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EuroSPI 2007 Proceedings

Proceedings

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EuroSPI

EuroSPI is a partnership of large Scandinavian research companies and experience networks (SINTEF, DELTA,STTF), the ASQF as a large German quality association, the American Society for Quality, and ISCN as the co-ordinating partner.

EuroSPI conferences present and discuss practical results from improvement projects in industry, focussing on the benefits gained and the criteria for success. Leading European industry are contributing to and participating in this event. This year's event is the 14th of a series of conferences to which countries across Europe and from the rest of the world contributed their lessons learned and shared their knowledge to reach the next higher level of software management professionalism.

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Welcome Address by the EuroSPI General Chair

Dr Richard Messnarz

EuroSPI is an initiative with 3 major goals (www.eurospi.net):

1. An annual EuroSPI conference supported by Software Process Improvement Networks from different EU countries.
2. Establishing an Internet based knowledge library, newsletters, and a set of proceedings and recommended books.
3. Establishing an effective team of national representatives (in future from each EU country) growing step by step into more countries of Europe.

EuroSPI is a partnership of large Scandinavian research companies and experience networks (SINTEF, DELTA,STTF), the ASQF as a large German quality association, the American Society for Quality, and ISCN as the co-coordinating partner. EuroSPI collaborates with a large number of SPINs (Software Process Improvement Network) in Europe.

EuroSPI conferences present and discuss results from software process improvement (SPI) projects in industry and research, focusing on the benefits gained and the criteria for success. Leading European universities, research centers, and industry are contributing to and participating in this event. This year's event is the 14th of a series of conferences to which international researchers contribute their lessons learned and share their knowledge as they work towards the next higher level of software management professionalism.

The greatest value of EuroSPI lies in its function as a European knowledge and experience exchange mechanism for Software Process Improvement and Innovation of successful software product and service development. EuroSPI aims at forming an exciting forum where researchers, industrial managers and professionals meet to exchange experiences and ideas and fertilize the grounds for new developments and improvements.

EuroSPI also established an umbrella initiative for establishing a European Qualification Network in which different SPINs and national initiatives join mutually beneficial collaborations (EQN - EU Leonardo a Vinci network project).

With a general assembly on 15.-16.10.2007 through EuroSPI partners and networks, in collaboration with the European Union (supported by the EU Leonardo da Vinci Programme) a European certification association has been created for the IT and services sector to offer SPI knowledge and certificates to industry, establishing close knowledge transfer links between research and industry.

With the support of the E-Learning EU project PLATO (2005 – 2007) an infrastructure for online learning has been set up for 12 European professions related with SPI.

Welcome to Potsdam by Stephan Goericke

Stephan Goericke

Local Chair

As the Director of the International Software Quality Institute (iSQI), I am proud that in 2007 EuroSPI2 agreed to come to Potsdam, where our institute is headquartered. In Potsdam, more than 5,000 people work in over 30 scientific institutions. In addition to important companies, decision makers and producers this region attracts more than 22,000 students in 44 courses of media and telecommunications.

Therefore I believe that Potsdam's University and the Hasso Plattner Institute have been the right locations for this year's partner conferences EuroSPI2 and CONQUEST. We need more close cooperations between science, research and business for enhancing the transfer of technology into practice. That is why we organize such conferences. They are networks that link potentials which are distributed over various locations and players and focus' on performance, clearly defined targets and competences.

These close cooperations - on the other hand - need standards and standardization since multinational participation in projects involves different levels of knowledge and qualification. Additionally, within the cross-sectional business area of IT it is very difficult to keep with the pace of innovation. Therefore people need to educate themselves on their job and that is why iSQI runs certification programs such as ISTQB Certified Tester, iSQI Certified Professional for Software Architecture, iSQI Certified Professional for Project Management, iNTCCM Certified Configuration Manager and iNTACS, the international ISO/IEC 15504 Assessor Certification Scheme. From this year on, our portfolio includes schemes for IT-Security Management, Secure Software Development as well as E-Health Management. You will hear more about these certifications at future conferences.

Contents

ImprovAbility™ guidelines for low maturity organisations

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Abstract

Too many improvement and innovation projects fail. We have studied characteristics of successful and failed projects. From this study we derived 20 parameters that influence success and failure. We used the parameters to build the *ImprovAbility*™ Model, which is a model that can be used to measure an organizations or a projects ability to succeed with improvement. In this paper we elaborate on selected parameters that have shown important and/or difficult in particular in low maturity organisations.

