

Automotive-Adept: A lightweight assessment method for the Automotive Irish software industry

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Abstract

In this paper we describe how a lightweight assessment method was developed to educate Irish software small-to-medium sized enterprises (SMEs)¹ in relation to becoming automotive software suppliers. The main goal of this assessment method is to provide software SMEs with a SPI path to becoming automotive software suppliers.

1 Introduction

In Ireland, Information and Communications Technology (ICT) is a growth sector which has been recognised strategically by government agencies as important to our economy. The success of the growth of this sector is attributed to a number of factors which include low corporation tax, an English speaking workforce, the availability of a highly qualified and educated workforce, a strong indigenous firm base and deployment of EU structural and cohesion funds to Ireland [2,3,4]. Between 2004-2005, revenue in ICT grew by 29%, while the growth rate of exports was 24%. However, Global Enterprise Monitor [5] and Forfás [3] have suggested that the Irish economy as a whole needs to increase resources and build a more self-sufficient indigenous industrial base to reduce the economic reliance on foreign direct investment. Furthermore, Forfás [3] indicated that the ICT sector in Ireland is critical to the continued success of the economy. Within the ICT sector, in software alone, there are 760 indigenous companies employing over 11,100 people. The indigenous software sector provides 47% of employment in the Irish software sector [6]. Current government initiatives are focusing on the further establishment and increased growth of indigenous firms in the sector to ensure that a greater level of enterprising activity can be achieved [7]. The increase in revenue within the software sector is dependant on software companies, both future and established, benefiting from new challenges and opportunities available in the marketplace.

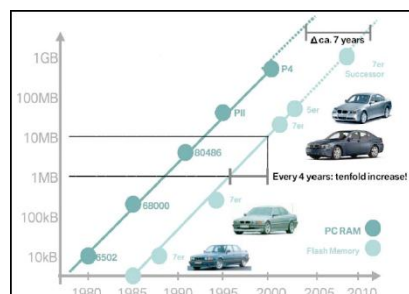


Figure 1 – Growth in the automotive Software Industry

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SMEs are enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding 50 million euro, and/or an annual balance sheet total not exceeding 43 million euro [1]

One such opportunity is the development of an automotive software sector. The requirement for the development of automotive software internationally is illustrated in Figure 1. As can be seen, since the early 1980s, there has been a tenfold increase in automotive software every four years, and this growth is expected to continue.

Due to this opportunity, researchers within Lero – the Irish Software Engineering Research Centre, focus their research on Automotive Software Engineering. Furthermore, processes in SMEs must be catered for in a different manner than within large companies [8]. With the expected development of an automotive software sector, the authors of this paper are interested in software processes, particularly within SMEs.

2 Software Process for Automotive Software Development

Software within cars can occur in different shapes and forms. Electronics and software are becoming more important to the workings of the car itself. The number of electronic control units (ECU) is increasing dramatically. The consequences of this are that 'normal' functions of the car, such as acceleration and wiper-control, are becoming more software-dependant. The more ECUs that there are in any car, the more interfaces need to be developed between these ECUs. Software developers need to focus on communications between networks and car systems. We can also see an increase in multi-media based systems where infotainment is becoming important. Drivers and passengers want to be able to have control of car functions and indeed, the infotainment aspect allows drivers and passengers to interact with the car in ways that may not have been possible previously. Cars can be required to interact with the environment around it – drivers may wish to be updated with traffic flows on their proposed routes.

Furthermore, safety regulations (for example, DIN 31000 [9]) are extremely important to the automotive industry. If something goes wrong with a car when being driven, the probability of the driver being in the proximity of the car is very high – 100%! Information which the driver requires can be safety-critical, for example, the speed at which the car is travelling. Car functions, such as braking, are safety-critical. While the driver can intervene in the execution of these functions, the increase in software dependence requires that operational safety must be accounted for when developing automotive software. As a result, increased volumes of quality automotive software needs to be developed.

