

Integrating Joint Reviews with Automotive SPICE Assessments Results

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Abstract. The continuous changes in customer requirements as well as the ever-increasing market-driven demand of innovation makes automotive software projects success strongly dependent on the customer-supplier communication and co-operation all along the software life cycle. Joint reviews and software process assessments (principally performed according to the Automotive SPICE model) are popular means used by car manufacturers and their suppliers of software-intensive components to face such a situation. Often these two resource-consuming techniques are performed in isolation, without being mutually supported. This paper presents an approach to integrate joint reviews with software process assessment results. The effectiveness of joint reviews depends on the degree of car manufacturer's knowledge and understanding of the supplier's way of proceeding in software development. We show how assessment results can be used as joint reviews inputs to support effectively the car manufacturers in conducting joint reviews.

Keywords: Joint Reviews, Software Process Assessment, Automotive SPICE, Software Process Improvement.

1 Introduction

Up to a few years ago, car makers could not clearly understand what the software component of Electronic Control Units (ECU) was about, nor intervene anywhere in the software development process, that was unrepented realm of subsystems suppliers. On the other hand, most suppliers were just emerging from years of experience limited to hardware design, barely coated with low-level software drivers. Today the competency and experience of car manufacturers in automobile's electronics is much increased. Nevertheless,, 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.

In fact, serious problems worldwide were arising with the first cars having a complex electronic components network, especially regarding the car body functions. This led manufacturers to reconsider their initially unquestioned acceptance of software as a minor component of car subsystems.

Such a hard situation, that caused huge loss of resources for automotive industry, was due to several reasons, the principal of them are listed in the following:

- Cultural transition from a mechanical (or electro-mechanical) centered approach in designing and producing automobiles towards an approach where the electronic (and then the software) plays a very important role. An important effect of such a cultural gap has been the difficulty of interaction between car makers and their software suppliers. In fact, often the language, and competency, were different from those of software suppliers and that heavily affected the car makers' software acquisition capability.
- Lack of standard approaches and platforms
- High complexity of the in-car ECU network that determined system integration problems.

In such a context the software acquisition process became a critical activity for a car manufacturer. In fact, because the high importance of the supplied software-intensive systems, they need to monitor and control the software development of their suppliers in order to avoid losses in terms of time and quality of product. This paper focuses on two widely adopted techniques aiming at allowing the car manufacturer to control and understand the supplier's way to produce software. These are joint Reviews and software process assessments.

This paper is structured as follows: in section 2 we present the most popular techniques used in the practice to controlling, monitoring and evaluating the software suppliers in automotive. In section 3 we discuss open problems occurring today in controlling and monitoring supplies in automotive. In section 4 we describe an approach to integrate the joint reviews and the software process assessments made according to the Automotive SPICE model [7], moreover the way such an approach is going to be adopted at FIAT Automobiles Group is presented. Finally, in section 5 conclusions are provided.

2 Controlling software suppliers in the practice

The increasing importance of the electronics in automobiles forced car manufacturers to acquire electronic components from many suppliers, with consequent problems in terms of interoperability, integration and distributed intelligence. Acquisition became a key process because the time-to-market as well the overall functionality of the

vehicle depends 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.

The success of the acquisition process depends on the capability of effectively managing the relationship between customer and suppliers. In particular, common and complete requirements understanding and monitoring the status of advancement of the supplies is still a challenge for many car manufacturers. The 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. Besides, customer's continuous requirements evolution must be seen as a technological challenge and not as an idiosyncrasy to be fought against.

To face this challenge, in practice, many car manufacturers adopt both software process assessments and joint reviews as means to control the capability of their suppliers in producing software. The purposes and the impact of these two approaches are different, in fact joint reviews address the on going activities of a project and aim at verifying specific requirements of a specific project (in terms of quality and completeness of delivered work products, compliance to plans and process requirements), while software process assessments provide general information of the supplier's software process and are more oriented towards the supplier selection phase.

In the following these two approaches are shortly described and discussed.

2.1 Joint Reviews

Generally speaking joint reviews are meeting where persons having different roles, responsibilities and perspectives join together to analysis 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]

On the basis of the authors' experience, two principal types of joint reviews can be identified.

- Internal joint reviews: they involve member of the software development team, and aim at reviewing key work products at specific project's milestones. Typically, they occur when a particular work product (e.g. software requirements) is to be released, and such a work product is to be used by different members of the team. In this case, the work product is jointly reviewed in order to achieve a formal agreement on its content.

- External joint reviews: they involve both members of the software development team and customer representatives. The object of these joint reviews is whether the content of specific work products (typically the specifications that are to be reviewed, understood and agreed) or the verification of managerial aspects of the development project (e.g. respect of planning, compliance with process requirements, control of risks, ...).