Keywords

ImprovAbility™, Process Improvement, Successful projects, Maturity according to CMMI and ISO 15504

1 Introduction

The Software Process Improvement (SPI) is about systematically evaluating your current status in relation to software processes, doing something to improve, and measuring whether the things done improved the situation. Many IT organizations have used considerable resources for SPI. However, investments in SPI often have not led to the changes and improvements expected. For example Goldenson and Herbsleb [1] found in a study of a larger number of organizations that had invested in SPI that 26% agreed that ”nothing much has changed” and 49% declared themselves to be disillusioned due to lack of improvements. And this study is not alone. Several others have found that SPI initiatives can fail (cf. [2], [3], [4]).

Thus unsuccessful SPI initiatives led to an interest in what is needed to achieve successful implementation of SPI (cf. [5], [6], [7], [8]). Grady [5] directs attention to the fact that an organization must be ready for SPI. If that is not the case the SPI initiative can be very costly and may fail. Zahran [6] for example points out the importance of understanding the business and organizational context before carrying out an assessment of an organization with the purpose of initiating SPI. Zahran calls this activity a pre-assessment phase and he recommends that this phase should be carried out before a decision is taken on whether to initiate SPI.

This leads to the research question that we address in this paper: How can you improve an organizations ability to improve?

Or said in another way: Can you, by examining some parameters, get a picture of whether you will succeed or fail with an Improvement initiative – being at the organizational or the project level - prior to launching it?

To sum up, we have found that you can increase the chance of success with process improvement by focusing on the organizations *ability to improve*. In this paper we will report on our findings from an in-depth study of success and failure when improving and a model – the *ImprovAbility*™ model - build from the results [cf. 10, 11]. We used an existing research collaboration called Talent@IT1 with 4 participating companies for our research. Each of the companies was asked to appoint four projects, one successful and one failed SPI project plus one successful and one failed normal innovation projects. We interviewed 14 projects - the project manager, 1-2 project members, the sponsor or owner of the project, typically a manager in the organization and finally a user of the product; for an SPI-project that meant a developer, and for innovation projects that typically meant an end user. We used Grounded Theory [cf. 12] as research method and ended up with the *ImprovAbility*™ model.

We use the *ImprovAbility*™ model in two ways:

1. To assess an organisations ability to innovation and process improvement.

2. To assess projects to help them identify areas that will increase the likelihood of their success.

So far we have completed 3 organisational assessments and 11 project assessments in very different projects including IT, product development, SPI and educational projects. The *ImprovAbility*™ model does go along very well with the CMMI and other maturity models. A CMMI assessment will identify **which processes** in the organisation need most attention and improvement where as an *ImprovAbility*™ assessment will identify **how to implement** the process improvement.

First we describe the roles and responsibilities with respect to process improvement. Second we introduce the *ImprovAbility*™ model and describe the 20 parameters in more detail. Finally we discuss some parameters that by our experience often lead to failure with process improvement in low-maturity organisations i.e. companies that would be measured to maturity level 1 or 2 in a CMMI or ISO 15504 assessment.

[1] The Talent@IT is a 3 year research project (2003 – 2006) sponsored by the Danish Ministry of Science, Technology and Innovation. The project partners are the IT-University of Copenhagen (research responsible), DELTA (project management and “owner” of the *ImprovAbility*™ model) and the four Danish enterprises ATP, Danske Bank, PBS and SimCorp. More information can be found on www.talent-it.dk

2 Roles and responsibilities in process improvement

Fig.1. shows the actors when it comes to product development and process improvement. Product development is basically developers developing new products to some end users that can be within the organisation or external – the vertical line. By analogy with this, process improvement is process improvers who develop new processes and tools for the developers.

