

We can observe, on the basis of our experience, that the expectations 3. and 4. in the above list have been substantially obtained by the car manufacturer. In fact, the mutual knowledge and the degree of understanding of the suppliers' way to produce software-intensive components is today better than before thanks to the Automotive SPICE assessment results. Also the car manufacturers' awareness of its own role in the software acquisition process and consequently the improvement of some practices has been largely obtained.

Unfortunately, the expectations 1. and 2. in the above list can be considered only partially obtained. In fact, the contribution of the performance of Automotive SPICE-based software process assessment didn't impact significantly on the capability of the car manufacturer to control and monitoring the supplier.

One of the main causes of that shall be found in the inherent nature of Automotive SPICE mechanism for assessing the software process.

In fact, to assess the capability of the software process, assessors use process instances (i.e. projects being representative of the organization's business goals) to collect evidences and consequently rate the Automotive SPICE process attributes.

Nevertheless, car manufacturers do not have the guarantee that the project the supplier undertakes for a specific supply has the same characteristics of the projects used as process instances by the assessors at assessment time.

In other words, a new project might be designed, planned, managed and conducted with a different level of care, effort and resources without following the same good practices as respect the project used as process instances for Automotive SPICE assessments.

That should not be surprising. Performing an assessment means to determine, in a disciplined manner, the capability of a set of selected processes.

Process capability is a characterization of the ability of an organization's process to meet current and predicted business goals, it is not involved with the evaluation of the specific techniques and management choices of a project.

In other words, determining the capability of a process means rating the ability of an organization of achieving the outcomes associated with a particular process, no matter how and no matter according what technical or managerial solutions.

So, there is no contradiction if an organization, having a process with high capability level, implements that process in a different (and possibly worse) way as respect as the standard way it performs. Such a situation doesn't depend neither on a defect in the SPICE assessment model, on a bad assessment made by the assessors, nor on the fact that the organization undertaking the assessment (the software supplier, in our case) was cheating during the assessment. It is simple due to management choices of the supplier. It can decide to devote different care in project without make invalid the results of the assessment already performed.

To face such a situation the car manufacturers should increase the efficiency of the assessment. The assessment activities should be not only aimed at the mere determination of the capability profile of the software suppliers, but they should be organized in order to be integrated in the project tracking and control the car manufacturer shall perform on their suppliers.

In Section 4. we present a mechanism to systematically feed the software supplier management activities with evidences obtained by Automotive SPICE assessments.

3.2. Benefits for Software-Intensive Component Suppliers

The Automotive SPICE-based initiative carried out by many European car manufacturers had important positive side-effects on the suppliers of software-intensive components too. In the following a list the principal benefits is provided:

- the requirements, in terms of capability profile, imposed by the car manufacturers determine a general awareness of the importance of software process improvement in the automotive software companies and, consequently, a general enhancement of the quality culture. The European car manufacturers', by means of the definition of a required Automotive SPICE capability profile for their software suppliers, triggered a software process improvement acceleration in the automotive software community.
- Automotive software suppliers have been provided with a de facto benchmarking mechanism. In fact, the capability profiles required by the car manufacturers become a target to be aligned with the competitors.

4. Using Automotive SPICE Assessment Evidences to Control Software Acquisition

The effectiveness of the software supplier management in terms of development project tracking and control depends on the amount and quality of information the car manufacturer can have at its disposal. In fact, only having a complete set of information allows the car manufacturer to get full understanding of the status of the supplier's project.

The information collected during the Automotive SPICE Assessment represents a valuable source for the tracking and control of suppliers' software development project. Such an information set, if well organized, stored, classified and made available, can support the improvement of the control and tracking activities of the supplier. In this section we draw up a way to manage such data according to the process rating in terms of capability level.

Supplier's software development project tracking consists of document analysis and communications aiming at controlling the suitability, effectiveness and efficacy of:

A - Technical solutions adopted in the specific project

B - Management choices adopted in the specific project

Moreover, such a tracking should aim at verify the:

C - Quality of Work Product (i.e. documents, artifacts, …) developed
D - Content of the Work Products developed

The kind of evidences collected during an assessment that can be used to perform project tracking depends on the level of capability achieved by a specific process. In fact, the higher the capability level high the more the amount of useful information available.

In the following we discuss the nature of information that can be obtained from an assessment according to the capability level achieved by the process assessed.