In particular, in this paper we consider external joint reviews involving software suppliers (i.e. typically suppliers of Electronic Control Units (ECU) to be integrated into the automobile's network) and car manufacturers (i.e. system integrators).

This kind of joint reviews are an effective mean to control and monitor the advancement of a software development project as well as verify the quality of the intermediate work products.

2.2 Software Process Assessments

The traditional reliance on Quality Systems Standards such as ISO9001, QS9000 [5] and ISO/TS 16949 [6] has not provided sufficient confidence in the software area. The car manufacturers, like others in the defense and aerospace industries, have turned to international standards for software process assessment, based on ISO/IEC 15504 (known also as SPICE) [7] and/or the Capability Maturity Model Integration (CMMI) [8], as a mean to identify and control supplier related risks and to assess supplier's software capability [9], [10], [11]. A common trend in the European automotive industry to face this question consists of principally addressing the improvement of the software acquisition process. While different car makers set up their own improvement program, a commonly adopted policy 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. Furthermore, the focus on software capability determination by means of software process assessment has determined a common trend among the European Car Makers in using Automotive SPICE as a mean for determining a qualification mechanism. Such a qualification mechanism is based on the definition of a target capability profile that the suppliers shall reach to be admitted in the supply selection.

Benefits derived from the Automotive-SPICE initiative not only can be quantified as an increased degree of satisfaction for the quality of the acquired software product, but include some positive "side effects" as:

- better supplier selection (only supplier having a high capability profile can be selected);

- better project monitoring (customer can identify the principal phases and work products to be controlled during the supplier's software development process);
- 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);
- identification of internal improvement areas (both for customer and suppliers) addressing specific processes (e.g. Requirement Management, Testing Management, etc.) and work products.

The strategy adopted by many European Car Makers based on SPICE capability profile as a mean for qualifying their suppliers gives practical benefits and opportunities also for the automotive software suppliers. In particular, it has been provided an important stimulus to accelerate the suppliers' software process improvements. Moreover it can be used as a sort of benchmark where the required capability profile becomes a target to be aligned with the competitors.

3 Capability Determination vs. Project Performance

External Joint Reviews are practices performed by manufacturers to interact with their software suppliers with the aim of monitoring and, if case, driving the performance of the supply-related development project.

In the automotive domain, external Joint Reviews are planned and performed at specific and predefined times conciliating and synchronizing supplier's software development project milestones with car development phases (typically such external joint reviews are performed after requirements elicitation/analysis, at development project planning, once software design has been defined or at software testing planning time). Moreover, Joint Reviews can be iterated when the development project is composed of several incremental cycles.

The principal purpose of these joint reviews is to make the car manufacturer able to understand the status of the supplier's project in order to verify its schedule, the quality of the technical solutions adopted and the compliance to its own needs.

The effectiveness of external joint reviews 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. For example, the availability of project planning documentation is necessary to understand the suitability of the resources to be allocated to the project, test planning documentation for the completeness and trust of software testing.

Unfortunately, often car manufacturers aren't able to make the external joint reviews effective because the evidences provided by the software suppliers aren't complete enough. That reduces the benefits that can be expected by the joint reviews.

It is a common practice (principally in the European automotive industry) to ask potential software suppliers a specific capability profile according to the Automotive SPICE model. It is even common that car manufacturers sponsor the initial assessment for determining such a capability profile. The return of such an investment is, for the car manufacturer, the possibility to know the capability of a defined set of

suppliers' processes taken from the Process Reference Model of Automotive SPICE; such knowledge becomes one of the main criteria used by the car manufacturers for the supplier selection process.

Moreover, 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.

4 Integrating Joint Reviews and Software Process Assessments

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 this section we describe how joint reviews and software process assessment can support each other in the supplier monitoring and control activity.

We present a mechanism where software process assessment results and related evidences can be used to give information to support the car manufacturer in conducting external joint reviews with the supplier.

The mechanism we present is composed of three phases:

Phase 1.: Software Process Assessments: the car manufacturer sponsors software process assessments to a set of important¹ software suppliers. Sponsorship is important because it allows the ownership of the

¹ With the term *important* we intend characterise a supplier that is either a new one or that is supplying a critical component for the vehicle.

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.

According to what stated in Section 2.1, the objects (i.e. the project aspects to be evaluated) of an external Joint Review can be:

- A - Technical solutions adopted in the specific project
- B - Management choices adopted in the specific project
- 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 during a Joint Review 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 in a Joint Review. 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 joint review of different projects.