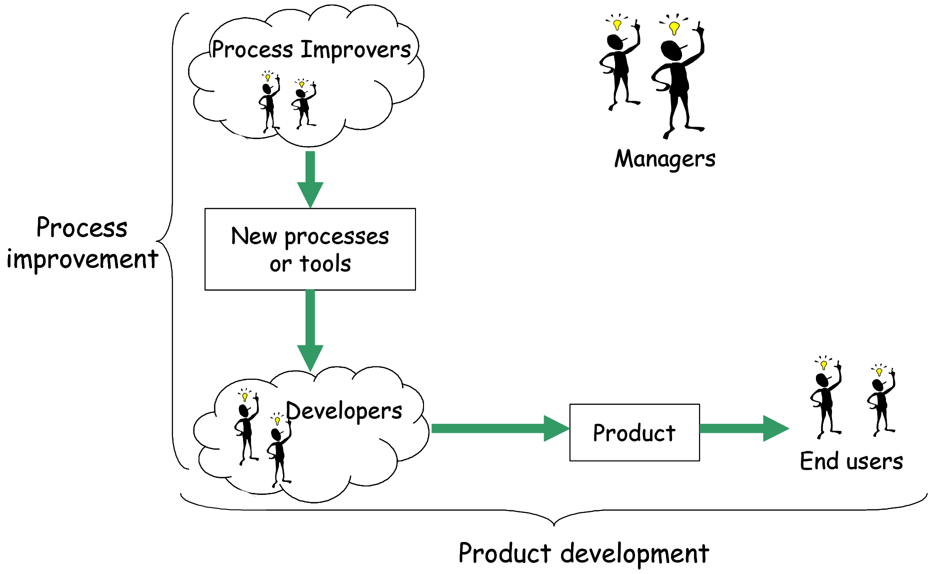

Fig. 1. The actors in product development and process improvement

Around these people are the managers who starts and stops projects, allocate resources, prioritize projects, follow-up on running projects, etc. In our description project managers are part of the project team they are managing i.e. product or process development team. The managers in this set-up are higher level or senior managers.

3 The *ImprovAbility*™ Model

The resulting model with 20 parameters in four groups looks like depicted in figure 2. The core assumption behind this model is that the parameters identified from success and failure projects can be used to identify an organizations ability to improve by encouraging activity that has shown to be related to success and avoiding activities that has shown to lead to failure.

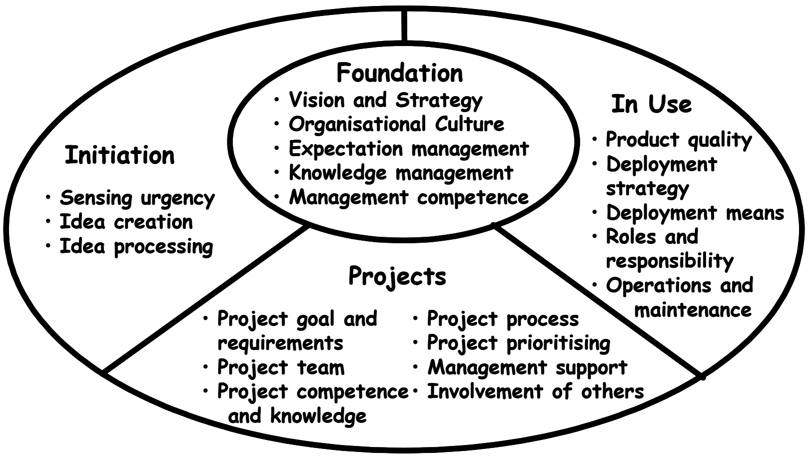

Fig. 2. The *ImprovAbility*™ model with 20 parameters in 4 groups

The model is depicted as a stylistic torus i.e. it is not an oval. In geometry the torus is a surface of revolution generated by revolving a circle in three dimensional space about an axis coplanar with the circle, which does not touch the circle [9]. In the ImprovAbility model initiation of projects, the projects and using the products are activities that constantly are circling around the organisational foundation, which is relatively stable compared to the projects.

Each of the 20 parameters in the model is shortly described in Table 1 – 4 below.

Table 1. Foundation Parameters

Vision and strategy	To what extent has the organisation a business strategy and/or a vision that is decided and communicated?
Organisational culture	To what extent has the organisation a culture that encourages improvement and innovation?
Expectation management	To what extent has the organisation systematic management of expectations in relation to both organisational changes and daily work?
Knowledge management	To what extent is knowledge systematically gathered, stored and used?
Management competence	To what extent has the organisation the necessary competence at the management level?

Table 2. Initiation Parameters

Sensing urgency	To what extent is the organisation able to sense the urgency for change? For example because existing ways of working have become obsolete or because existing products are too old or maybe the organisation has simply arrived in an untenable position.
Idea creation	To what extent is the organisation able to identify, foster and create many ideas for new SPI and IT processes or products? Preferably form many different sources such as user needs, new technology or new strategies.
Idea processing	To what extent are new ideas captured and decided on?

Table 3. Project Parameters

Project team	To what extent are the people allocated to projects highly motivated and are they having the right attitude and profile for the projects? Competent project management? Team sitting physically together and close to users? Does the team work as a team?
Project process	To what extend do the projects have good estimates, plans, follow-up, risk management, testing and quality reviews?
Project competence and knowledge	To what extent do the projects have the necessary technical knowledge? Domain knowledge? Development model and method(s)?
Project prioritizing	To what extent are projects prioritized in relation to each other? And in relation to schedule, cost, scope and quality? Are priorities communicated and understood? Are priorities stable?
Project goal and requirements	To what extend are project goals, expected benefits and formulated requirements precise, unambiguous and stable? Do the projects – developers as well as users - perceive their goals and the rationale behind as reasonable?
Management support	To what extend is management in the organisation supporting the projects? That could be allocating the right resources at the right time. It could also be about participation in a steering committee. Or it could involve demanding results.
Involvement of others	To what extent are other stakeholders (than the team and management) involved? This could for example include early user involvement. External resources? Consultants? At the right time and in the right way?