The ISO/IEC 15504 standard, as well as every compliant assessment model including Automotive SPICE, has a five-value scale for measuring the capability of single processes. Processes having the capability level rated as 1, don't provide relevant information to be used for our purposes. In fact, capability level 1 means that the process outcomes are obtained but neither the project is managed nor a standard process is in place, then the information collected unlikely can be used to support the tracking and control of projects different than the ones they have collected in..

For this reason, we consider in this paper the evidences derivable from assessments that have reached a capability level 2 or 3. We don't consider capability levels 4 and 5 because, in the practice, the most common assessment profiles required in automotive don't ask for Automotive SPICE capability levels higher than 3. [14]

A process capability level 2 means that the organization is able to manage the process-related activities and artifacts of its own projects. In some sense, evidences collected about a process rated at capability level 2 indicate the potentiality of the organizational unit. Then, the evidences on how the projects used as process instances in the assessment have been managed can be useful because it is possible to ask the justification of possible under-management of the current project.

Having a process rated at level 3, means that a standard process is adopted, then the same process (i.e. technical and managerial practices as well as documentation characteristics), should be expected also for the current project to be tracked and controlled. Possible differences shall be justified by the supplier.

In Table 1. a list of possible evidences collectable in a process assessment that can support the supplier control and tracking is provided. Such evidences are grouped by capability level and cross-mapped with the four different purposes of project tracking described above.

The evidences described in Table 1 are all available after an Automotive SPICE process assessment. These evidences and information, if suitably managed, can support supplier software project tracking. In the following a few examples are provided in order to better explain how assessment evidences in Table 1 can be used by a car manufacturer to track and control a supplier's project.

Example 1: let's suppose to have the Software Design (ENG.5) process rated at capability level 2 by an Automotive SPICE assessment. That means that the evidences corresponding to the first line of table 1 should be available. In particular, the needs in terms of personal skills (see third bulled in the Management Choices column) and the correspondent responsibility allocation (see second bulled in the Management Choices column), shall be available. Then, if the projects used as process instances during the assessment has characteristics similar to those of the project under tracking, it should be expected that the characteristics of the human resources allocated in both cases are almost the same.

Table 1: Evidences collectable in process assessment by capability level

	Automotive SPICE Capability Level 2	Automotive SPICE Capability Level 3
A – Technical	- Criteria for resource allocation	- Necessary infrastructures and work

Solutions	defined (tools, facilities, infrastructures …)	environment identified - Necessary infrastructures and work environment allocated - Data and analysis on the suitability and effectiveness of technical solutions used in project available
B – Management Choices	- Project's objectives (in terms of quality of artefacts, process cycle, resource usage) defined - Criteria for responsibility allocation in the project defined - Skills profiles needs for the project defined	- Tailoring guidelines existing - Interaction with other processes described - Roles and competencies identified - Project conformance to the standard process verified - Necessary competencies identified - Data available and analysis made on the suitability and effectiveness - Necessary resources allocated to the project
C – Quality of Work Products	- Requirements for work products (structure) defined - Review and approval criteria for work products defined - Dependencies among work products identified	- necessary resources allocated to the project
D – Content of Work Products	- Requirements for work products (contents) defined - Review and adjusting of work products performed	- Project conformance to the standard process (including work products) verified

Example 2: let's suppose the Software Testing (ENG:8) process rated at capability level 3, in this case, the effectiveness and suitability of the technical solutions adopted in the project have been evaluated. The same evidence should be available for the current project. Then, at monitoring time, the supplier can be asked to provide such evidences in order to understand if the project is conducted with appropriate technical support.

A way to use effectively the information available from Automotive-SPICE assessments is its integration in the joint reviews.

Generally speaking, joint reviews are meeting where persons having different roles, responsibilities and perspectives join together to analyse the status of an activity or the content of a product. The purpose of such an analysis is to ensure that agreed objectives and requirements are satisfied. Joint reviews are conducted with a substantial degree of formality and are regulated by precise requirements. [3]

The object, scope and goals of joint reviews can be different depending on the project/product development phase. They can address issues at both project management and technical levels and are held throughout the life of a development project. [4]

The integration of software process assessment and external joint reviews is able to provide an added value respect the performance of these two techniques in isolation.

In [17] we presented a mechanism to transfer software process assessment results and related evidences supporting joint reviews with the supplier. Such a mechanism is composed of three phases:

> Phase 1: Software Process Assessments: the car manufacturer sponsors software process assessments to suppliers of software-intensive components. Sponsorship is important because it allows the ownership of the assessment results.

Software Process Assessment reports should be compliant with the requirements contained in the ISO/IEC15504 Part.2 and, in addition, should provide specific information to be used to support the external joint reviews.