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 in a process capability level 2 assessment indicate the potentiality of the organizational unit. Then, the evidences of how the projects used as process instance in the assessment has been managed can be useful in a joint review because it is possible to ask the justification of possible under-management of the reviewed 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 process under joint review. Possible differences shall be justified by the supplier.

In Table 1. a list of possible evidences collectable in a process assessment that can support a joint review is provided. Such evidences are grouped by capability level and cross-mapped with the four types of object a Joint Review can have.

The evidences described in Table 1 are all available after an Automotive SPICE process assessment is made. These evidences and information, if suitably organized and provided, can support Joint Reviews. In the following a couple of example are provided in order to better explain the use in a joint review of the information described in Table 1.

Example 1: let's suppose to have the Software Requirements Analysis process rated at capability level 2 by an Automotive SPICE assessment. That means that the evidences corresponding to the first line of table 1 are 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 project used as process instance during the assessment has characteristics similar to those of the project under Joint Review, it should be expected that the human resources allocated to the two projects are almost the same.

| | A Technical solutions | B Management choices | C Quality of Work Products | D Content of Work Products |
|--------------------|---|--|--|--|
| Capability Level 2 | <ul style="list-style-type: none"> - Criteria for resource allocation exist (tools, facilities, infrastructures ...) | <ul style="list-style-type: none"> - Definition of project's objectives in terms of quality of artefacts, process cycle, resource usage - Criteria for responsibility allocation in the project exist - Definition of skills profiles needs for the project | <ul style="list-style-type: none"> - Definition of requirements for work products (structure) - Definition of review and approval criteria for work products - Identification of dependencies among work products | <ul style="list-style-type: none"> - Definition of requirements for work products (contents) - Review and adjusting of work products |
| Capability Level 3 | <ul style="list-style-type: none"> - Infrastructures and work environment needed identified - necessary infrastructures and work environment allocated - Data and analysis on the suitability and effectiveness of technical solutions used in project available | <ul style="list-style-type: none"> - Tailoring guidelines exist - Interaction with other processes are described - Roles and competencies identified - Verification of the project conformance to the standard process - necessary competencies identified - Data available and analysis made on the suitability and effectiveness - necessary resources allocated to the project | <ul style="list-style-type: none"> - Procedures to support the implementation of the standard process exist | <ul style="list-style-type: none"> -Verification of the project conformance to the standard process (including work products) |

Table 1. Evidences collectable in process assessment by capability level

Example 2: let's suppose to have the Software Testing 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 project under review. Then, at joint review time, the supplier can be asked to provide such evidences in order to understand if the project is conducted with appropriate technical support.

4.1 A Pilot Initiative at Fiat Group Automobiles

Fiat Automobiles Group, in cooperation with the System and Software Evaluation Centre of the CNR's Information Science and Technologies Institute (SSEC), is undertaking an activity aimed at improving its capability in managing, controlling and driving the acquisition of software-intensive systems since year 2000 [14], [15], [16]. Such an activity has been mainly based on the performance of SPICE (and, since year 2004, Automotive SPICE) software process assessments with the aim of determining a supplier qualification mechanism based of the achievements of a predefined capability profile. Only suppliers having such a capability profile can be qualified as suppliers. Today FIAT Group Automobiles is able to know the way its own suppliers develop software because it got an understanding of their processes by means these assessments.

In addition, FIAT Group Automobiles is conducting, on a regular basis, external joint reviews (called Design Reviews) with its own suppliers in order to monitor their software projects. These joint reviews consist of a verification of the suitability and correctness of key work products and managerial practices; they are primary means to:

- Verify completeness and quality of delivered work products
- Monitor respect of plans and other process requirements
- Monitor and control project risks
- Ensure that safety and security are properly managed
- Manage open issues
- Provide recommendations of alternatives.

The FIAT Group Automobiles design review process requires that four design reviews shall be planned and performed for each project. In the following the purpose of these reviews is shortly described:

- Software Requirements Review (SRR): This review shall ensure the correctness and completeness of the software requirements to be implemented. In addition the review will focus on project management.
- Software Architecture Review (SAR): This review shall confirm correctness and completeness of software architecture, agree on the technical approach and on implementation choices.
- Software Test Readiness Review (STRR): This review shall be conducted to confirm successful completion of coding, unit testing and integration testing and to gain confidence for the beginning of the software validation.
- Software Validation Review (SVR): This review shall be conducted to confirm successful completion of validation phase, and to gain confidence for the

delivery to Fiat Group Automobiles. A successful validation review does not imply acceptance, as the software shall undergo a separate acceptance process after the validation review.

Because problems similar to those described in Section 3 occurred, FIAT Group Automobiles, with the support of the SSEC, is going to implement the mechanism described above to integrate Automotive SPICE assessments results with the design reviews. Fiat Group Automobiles is going to sponsor Automotive SPICE software process assessments to a selected group of software suppliers.