Table 4. In Use Parameters

Deployment strategy	To what extent is a deployment strategy for new processes or products decided on and followed?
Product quality	To what extend are new processes and products that are deployed of high quality? Few defects? User friendly? Low complexity? Compatible? Efficient? Have relative advantages for the user?
Deployment means	To what extend is the optimal mix of information, communication, education and training, plus marketing of new processes and products applied?
Roles and responsibility	To what extend are roles and responsibilities in relation to deployment and use well defined and enacted?
Operations and maintenance	Are the products or processes operable in daily use? Is it possible to maintain the products or processes as needed?

4 The important parameters for low-maturity organisations

Let’s take a closer look at some selected parameters that – based on our experience using the model in assessing organisations and running projects – seem to introduce difficulties for many low maturity organisations. Based on only 11 project assessments, it is too early to look for parameters that have had a high respectively low score. Instead this chapter summarises some general observations we have seen during many years of consultancy work in companies of different maturity. This is not scientific but reflections on how some of the parameters are often treated in low maturity companies.

4.1 Sensing Urgency

This parameter is about the mechanisms used in organisations to recognise the need for change. In organisations selling products on the commercial market a close relationship between producer and customer can ensure the necessary input to the organisation regarding new products or upgrades of existing products. In successful organisations these mechanisms work well as the company would otherwise soon be out of the market.

When it comes to process improvements things are very much different. Only rarely customers request documented and working processes from their suppliers although there was a big market request (at least in Europe) for ISO 9000 certification in the late part of last century. However, having an ISO 9000 certificate does not necessarily imply process improvement or e.g. documented CMMI levels. There is no real customer pressure for process improvement – the pressure must come from within. Management must believe that process improvement will lead to higher maturity and improved competitiveness.

In low maturity organisations focus is primarily on products and product development. If management does not appreciate a need for and insists on process improvement there is a good chance that the projects will ignore the process work. The projects are focused on the products and meeting the deadlines and they experience SPI as additional work without any benefit for the project, at least not here-and-now. As projects are normally under time and resource pressure it is easier to do things the way they are used to do rather than to learn something new. New things take longer time in the beginning.

Sensing urgency is necessary for management to appreciate process improvement and their commitment must be rooted in this. It is not enough with process improvement being nice-to-have, it must be a need-to-have and the message must be communicated and clear for everybody in the organisation. Otherwise it will be business as usual very soon.

4.2 Involvement of others

A major cause of products being unsuccessful can be related to lack of involvement of others during development. Especially users and customers must be involved but all stakeholders are important. It is exactly the same with process improvement – involving users (i.e. product developers) and other stakeholders are mandatory.

SPI is very much about understanding what people actually do when working and build up new competence to introduce a more suitable and uniform way of working. It is to some extent of course about developing and writing procedures, but writing them without deep understanding about what is actually done, why it is done in this way and what best practice for this type of process is, will lead to unused processes and no improvement. So a key parameter for process improvers is involving others:

- The users of the process
- The management
- Other stakeholders

The users must be involved broadly because they are actually the only ones who know what it is about. Developers who are unfamiliar with process thinking, may not be able to describe what they are doing i.e. formulate the process. The process developers tasks are to understand what the developers are doing, make them reflect about it and help them formulate their work in a useful and understandable way. Many SPI initiatives start by studying best practice and writing processes on that basis. Most likely the developers will understand the words but not be able to work accordingly – they need to be more involved in the process design.

Another important issue is unclear terminology. The developers often use the same words differently because their frame of reference is unclear and heterogeneous. It takes a long time and hard work just to agree on what things mean in practice and reality.

Finally the process developers have to involve other stakeholders and management in order to meet their needs and goals. Empathy, negotiation skills and trying to reach consensus are important qualifications for process developers.

4.3 Management support and Management competence

It is well documented that management support is needed for process improvement to be successful. Another parameter – management competence is equally important. The two parameters are quite different though there are also similarities. Management support is a parameter in the Projects group which indicates that it is the support to the specific projects that is considered: Does management support the projects by allocating sufficient resources when needed, do they participate in a steering group or the like to help the project e.g. when a problem or crisis occurs, do they demand the results, etc.

Management competence is an organisational parameter in the Foundation group i.e. the foundation of all projects. The parameter focuses on whether the management can make the right decisions in the right time, do they ask the difficult questions and are their decisions visible and consistent? The parameter is dual as the focus is both on how management react (more or less competent) and on how the projects act to make it possible for the management to act competent. Problem with management competence can arise from the managers themselves or from the projects if they prevent the management to act competent e.g. by hiding information or being unrealistic.

