SPI in the Italian Automotive Industry: Issues from the Automotive SPIN Italy

Abstract

Today automotive is an application field where innovation is growing at the highest rate. Innovation in automotive is principally due to the market-driven demand of new features that only electronic devices on the vehicles can provide. Electronic devices, more and more complex and connected by CANs (Control Area Networks), control more than 85% of the automobile's functionalities. The way the automotive industry is facing the challenges arisen in the last years is the subject of this paper. The authors, starting from the experience of the Automotive SPIN Italy, give a picture of the achievements and the open issues in the Italian automotive industry.

Domain

[Automotive]

Topic

[Software Process Improvement]

1 Introduction

Not many years ago, Information Technology made its first appearance in automobile functions control. Since then, technical solutions have run again through all the stages of the longer evolution of computer systems. Doubtfully accepted at first in a community of electrical engineers, in the form of program-control based devices, they have now boom-evolved into integrated networks of tens and tens of active nodes, each one performing complex, often time-constrained, functions. Continuous market pressure for all-in-a-car integrated services (including engine control, x-by-wire drive, passenger comfort control, environment interaction, web services) claims for deployment of the most advanced system and software engineering research results. Automotive issues have become a leading applicative domain for experimenting advances in these fields [1], [2].

Car makers are facing these challenges addressing the software issues from the process and product perspective. In fact, single and international initiatives arose in the last decade aiming at making the organizations more mature in managing the more and more critical and complex software part of automobiles.

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 untrepassed 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.

Increasing competition among car makers has then demanded 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.

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 facts, serious problems worldwide were arising with the first automated cars, 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.
    - Car makers started to realize that investments had to be made much in human resources and in new technology (although software was no new technology, its intensive adoption and impact were new issues). 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.

To face these problems automotive industry adopted some countermeasures. These countermeasures can be categorized into two classes: product-based and process-based.

Product-based countermeasures:

these are standards and technical solutions aiming at improving the design and construction of software product in automotive. In the following, they are listed

- AUTOSAR (AUTomotive Open System Architecture) [12].
- MISRA (Motor Industry Software Reliability Association): [13],
- OSEK (Offene Systeme und Shnittstellen fur die Elektronik in Kraftfahzeugen): [14].
- Product Lines: it is a well known approach to software development aiming at sharing set of software assets using a common means of production [15]. In automotive, product lines have been successfully adopted by software suppliers that supply software-intensive components to many car manufacturers [3, 22].

Process-based countermeasures:

The traditional reliance on Quality Systems Standards such as ISO9001, QS9000 [8] and ISO/TS 16949 [9] has not provided sufficient confidence in the software area. The motor vehicle 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) [4] and/or the Capability Maturity Model Integration (CMMI) [10], as a mean to identify and control supplier related risks and to assess supplier's software capability [5], [6], [7]. This choice has been supported by some large-scale awakening effort: In year 2001 an initiative was launched by the Procurement Forum [16] 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 [11].

This paper is structured as follows: in section 2 an initiative called "Automotive SPIN (Sotware Process Improvement Network) Italy is presented; in section 3 the software-related open issues arose from the participants in the Automotive SPIN Italy are presented discussed and, finally, in section 4 conclusions are provided and the future works are presented.

2 Automotive Software Process Improvement Network Italy

A Software Process Improvement Network (SPIN) is an organization of professionals in a given geographical area who are interested in software process improvement. In particular, the Automotive SPIN Italy is focused on software process improvement in the automotive domain.

The purpose of such a SPIN is to networking professionals and researchers in automotive software and embedded systems to share experiences and knowledge in the area of the software process improvement and software engineering in automotive.

Automotive SPIN Italy, is composed of research institutions, car makers, certification bodies, and many Italian automotive suppliers and software companies. The complete list of the SPIN member can be found at www.automotive-spin.it

Automotive SPIN Italy, has a very light organization composed of a president, a management board charged of organize the workshops and promote the SPIN-related initiatives and the members. The membership is free and doesn't require any bureaucratic accomplishment but only a simple login. The means used by Automotive SPIN to fulfil its objectives are:

- A web site (www.automotive-spin.it) where the registration can be made, a newsletter is available for announcements and new initiatives publicity, a forum for allowing the SPIN member to discuss on specific topics of interests, a download area where standards, technical papers and presentations are available.
- Periodic workshops. These workshops are open events, organized as a mix of invited speakers presentations on topic of interests, experience reporting by means of SPIN members to share lessons learned and open discussions and panels on arguments arising form the SPIN member.