Phase 2: Process mapping: the processes in the assessment scope are mapped on the planned Joint Reviews. Each Joint Review has a purpose, a set of input items and a scope (in terms of activities and work product to be reviewed); they are to be used to guide such a mapping.

Phase 3: Joint Reviews: the external joint reviews should be prepared and conducted taking into account the additional information from the process assessment the supplier involved in the joint review undertook.

5. Conclusions

Supplier's software projects control and tracking is very important for the automotive industry. European car manufacturers undertook the Automotive SPICE initiative, with the aim of defining an automotive-specific framework for supplier's software process evaluation and qualification.

Today, after almost a decade and hundreds of software process assessment made, a first cost-effectiveness evaluation can be done. Our opinion, based on a wide experience in software process assessment and improvement initiatives in automotive, is that to be cost-effective, Automotive SPICE assessments, should be used for supporting supplier's project control and tracking also.

We described, by means of examples, how the usage of Automotive SPICE assessment can be extended over the mere process capability determination In particular, we discuss how Automotive SPICE evidences collected during Automotive SPICE assessment can be used for supplier's software project tracking and control purposes.

6. References

[1]   Leen G, Hefferman D, Dunne A. Digital Networks in the Automotive Vehicle, IEE Computer and Control Eng. Journal Dec. 1999 ; pp. 257-266.

[2]   Kassakian JG. Automotive Electrical Systems: The Power Electronics Market of the Future. Proceedings of Applied Power Electronics Conference (APEC2000, IEEE Press 2000; pp. 3-9.

[3]   ISO/IEC 12207 Amd 1:2002, Software Engineering – Software life cycle processes.

[4]   Staples M., Mahmood N. Experiences Using Systematic Joint Review Guidelines. 2007. Journal of Systems and Software Vol. 80, Issue 90, pp. 1425-1437.

[5]   Quality System Requirements (QS-9000 Third Edition) Vers. 03.00. DaimlerChrysler, Ford Motor Company and General Motors Quality Publications: 1998.

[6]   ISO/TS 16949- Quality Management Systems - Automotive Suppliers - Particular Requirements for the Application of ISO 9001:2000 for Automotive Production and Relevant Service Part Organizations, 2002.

[7]   ISO/IEC 15504 International Standard "Information Technology – Software Process Assessment: Part 1–Part 5" 2006.

[8]   Chrissis MB, Konrad M, Shrum S. CMMI Guidelines for Process Integration and Product Improvement. Addison-Wesley, 2004.

[9]   Paulk M. Top-Level Standards Map: ISO 12207, ISO 15504 (Jan 1998 TR) Software CMM v1.1 and v2", Draft C. Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA, 1998. (available at http://www.sei.cmu.edu/pub/cmm/Misc/standards-map.pdf date of access January, 31 2007).

[10]   Hailey V. A comparison of ISO 9001 and the SPICE framework. SPICE: The Theory and Practice of Software Process Improvement and Capability Determination. IEEE CS Press, 1998.

[11]   Jung HW, Hunter R. The relationship between ISO/IEC 15504 process capability levels, ISO 9001 certification and organization size: an empirical study Journal of Systems and Software 2001; 59: 43–55.

[12]   www.procurementforum.org

[13]   http://www.automotivespice.com

[14]   Fabbrini F., Fusani M., Lami G., Sivera E. A SPICE-based Supplier Qualification Mechanism in Automotive Industry. Software Process Improvement and Practice Journal 2007; Vol. 12 Issue 6 pp. 523-528.

[15]   Fabbrini F, Fusani M, Lami G, Sivera E. Performing Process Assessment to Improve the Supplier Selection Process - An Experience. Proceedings of the Automotive European Software Process Improvement Conference EuroSPI2002 2002; 267-274.

[16]   Fabbrini F, Fusani M, Lami G, Sivera E. Software Process Assessment as a Mean to Improve the Acquisition Process of an Automotive Manufacturer. Software Process Improvment CMM&SPICE in Practice. Verlag UNI-DRUCK: Munchen, 2002: 142-154.

[17]   Fabbrini F, Fusani M, Lami G, Sivera E. Integrating Joint Reviews with Automotive SPICE Assessments Results. Proc. of the International Conference on Software Process, Leipzig, Germany. 10-11 May 2008. (forthcoming).Smith, A.B., Jones, C.D. and Roberts, E.F., "Article Title", Journal Title, Date, pp. 1-10.