To implement successful SPI in low maturity organisations requires a lot from management. They have to lead and constantly be in the frontline. It is definitely not enough to leave it to process experts alone to implement SPI. And management support is not enough, management competence is also required. The management team must be trained or even better have a coach to help them implement SPI. This is the only way to ensure proper SPI competences and avoid failures. Very often SPI initiatives are initiated with too little knowledge of the paths and the destination of this voyage and they fail.

It is not unusual to observe, that the first two or three SPI initiatives fail before the organisation have learned to master the disciplines.

Management support is also allowing and demanding users of processes i.e. the developers to be involved in the process improvement work. The management must accept that it requires resources to implement process improvement and the necessary overhead must be planned in all projects so it is visible for everyone that SPI work is not only allowed but also required even if projects are delayed accordingly until the processes work.

4.4 The In-Use parameters

All parameters in the In use group are important when it comes to SPI. Most projects focus on the content e.g. the product functionality or process. When the product / process development is to complete the last resources are spent on refinements, enhancements and last minute bug-fixes leaving no resources for deployment. It is therefore extremely important to consider the deployment strategy very early and plan the deployment carefully. What kind of training is needed? Who can do the training? What will the content and duration of seminars and workshops be? Who will implement it? It is our experience that the SPI projects are aware of this, but they postpone the planning until needed and then it is too late. The SPI projects tend focus on the content i.e. how the process will look and forget about roll-out and deployment. It ought to be the opposite. Plan how the process will be deployed and then develop the processes accordingly. A good advice is to plan for at least one pilot deployment before full scale roll-out.

Product quality is equally important for processes as for products. When we evaluate product quality we do it with the eyes of the users: do they get what they need? Can they understand it and use it? What are the benefits of the new process with respect to the existing process etc? The users are the only ones who can judge whether product quality was sufficient or not.

Finally the deployment roles and responsibilities are important. The management has an important role in requesting the new processes and tool to be used. Otherwise the users will do as they are used to. They are very busy and it takes time to learn a new product or process so it is much easier to do as they are used to. The users also have their responsibilities e.g. they must request proper and adequate support from the process experts to help them out when problems arises.

4.5 Project process

It is interesting to observe, that most process improvement projects in low maturity companies do not follow any development model. The organisation may have a development model for their product development projects, but when it comes to process improvement, it is ignored – don’t take your own medicine! Don’t forget, that estimation, planning, project monitoring and control, risk management, quality assurance and testing also works for process improvement projects.

This parameter covers many of the CMMI processes in particular the project management and engineering processes when it comes to product development and project management and process management processes when focus is on SPI. We often see organisations having a development model with some processes build in but when it comes to SPI projects the trend in low maturity companies is that there is no model to follow for them. It would be wise if SPI project should follow the same principles as product development projects. Often SPI projects are manned with part time team members. If there is no visible plan it is almost certain that product development activities will be prioritized to SPI activities.

5 Conclusion

The above guidelines are very general but they seem to be highly relevant especially for low maturity organisations. The paper provides observations on 6 of the 17 parameters in the *ImprovAbility*™ model typically seen in low maturity companies. These observations can be used by e.g. process workers and managers in low maturity companies to reflect on their own situation giving inspiration on what to do and in particular what to try to avoid. Further SPI consultants can use the observations to do a micro assessment on the 6 parameters to see what direction their customers are heading and provide appropriate guidance to avoid common pitfalls.

Full *ImprovAbility*™ assessments and project assessor training can be provided from DELTA-axiom on commercial terms.

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For the last 9 years he has worked at DELTA as a consultant in SPI – requirements specification, test, design of usable products and development models. Mr. Christiansen is also *ImprovAbility*™ assessor and trainer of *ImprovAbility*™ project assessors.

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For the last 12 years he has worked at DELTA as a consultant and registered BOOTSTRAP, ISO 15504 lead assessor, CMMI assessor and *ImprovAbility*™ assessor. He has participated in more than 40 assessments in Denmark and abroad for companies of all sizes.

He was the project manager in the Danish Centre for Software Process Improvement project, a more then 25 person-year SPI project and Talent@IT a 26 person-year project that involves 4 companies, the IT University in Copenhagen and DELTA. Mr. Johansen is also the co-ordinator of a Danish knowledge exchange group: Improving the Software Development Process, which is the Danish SPIN-group.