Automotive SPIN has been founded in the March 2007, the number of members is 25% increased in six months (between the first and second Automotive SPIN Italy workshops) both in terms of individual participants and companies.

Automotive SPIN Italy workshops represent an incomparable opportunities to understand the open problems and the hot topics form the Automotive community. Workshops are able to produce, challenging requests for researchers and to identify improvement opportunities and technical solutions for the industry. In the following section we discuss the principal open issues arising from the Italian automotive software community.

3 Software Engineering Open Issues in Automotive

In this section the challenges arisen within the Automotive SPIN Italy are described and discussed.

3.1 System vs. software

Requirements specification and management is one of the most important activities in every software development project. In automotive it becomes even more critical

because of the usual very high volatility of requirements. Working out precise, complete and correct requirements as well as providing them at the right level of detail to the developers is a necessary condition for the success of a project.

In practice, requirements are often delivered to the software developers still in the same format, contents and level of detail of the system requirements (i.e. the requirements describing the behavior of the final product composed of hardware, mechanics, and software). System requirements are often produced, analysed and also agreed with the customer, but they are hardly transformed into software requirements. The effect of such a situation can compromise the project objectives because software developers and testers have little or no basic information to develop and test software they release.

The risk cannot be underestimated that the software is affected of too much interpretation freedom by the software developer and, principally, software testing risks to be coarse if planned and defined against too high-level requirements. In particular, software engineers alone can't easily understand the impact into the software of interactions between system components. This and other analogous situations are going to remain and grow, unless systems and software engineers make more efforts to understand each other, which from our field experience was not common.

3.2 Customer/Supplier relationships

The increasing importance of the electronics in automobiles forced car manufacturers to acquire electronic components from many suppliers. 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 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.

3.3 Safety

The notion that the numerous and interconnected car functions, including the ones apparently performed by the driver, are now mediated by software, together with the well-known story that software can fail, brings forward the issue of safety.

As there are standards for automotive software process maturity, so there are expectations for automotive system-and-software safety standards. ISO 26262 [17] is not ready yet, but its draft documents are well known in the automotive environment. It comes from a popular standard for safety of programmable control systems, IEC 61508 [18], that has scarcely been applied to the project of car control units.

While we believe, supported by our experience, that adoption of Automotive SPICE criteria for selecting suppliers has had a positive impact on the suppliers´ software processes, we also believe that the achievement of an adequate system safety level through standard compliance is still uncertain. Reasons are:

- The standard ISO 26262, while is including the notion of supporting processes, has still the IEC 61508 “phased-development” view and little concern of processes like those defined in SPICE, even if it prescribes the application of software engineering practices and techniques in a disciplined way, according to system safety requirements, which should be previously determined.
- There is little integration between systems and software engineering. Safety is a system property, and can be better understood and implemented having the vision of a system in which all the components interactions are well known (software is usually the weakest of such components): In particular, it cannot be ensured by software engineering alone. The concern we expressed in Section 4.1 is somewhat amplified when safety is a goal.
- After all, car makers, yet recognizing that the issue is highly important, for now seem not be pushing for safety the way they do for capability profiles, nor they select their suppliers on the basis of safety criteria.
- The standard uses a way to select technology, including the highest and most innovative one. However, there is still much interpretation freedom left to the adopting authorities. As are criteria to select suitable technology and to integrate the various proposed techniques. This would not be intrinsically harmful, if separation of requirements from their implementation were a key factor in the standard, as it was for SPICE [24].
- Even when a standard is officially recognized and adopted by all the stakeholders, what mainly matters to the manufacturer is standard compliance.
- This fact bears two important aspects of concern:
    1. it leaves to the validity of the standard itself and to the process of the adoption of the standard the responsibility related to safety
    2. it leaves the certification of conformance to standard unresolved [19]

  These concerns might weaken end-user confidence on “real” vehicle safety, if only they were aware of the issue.