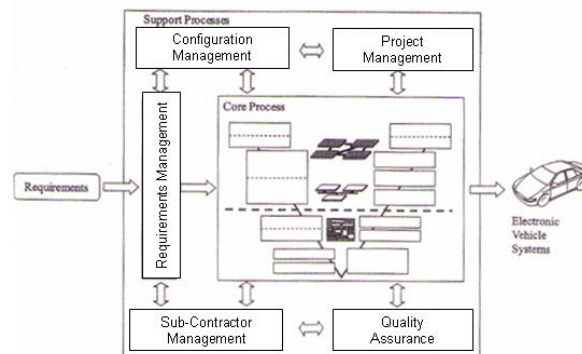


Figure 2 – Support processes for Electronic Systems and Software Development (Adapted from Schauffele and Zurawka, [9])

The implementation and improvement of software processes can be used to support the development of safety-critical automotive software as in the approach illustrated in Figure 2. While core development processes are required, there is also a need for support processes such as configuration management, project management (including risk management), requirements management, subcontractor management and quality assurance. Due to the challenges of controlling the increased complexity that innovations bring, a HIS (Herstellerinitiative Software)² process

² HIS (Herstellerinitiative Software) and consists of Audi, BMW group, DaimlerChrysler, Porsche and Volkswagen. The HIS group is working together on a couple of topics to try to achieve consensus and standardization.

assessments working group was “funded to establish a common approach for determining software capability/maturity of suppliers” [10].

For SMEs looking to take up the opportunity offered by the growth in the automotive software sector, they need to ensure that their processes can be assessed with this in mind. The remainder of this paper presents how a lightweight assessment method has been developed to provide software SMEs with feedback in relation to how their existing software development practices will be required to change in order to become automotive software suppliers.

3 Automotive SPICE™

One of the challenges that faced the HIS process assessment working group (mentioned above) was that each manufacturer had a different approach regarding how to evaluate a suppliers capability/maturity [10]. For example, BMW and Porsche used an internal questionnaire [10]. Based on the different requirements for a common assessment method, ISO/IEC TR 15504 [11] (also known as SPICE) has been adopted for supplier assessment within the HIS. From 2001 to 2006, HIS members have executed some 200 SPICE assessments [13]. According to [14] “the focus on software capability assessment has already provided significant business benefits in use, but at the same time has highlighted the scale of the potential problem, particularly with suppliers of safety-critical embedded software system components”.

Automotive SPICE™ is an initiative of the Automotive Special Interest Group (SIG)³, which is a joint special interest group of The SPICE User Group⁴, and the Procurement Forum⁵ together with major automotive manufacturers [14]. One of the reasons behind this initiative is that the experience (gathered during assessments) indicated that there is a demand for an automotive specific guidance of the standard [10]. The first version of Automotive SPICE™ was published in August 2005 (Process Assessment Model (PAM) V2.2 and the Process Reference Model (PRM) V4.2). The Automotive SPICE™ Process Assessment Model is based on the ISO/IEC 15504-5 [14]. The second version, PAM V2.3 and PRM V4.3, was published in May 2007. From ISO/IEC 15504 Automotive SPICE™ has selected 31 processes. Furthermore, from 2007, all HIS members will perform and accept only Automotive SPICE™ assessments. Therefore assessments based on ISO/IEC TR 15504 will probably not be performed. The results of the assessments can be used for the identification of process improvements for a supplier as well as a criterion for supplier selection [14].

4 Introducing Automotive SPICE™ into Irish software

An important step in developing an Irish automotive software development industry is to gain an understanding of the current state of software development practice within SMEs interested in becoming automotive software suppliers. The Adept method [15] was previously developed by the authors to provide a light-weight assessment of process areas against the generic SPI models of CMMI [16] and ISO/IEC 15504. This paper describes how the Adept method has been extended to provide awareness and feedback in relation to Automotive SPICE™ process areas with the overall objective of encouraging software companies to consider becoming automotive software suppliers. This extended Adept method is known as Automotive-Adept. This method will diagnose weaknesses in a company’s software development process.

³ The members of the Automotive SIG includes Audi AG, BMW Group, DaimlerChrysler AG, Fiat Auto S.p.A., Ford Werke GmbH, Jaguar, Land Rover, Dr. Ing. h.c. F. Porsche AG, Volkswagen AG and Volvo Car Corporation [14]

⁴ The SPICE User Group is a non profit Membership Organisation. The SPICE User Group has several initiatives that are developing sector based Process Assessment Models such as **Automotive SPICE** and **Medi SPICE**.