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Maintaining a Large Process Model Aligned with a Process Standard: an Industrial Example

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Abstract. An essential characteristic of mature software and system development organizations is the definition and use of explicit process models. For a number of reasons, it can be valuable to produce new process models by tailoring existing process standards (such as the V-Modell XT). Both process models and standards evolve over time in order to integrate improvements or adapt the process models to context changes. An important challenge for a process engineering team is to keep tailored process models aligned over time with the standards originally used to produce them. This article presents an approach that supports the alignment of process standards evolving in parallel to derived process models, using an actual industrial example to illustrate the problems and potential solutions. We present and discuss the results of a quantitative analysis done to determine whether a strongly tailored model can still be aligned with its parent standard and to assess the potential cost of such an alignment. We close the paper with conclusions and outlook.

Keywords: process modeling, process model change, process model evolution, model comparison, process standard alignment

1 Introduction

Documenting its software development processes is a step that every software organization striving to achieve a high level of process maturity must take sooner or later. One problem that many organizations face when first attempting to perform this crucial task is the lack of appropriate expertise: Documenting a complete set of organization-wide development processes is potentially a very large undertaking, and doing it successfully requires highly specialized knowledge that organizations often lack. For these reasons, customizing an existing standard process model can be an excellent option for many organizations, as opposed to documenting their processes "from scratch". A standard process model (e.g., the German V-Modell XT [1]) offers them a solid framework, which can greatly help to guarantee that the resulting process documentation is complete and detailed enough, and that it is structured in such a way that it is useful to process engineers and process performers alike.

Since tailoring is central to process standard adoption, standard models should ideally offer a mechanism for making adaptations in a systematic way, and for keeping those adaptations separated from, but properly linked to, the original standard. Unfortunately, most existing models have not yet reached the point where they can support this type of advanced tailoring out-of-the-box. Therefore, most customization is performed in practice by directly modifying a copy of the original model until it reflects the practices of a given organization. This way, organizations can quickly get up to speed with their own process definition, requiring only access to a standard process model and its corresponding editing tools (which are often distributed together with the model, or are freely available.)

Although very useful in practice, this type of *ad hoc* process model tailoring also introduces some problems, the largest of which is probably long-term maintenance. As soon as tailoring starts, the organization-specific model and the standard model take different paths, and after some time, they will probably diverge significantly. At some point, every organization relying on a customized process model will be confronted with the problem of deciding if it should try to keep it *aligned* with the standard, or if it should rather maintain it as a completely separate entity.

This decision is not easy at all. On the one hand, maintaining the customized model separately implies that, potentially, many corrections and improvements done at the standard level will not be adopted, and also involves the risk that the practices documented for the organization deviate unnecessarily from mainstream accepted practices. On the other hand, keeping the model aligned with the standard implies integrating changes from the standard into the local documentation at regular intervals, a task that, to our knowledge, is not well supported by existing tools and that can be very expensive and unreliable if performed manually.

We believe that this and other similar problems related to process model maintenance can be greatly mitigated by properly managing the evolution of process models. We have devised our *DeltaProcess* [2, 3] approach for process model difference analysis with this goal in mind. The approach makes it possible to efficiently and reliably identify changes in newer versions of a process model with respect to its older versions. It also makes it possible to perform analyses that classify changes in a model (e.g., a process standard) according to their relevance to another model (e.g, a customized model). We expect that by making use of this information, process engineers will be able to save significant effort and produce much more reliable results when trying to align complex process models.

We are currently conducting a study intended to investigate the above hypothesis. In the study, we are trying to help a company to align a process model, customized over a period of about one and a half years, with its corresponding process standard. The rest of this paper uses this case study as an example to illustrate the problems involved in keeping complex process models aligned. The paper is organized as follows: Section 2 describes the process alignment problem and the challenges it presents to process engineers. Section 3 presents a brief description of our *DeltaProcess* approach. Section 4 describes an analysis we performed as part of our ongoing case study to determine the viability of aligning two large process models. Section 5 closes the paper with conclusions and future work.

2 Aligning a Customized Process Model With a Standard

In this section, we provide a more detailed description of the problem that occupies us in our case study, namely, aligning a large industrial-grade, customized process model with the standard from which it was originally derived. In order to provide the reader with a complete view of the problem, we describe the process model standard (the German V-Modell XT), the company performing the customization, and the extent and characteristics of their customized model. The section concludes with a discussion of related work, and of why existing approaches are not completely adequate to solve the problem we are dealing with.

2.1 The German V-Modell XT

The V-Modell XT [1] is a prescriptive process model intended originally for use in German public institutions, but finding increasing acceptance in the German private sector. Its predecessor, the so-called V-Modell 97, was developed in the 1990s and released originally only in the form of a text document. The V-Modell XT is the result of a recent effort by a publicly-financed consortium of private companies, and government and research institutions to “modernize” the original V-Modell. This effort included converting the original document-based process description into an actual process model with formalized entities and relationships, creating a set of tools to manage instances of the model in this new representation, and improving and extending the actual model contents.