3.4 Automotive SPICE Assessments and Assessor qualification schemes

To completely achieve the goals of the Automotive-SPICE initiative (see Section 2), some issues are still to be solved. The principal one is the mutual recognition among

different car manufacturers of the assessments made by the software suppliers. To solve such a problem two questions should be addressed:

- The qualification mechanism for assessors: Today two international assessor qualification schemes exists [20], [21]. In order to allow a mutual recognition of the assessors, and consequently of the assessments performed among different car manufacturers, the qualification mechanisms should be unified. This is not going to be an easy achievement: some car manufacturers recognize only assessments performed by assessors they qualified according to company-specific qualification schemes. Such a situation determines possible different levels of accuracy and confidence in assessment results and a limited validity of the assessments, with the consequence of forcing software suppliers to adopt the costly decision of requiring multiple assessments on the same processes, to fulfill different customers' needs.
- The capability profile required by each car manufacturer: each car manufacturers has a specific capability profile to qualify its software suppliers. Such a situation forces the software producers to undertake several Automotive SPICE assessment because the impossibility to have an unique assessment valid for all car manufacturers. Define a common minimum valid capability profile agreed by all the car makers would optimize the application of Automotive SPICE.

3.5 Standard Harmonization

Software producers shall comply with the car manufacturers' requirements in terms of process capability/maturity in order to be admitted in their supplier lists.

Nevertheless, car makers adopt different qualification mechanisms for their software suppliers, based on either the achievement of a predefined Automotive SPICE capability level or a specific CMMI maturity level.

Moreover, other new standards are becoming valid for software producers in automotive, as for example the safety-related standards ISO 26262 and IEC61508 (see section 3.3.).

Such a multiplicity of standard and rules claims for a harmonization and mapping because the effort software producers are required to do for being compliant with all of them is becoming very relevant.

3.6 Model-based Software Development vs. Automotive SPICE/CMMI

Model-based software development became in the past few years a widely adopted technique for constructing code in automotive.

It is not the purpose of this paper to describe the model-based software development methodology and to discuss how it differs from the "traditional" software construction approach. A extensive literature on such a topic already exists [25], [26].

Such a methodology, has several advantages for software developers, in fact it is possible to "test" the models (i.e. verify their dynamic behavior) by means of test cases that can be re-used on the software once the code has been automatically

produced. Moreover, the model-based approach allows automatic code generation from the models.

Nevertheless, both Automotive SPICE and CMMI, don't match perfectly with such a new methodology. In particular, the model-based approach impacts principally on two processes of the Automotive SPICE Process Reference Model: ENG.5 (software design process) and ENG.6 (software construction process), but these two process need to be interpreted and it is not easy, for software producers, to map them on the way they develop software.

For this reason, it is rising up a demand for making Automotive SPICE (and also CMMI) more directly applicable in the case of model-based development.

3.7 Tool Integration

Sophistication of products, safety regulations, design procedures make the process to develop software-based components in automotive more and more complex. To support software development many automatic tools exist, some of them general purpose products, as for example tools for configuration or requirements management; while others are more specific for automotive domain, as for example modeling tools and programming tools. These tools produce many artifacts and update different databases, all items that need to be shared among different teams, often geographically distributed, and accessed in different phases of the same project, determining demands in terms of consistency and fine traceability that are not fully satisfied.

There is then the need of integrating the development process activities and the related technologies and their artifacts, in order to manage the interactions between activities and the dependencies among artifacts. This achievement should also take more and more advantage of automation. Meta- or super-tools might then be the protagonists of the next technological advance in automotive [23].

4 Conclusions and future works

The exponential increase of the electronics systems in automobiles occurred in the last decade forced the automotive industry to make deep changes in their way to design and produce and maintain vehicles, in their work organization, as well as a cultural revolution in their approach to the relationship with electronic suppliers. The advent of software process related standards raised the interest of car manufacturers, who perceived in the standard adoption a way to cope with the long-endured problem of monitoring software suppliers. In Europe, SPICE standard has been extensively adopted by most car manufacturers, who have been starting joint initiatives to take advantage of the new technologies.

This paper has presented a short survey of the area, pointing out open issues from the Italian automotive industry. Such a survey is based on the experience of gained in the Automotive SPIN Italy where several automotive software producers meet together and share experiences and open problems.

The open issues identified in this paper can be considered as research questions for researchers, inputs for standardization working groups as well as improvement areas for practitioners.

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