⁵ The **Procurement Forum** is open to commercial, governmental and none profit organisations engaged in the acquisition of information and communications technologies (ICT), products and services. **Special Interest Groups** are established to encourage members to jointly research, debate and progress key topics or sector interests that in turn add results, and contribute best practice methods and tools to the wider Procurement Forum knowledge base for the benefit of all members.

The Automotive-Adept method enables software development organisations to gain an appreciation of the fundamental process areas from the CMMI[®] and Automotive SPICE[™] SPI models. It was designed to adhere to 8 of the 10 criteria outlined by Anacleto et al. [17], for the development of lightweight assessment methods. Therefore the following criteria are adhered to by the Automotive-Adept method: *low cost, detailed description of the assessment process, guidance for process selection, detailed definition of the assessment model, support for identification of risks and improvement suggestions, conformity with ISO/IEC 15504, no specific software engineering knowledge required from companies' representatives, and tool support is provided.* The exceptions being that *no support is provided for high-level process modelling and the method is not made publicly available.*

The Automotive-Adept method shares the following requirements with Adept: improvement is more important than certification and a rating is not required; the amount of preparation time required by the company for the assessment should be minimal; the assessment should be performed over a short period of time; and the assessment method should enable companies to select assessment in process areas that are most relevant to their business goals.

The main goal of the Automotive-Adept method is to encourage software SMEs to become automotive software suppliers. However, we were also conscious of the fact that the Automotive-Adept method provides an ideal opportunity to educate software SMEs in terms of generic SPI and we did not wish for the assessment to be deemed “a waste of time” if the company decided not to become an automotive software supplier. Therefore, the Automotive-Adept method provides both automotive specific and non-automotive specific recommendations. Consequently, we felt that it would be useful to provide the assessed company with feedback in relation to both CMMI[®] and Automotive SPICE[™] process models. This enables such companies to decide whether they wish to follow a CMMI[®] or an Automotive SPICE[™] SPI path. Typically, companies desiring generic SPI will follow the CMMI[®] path whereas those wishing to become automotive suppliers will pursue an Automotive SPICE[™] SPI path. This means that the Automotive-Adept method is therefore not only applicable to companies set upon becoming automotive software suppliers but also to companies wishing to improve their software development practices and open to considering the automotive domain.

The Automotive-Adept method provides the assessed company with a findings document that will provide them with a report of their software development processes both in terms of CMMI[®] and Automotive SPICE[™].

4.1 The Automotive-Adept method

Whilst the Adept method considers ISO/IEC 15504 it's primary focus was to assess against appropriate process areas from the CMMI[®] model. Therefore, we based the Automotive-Adept method upon relevant process areas from the CMMI[®] model and included input from the Automotive SPICE[™] model. This enabled the existing Adept questions to be established as the foundation for the new method and for new questions to be added to enable coverage of relevant Automotive SPICE[™] process areas. The Automotive-Adept method consists of an assessment component for each CMMI[®] process area that is deemed applicable for Irish SMEs wishing to become automotive software suppliers. However, even though each assessment component adopts a CMMI[®] process area name, it will provide equal coverage of both the CMMI[®] and Automotive SPICE[™] models by containing questions that relate to Automotive SPICE[™] and CMMI[®].

A key decision in the development of the Automotive-Adept method was to decide what process areas are most applicable. The process areas included in Automotive-Adept were chosen because:-

- A. Based on our previous research, they are process areas which provide a significant level of benefit to Irish SMEs software development organisations [18,19,20,21];
- B. They have been highlighted within automotive engineering literature as fundamental to the development of efficient software development [9];
- C. They have process area counterparts included within the HIS subset of 15 process areas;
- D. They were previously included in the Adept method.