As of this writing, three major versions of the V-Modell XT have been released, namely 1.0 (finished in January 2005 with a minor update in March 2005), 1.1 (finished in July 2005) and 1.2 (finished in January 2006 but released in May 2006.) Further active development by a team of experts from the development consortium is still ongoing. All V-Modell XT releases are freely available and can be downloaded at no cost from the Internet (see [1].)

For editing purposes, instances of the V-Modell are stored as XML files that can be processed using a set of specialized tools (also freely available as an Internet download). The model is structured as a hierarchy of process entities, each having a number of attributes. Entities can be connected to other entities through a variety of relations. Version 1.2 of the V-Modell XT is comprised of about 2100 process entities with over 5000 attributes, and connected by some 4100 entity relations. The paper documentation generated automatically from this model is 620 pages long. Also, the current model schema contains 38 classes and 43 different types of relations. Most of these numbers are only approximate, but should be able to give the reader a general idea of the size and complexity involved.

2.2 A Customized Version of the V-Modell XT

We are performing our case study in the context of a medium-sized (about 1200 employees), privately-held company that is an early adopter of the V-Modell XT. Although information technology is not its main business, this company has a software development division with about 70 employees, which is mainly dedicated to the development and maintenance of the company's own information systems. The idea of introducing the V-Modell XT arose in 2005 as part of a software process improvement effort. Since it was judged that the V-Modell XT in its standard form was not adequate for internal use, the company's software process group started a customization effort at the end of 2005, whose first results were seen a year later with the introduction of the model as official guidance for new development projects. The tailored model is based on version 1.1 of the V-Modell, which was the current version at the time the customization effort was started.

The tailored model differs significantly from the standard V-Modell XT. During customization, more than half of the original entities were erased because they were considered irrelevant for the company. The resulting trimmed model was afterwards extended with a number of new entities. Many of the entities preserved from the original model were also adapted, by changing names and descriptions as necessary to fit the local processes and terminology. Despite the extensive changes, the final model still uses the original V-Modell XT metamodel without modification.

As mentioned above, Version 1.2 of the V-Modell XT was released in May 2006, when the company's process customization effort was already quite advanced. As of this writing (March 2007), no attempt has been made to integrate any of the additions and corrections present in version 1.2 into the company's customized model, although members of the software process group have expressed their interest in doing this at least to some extent. This is currently not a high priority because the customization process was finished only recently, but it is acknowledged that there may be corrections and additions in the new V-Modell XT version that could benefit the tailored model.

Due to the size and complexity of the models involved, it is very difficult to manually determine the actual extension of the changes performed on each one of them, and this, in turn, makes it difficult to estimate the effort involved in aligning the tailored model with the standard. As discussed in the following section, determining the extent of the changes and analyzing them to find those that are suitable for incorporation into the tailored model and those that may lead to conflicts has been, until recently, a mainly manual, and thus potentially expensive and unreliable, process.

2.3 Difference Identification in the V-Modell

Comparing source code versions and analyzing the resulting differences is a task software developers perform on a daily basis for a variety of purposes, including sharing of changes, review and analysis of changes done by others, and space-efficient storage of multiple versions of a program. Such comparisons can be performed using widely available software, such as the well-known diff utility present in most UNIX-like operating systems, and other similar programs. Diff relies on interpreting files as being composed of text lines (sequences of characters separated by the newline character) and then finding *longest common subsequences* (LCS) of lines by using an efficient algorithm (see [4] for an example). Lines not belonging to a common subsequence are considered to be differences among the compared files.

In most practical cases, entities in a process model are connected in an arbitrary graph structure (the V-Modell XT is a good example of this). Since LCS algorithms can only operate on sequential structures, it is thus impossible to apply them directly to most process models. Nonetheless, the idea of using diff or a similar LCS-based program on process models is still appealing. The reason is that many useful tools, including most source code versioning systems, rely on an LCS algorithm implementation as their only comparison mechanism, and it would be valuable if these tools would work on process models, as opposed to working only on program source code.

For the the team working on the V-Modell XT, for example, it was necessary to introduce a code versioning system to support collaborative work, since members of the team work separately and in parallel on different aspects of the model's contents. In order to do that, each team member changes a separate copy of the model, and later uses the versioning system to *merge* the changes into the main development branch. The merge operation, however, is based on finding a minimal set of changes using diff, and, thus, requires diff to produce somewhat usable results when applied to the V-Modell XML representation. The V-Modell solution to this problem is to format XML files in a special way, carefully controlling the order of elements in the file, and ingenuously introducing line breaks and comment lines into the XML representation. When working with XML files formatted this way, diff is able to recognize simple changes, like added or deleted entities or changed attributes, as separated groups of inserted, deleted, or changed lines.