The Automotive SPICE assessments FIAT Automobiles Group sponsored until now, had the assessment scope depicted in Figure 1.

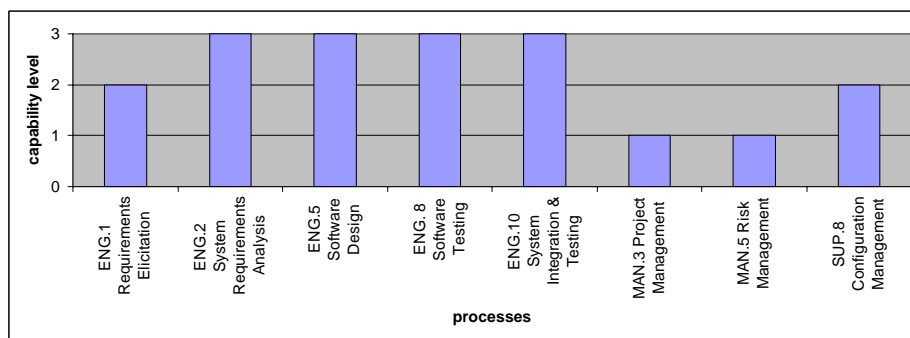


Figure 1: FIAT Automobiles Group Automotive SPICE assessment scope, until year 2007

To improve the integration between design reviews and Automotive SPICE assessment results, the assessment scope is going to be modified by adding new processes and modifying the target capability levels. The current scope, in fact, doesn't allow an adequate coverage of the four design review phases.

A possible new scope will be composed of the processes listed in the following:

- ENG.1 Requirements Elicitation,
- ENG.2 System Requirements,
- ENG.3 System architectural design,
- ENG.4 Software requirements analysis,
- ENG.5 Software design,
- ENG.6 Software construction,
- ENG.7 Software integration test,
- ENG.8 Software testing,
- ENG.9 System integration test,
- ENG.10 System testing,
- SUP.1 Quality assurance,
- SUP.8 Configuration management,
- SUP.9 Problem resolution management,
- SUP.10 Change request management,
- MAN.3 Project Management.

In figure 2, the mapping between the design review phases and the processes in the assessment scope is shown. The link between a design review phase and a process

indicates that the results of the assessment of such a process should be used in the correspondent review phase.

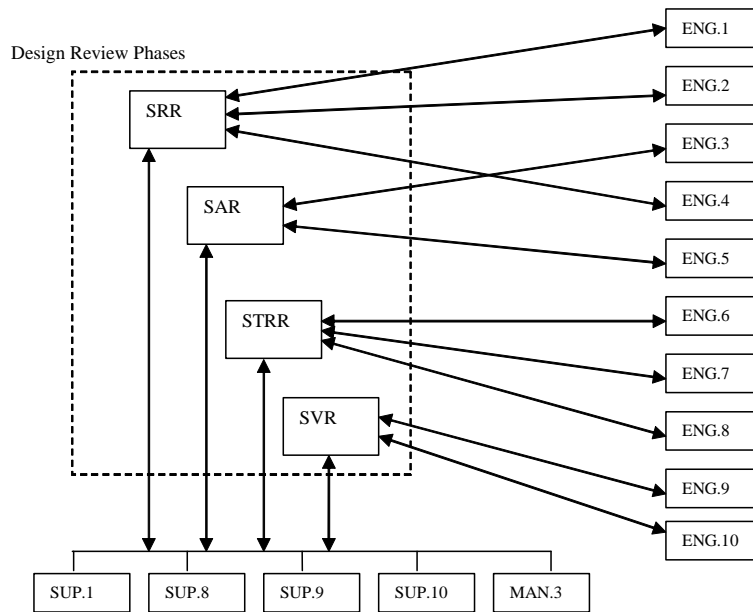


Figure 2. Mapping between Design Review Phases and Process into the Assessment Scope

5 Conclusions and Future Works

In this paper we proposed a mechanism to integrate the Automotive SPICE assessment results into the joint reviews. Such a mechanism allows using the evidences collected during a software process assessment to support the joint reviews between FIAT Group Automobiles and its suppliers of software-intensive devices. To adopt the mechanism we propose, software assessments reporting shall be modified by providing information suitable to be applied in the different design reviews FIAT Group Automobiles performs regularly. The mechanism described in this paper can be considered as a way to conciliate the products based software evaluation and the process-based one.

FIAT Group Automobiles is going to sponsor a number of Automotive SPICE assessments in order to be able to apply such a mechanism on a sample set of important suppliers. The next step will be the definition of techniques to quantitatively evaluate the possible advantages obtained with the application of the mechanism.

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