We then analysed each of the CMMI[®] process areas using the above factors (See Table 1)

Table 1. Suitability of CMMI[®] process areas for inclusion in Automotive-Adept method

CMMI[®] Process Area	Satisfies A	Satisfies B	Satisfies C	Satisfies D
Requirements Management	Yes	Yes	Yes	Yes
Project Planning	Yes	Yes	Yes	Yes
Project Monitoring & Control	Yes	Yes	Yes	Yes
Configuration Management	Yes	Yes	Yes	Yes
Measurement & Analysis				Yes
Process & Product QA		Yes	Yes	Yes
Supplier Agreement Management		Yes	Yes	
Requirements Development				Yes
Technical Solution			Yes	Yes
Verification				Yes
Product Integration			Yes	Yes
Validation				Yes
Organisational Process Focus				
Integrated Supplier Management			Yes	
Organisational Environment for Integration				
Organisational Process Definition				
Organisational Training				
Integrated Project Management				
Risk Management				Yes
Decision Analysis & Resolution			Yes	
Integrated Teaming				
Organisational Process Performance				
Quantitative Project Management				
Organisational Innovation & Deployment				
Causal Analysis & Resolution				

Table 1, illustrates, that only four of the twenty-five process areas from the CMMI[®] model satisfied all four factors and should be included in first release of Automotive-Adept.

4.1.1 What Automotive SPICE[™] processes are included?

In addition to the Automotive-Adept method enabling assessment against four CMMI[®] process areas it should also assess the Automotive SPICE[™] process areas that are related to the four selected CMMI[®] process areas. The procedure for selecting the Automotive SPICE[™] process areas was as follows:-

Step 1. Select one of the four CMMI[®] process areas for inclusion in Automotive-Adept;

Step 2. Serially scan the chosen CMMI[®] process areas against the following list of 15 HIS process areas and select related Automotive SPICE[™] process areas:-

- System requirements analysis; System architectural design; Software requirements analysis; Software design; Software construction; Software integration; Software testing; System integration; Software testing; System integration; System testing; Quality assurance; Configuration management; Problem resolution management; Change request management; Project management; Supplier monitoring.

Step 3. Repeat Steps 1 and 2 for each of the four CMMI[®] process areas.

As a result of performing these steps the CMMI[®] to Automotive SPICE[™] process (software related) area linkages were determined (see table 2) and the Automotive-Adept method will provide coverage of 4 CMMI[®] process areas and 5 Automotive SPICE[™] process areas.

Table 2. CMMI[®] to Automotive SPICE[™] process area linkages

CMMI[®] Process Area	Related Automotive SPICE[™] process Area
Requirements management	Software requirements analysis Change request management
Project Planning Project Monitoring & Control	Project management Problem resolution management
Configuration management	Configuration management

To encourage uptake of the Automotive-Adept assessment by Irish software SMEs we wish to reduce the cost and time associated with the assessment. On-site interviewing is restricted to one day as this proved attractive to companies in relation to performing the Adept assessment [15]. Consequently, the first release of the Automotive-Adept assessment method will be limited to providing coverage of the selected four CMMI® and (the related) 5 Automotive SPICE™ process areas. However, in future releases we will increase the scope of the assessment to include additional process areas (the next release will include *Process and Product Quality Assurance* and *Supplier Agreement Management*) which would then provide coverage of all six of the main support processes for electronic systems and software development [9]. Companies wishing to be assessed in all six of these processes will then be able to extend the assessment across 2 days.

4.2 The Stages of the Automotive-Adept Method

The Automotive-Adept method is divided into eight stages (see Figure 3). The assessment team consists of two assessors who conduct the assessment between them.

Stage 1 (*Develop Assessment Schedule and Receive Site Briefing*) involves a preliminary meeting between the assessment team and the software company wishing to undergo a SPI assessment. The assessment team will discuss the main drivers for the company embarking upon an Automotive-Adept assessment and try to establish if the company is interested in becoming an automotive software supplier. During **stage 2** (*Conduct Overview Briefing*) the lead assessor provides an overview of the Automotive-Adept method for members of the assessed organisation who will be involved in subsequent stages. This session is used to remove any concerns that individuals may have. **Stage 3** (*Analyse Key Documents*) provides a brief insight into project documentation. The primary source of data for the Automotive-Adept method is through a series of process area interviews conducted during stage 4.

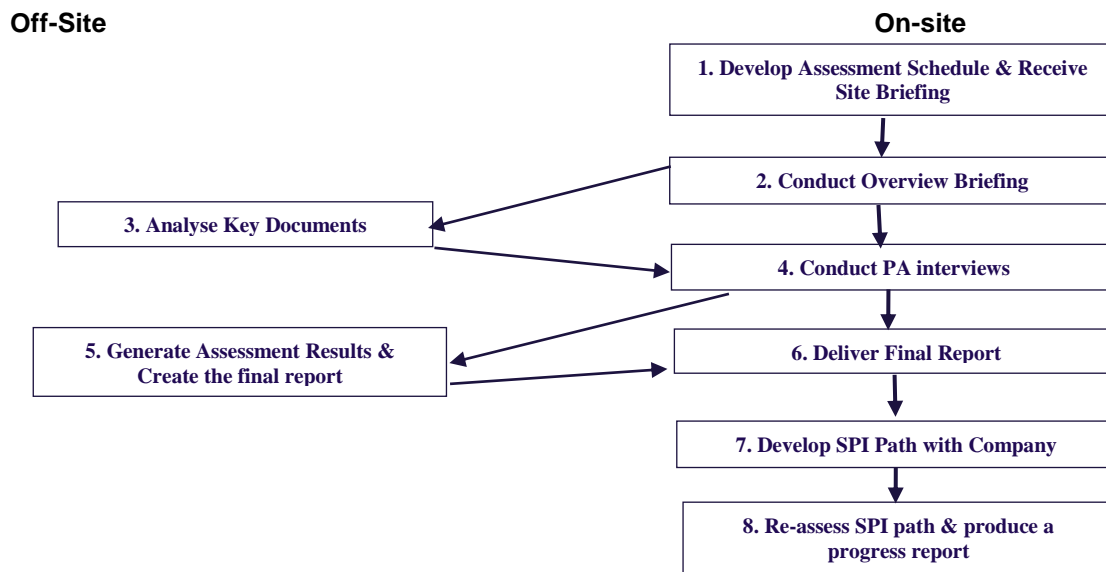


Figure 3. Automotive –Adept Stages

The main part of the Automotive Adept method is **stage 4**. In this stage key staff members from the assessed organisation are interviewed. There are 4 interviews. Each interview is scheduled to last approximately 1.5 hours. Each interview involves two assessors, and at least one representative from the company is present for each process area interview.

Table 3 illustrates that the process area interviews within an Automotive-Adept assessment includes additional questions to provide coverage of relevant Automotive SPICE™ process areas in addition to the CMMI® process area. When developing the interview questions we mainly looked at the base practices and did not perform a detailed investigation into similarities and differences between CMMI® and Automotive SPICE™. Instead we checked the relevant interview questions from the Adept method to see if they covered their counterpart in Automotive SPICE™.

Table 3. Breakdown of Automotive-Adept Questions

Automotive-Adept Interviews	CMMI [®] only questions	CMMI and Automotive SPICE [™] questions	Automotive SPICE [™] only questions
<i>Requirements management</i>	7	7	18
<i>Project Planning</i>	21	25	2
<i>Project Monitoring & Control</i>	8	19	8
<i>Configuration Management</i>	14	6	4

Despite there being a reasonable amount of commonality between the related process areas in CMMI[®] and Automotive SPICE[™], the questions we have associated with process areas within each model would not (in isolation) provide full coverage of the related process area in the other model (as illustrated in Table 3). Therefore companies will receive feedback in relation to the current state of their practices against both models (unless a company specifies that they are only interested in one of the models).

In the Requirements Management interview within the original Adept assessment, the assessors asked 14 scripted questions that provided coverage of the specific goals of the CMMI[®] *Requirements Management* process area. The Automotive-Adept method is much more comprehensive in its coverage of requirements management in that it not only contains CMMI[®] based questions but also 18 additional questions that are specifically related to the Automotive SPICE[™] process areas of *Software Requirements Analysis* and *Change Request Management*. The Automotive-Adept method is designed to provide feedback in relation to the CMMI[®] and Automotive SPICE[™] models – however the questions have been organised so that it is also possible for an organisation to only be assessed against one of the models.

The *Project Planning* interview within Adept had to ensure that sufficient questions were used to provide coverage of the goals and practices of the CMMI[®] *Project Planning* process area. Whilst this is also a requirement of the Automotive-Adept method, this new method also has to ensure that sufficient questions are asked to collect evidence of working practices that will satisfy the outcomes and base practices stated within the Automotive SPICE[™] *Project Management* process area. It should be noted that only the planning part of the Automotive SPICE[™] *Project Management* process area may be mapped against the CMMI[®] *Project Planning* questions.

The *Project Monitoring & Control* interview within Adept had to ensure that sufficient questions were used to provide coverage of the goals and practices of the CMMI[®] *Project Monitoring & Control* process area. Whilst this is also a requirement of the Automotive-Adept method, this new method also has to ensure that sufficient questions are asked to collect evidence of working practices that will satisfy the outcomes and base practices stated within both the Automotive SPICE[™] process areas of *Project Management* (only the management part of the *Project Management* process area as the planning part is covered by the *Project Planning* interview) and *Problem Resolution Management*.

Within the *Configuration Management* interview questions are used to collect evidence of working practices that will satisfy the outcomes and base practices stated within the Automotive SPICE[™] *Configuration Management* process area and the goals of the CMMI[®] *Configuration Management* process area.

Stage 5 (*Generate Assessment Results and Create the Findings Report*) is a collaborative exercise between the assessors that results in the development of the findings report. The resultant findings report consists of a list of strengths, issues and suggested actions for each of the process areas evaluated. The findings report is developed through reviewing the interview notes for each of the 4 assessed process areas. **Stage 6** (*Deliver the findings report*) involves presenting the findings report to the staff in the assessed organisation who participated in the interviews. **Stage 7** (*Develop a SPI Path with the Company*) involves collaborating with staff from the assessed company to develop a roadmap that will provide guidance to the assessed company in relation to practices that will provide the greatest benefit in terms of the company's business goals. Companies wishing to become automotive suppliers will be recommended to focus upon establishing working practices that will assist them in future Automotive SPICE[™] assessments. **Stage 8** (*Re-assess the SPI Path and Produce a Final Report*) involves revisiting the assessed company approximately 3 months after the completion of stage 7 and reviewing progress against the SPI path that was developed in stage 7. The outcome of this stage will be an updated SPI path and a final report detailing the progress that has been accomplished along with additional recommendations. This stage is important as it provides feedback and assistance to the assessed company after a period of time. This stage also assists in

compiling research material in terms of SPI experiences.

5 Conclusions and Future Plans

The goal of this assessment is not certification but to provide a lightweight assessment method which indicates to companies: the current state of their software processes; recommendations as to how they might improve; the status of their software processes both in terms of CMMI[®] and Automotive SPICE[™]; and their suitability to become automotive software suppliers.

It is important to educate the software SMEs how they may become automotive software suppliers and how they should improve their software development processes so that they may compete within this domain. This requires an appropriate approach that facilitates education and engages software development managers in a quality agenda. The application of the Automotive-Adept method will help raise the level of SPI knowledge within the assessed organisations. Also, the high-level findings report and the detailed SPI path will provide a road map for SPI within each assessed organisation. Furthermore, as the Automotive-Adept method requires only 6 person-days of internal staff time, this should prove attractive to SMEs from a resource viewpoint.

From a research point of view the Automotive-Adept method: enables Lero to gain an understanding as to whether existing software development practices within Irish companies are more CMMI[®] or Automotive SPICE[™] based; assists Lero in understanding areas that will present Irish software development companies with difficulties if they are to become automotive software suppliers – therefore this awareness will enable Lero to provide guidance within these areas; and will enable Lero to gain an understanding in relation to the strengths (profile) that Irish software companies possess particularly in relation to supplying software to the Automotive industry.

This paper describes the first release of the Automotive-Adept method that provides coverage of 4 CMMI[®] process areas and 5 Automotive SPICE[™] process areas. In the future we plan to extend the number of process areas that may be assessed. We will initially extend the assessment to provide coverage of the remaining two process areas that are listed as being fundamental to the automotive industry [9]. These process areas will be *Process and Product Quality Assurance* and *Supplier Agreement Management*. The medium term aim will then be to provide coverage of each of the 15 Automotive SPICE[™] process areas included in the HIS, with a long term goal of providing coverage of all 31 Automotive SPICE[™] process areas.

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