Although this approach has effectively enabled the use of collaborative versioning tools for the model's development and maintenance, it is not free of problems. First of all, change integration works mostly correctly when integrating *non-conflicting* sets of changes, i.e., sets of changes that affect completely separate areas of the model. If, on the other hand, the change sets happen to touch the same area of the model (e.g., by altering the same attribute in different ways), a conflict is detected and marked. Solving the conflict requires a human being to look into the XML file where the changes have been merged and correct the conflicting lines manually using a text editor. This is a cumbersome process that requires detailed knowledge of the XML representation.

3 The *DeltaProcess* Approach

Considering the problems discussed in the previous section, we developed the *DeltaProcess* approach with the following goals in mind:

– Operate on models based on a variety of schemata. New schemata can be supported with relatively little effort.
– Be flexible about the changes that are recognized and how they are displayed.
– Allow for easily specifying change types that are specific to a particular schema or even to a particular application.
– Be tolerant to schema evolution by allowing the comparison of model instances that correspond to different versions of a schema (this sort of comparison requires additional effort, though.)

We claim that our approach is suitable for *difference analysis* as opposed to just difference identification (i.e., simple comparison). First of all, instead of defining a set of interesting change types in advance, we make it possible for the user to specify the types of changes that interest him in a schema-specific way. Additionally, since we use queries to find changes, it is possible for a user to restrict results to relevant areas of a model, according to a variety of criteria. Finally, postprocessing allows for applying specialized comparison and visualization algorithms to the resulting data, making it possible to display changes at a level of abstraction that is adequate for a specific task.

In this section, we provide a brief description of the *DeltaProcess* approach and its implementation *Evolyzer.* Readers interested in the inner workings of the approach are invited to read [2] and [3].

3.1 Description of the Approach

In order to compare models, the *DeltaProcess* approach goes through the following steps:

1. Convert the compared models to a normalized triple-based notation.
2. Perform an identity-based comparison of the resulting models, to produce a so-called *comparison model.*
3. Find relevant changes by using queries to search for patterns in the comparison model.
4. Postprocess the resulting change data, in order to refine the results or produce task-specific visualizations.

We explain these steps in some more detail in the following paragraphs.

The first step normalizes the compared models by expressing them as sets of so-called *statements*. Statements make simple assertions about the model entities (e.g., *e1 has type Activity* or *e1 has* *name “Design”*), or define relations among entities (e.g., *e1 produces product p1)*. Although we could have defined our own notation for the statements, we decided to use the standard RDF notation [5] for this purpose. Beside the standardization benefits, RDF has the formal properties required by our approach.

In general, using a normalized triple notation has a number of advantages with respect to other generic notations like XML:

- It is generally inexpensive and straightforward to convert models to the notation. Since the set of possible assertions is not limited and can be defined separately for every model, models in arbitrary notations can be converted to RDF without losing information.
- Models do not lose their “personality” when moved to the notation. Once converted, model elements are often still easy for human beings to recognize.
- The results of a basic, unique-identifier based comparison can be expressed in the same notation. That is, comparisons are models, too. Additionally, elements remain easy for human beings to identify even inside the comparison.
- Thanks to normalization, a single, simple pattern notation can be used to describe a large number of interesting changes.

In step 2, two or more normalized models (in our case study, we perform many analyses using a three-way comparison) are put together into a single so-called *comparison model*. In this new model, statements are marked to indicate which of the original models they come from. One central aspect of the comparison model is that it is also a valid RDF model. The theoretical device that makes this possible is called *RDF reification,* and is defined formally in the RDF specification [5]. The main purpose of RDF reification is to allow for statements to speak about other statements. This way, it is possible to add assertions about the model statements, telling which one of the original models they belong to.

Changes appear in the comparison model as combinations of related statements that fulfill certain restrictions. For example, the change *a1's name was changed from “Design” to “System Design”* appears in the comparison model as the statement *a1 has name “Design”* marked as belonging only to the older version of the model, and the statement *a1 has name “System Design”* marked as belonging only to the newer version of the model. Since the number of statements in a comparison model is at least as large as the number of statements in the smallest of the compared models (the three-way comparison model used for the case study contains almost 18,000 statements), automated support is necessary to identify such change patterns reliably. For this reason, in step 3, a pattern-based query language is used to formally express interesting change types as queries. By executing the queries, corresponding changes are identified in the comparison model. There is already a standardized notation (SPARQL, see [6]) to express patterns in RDF models. With minimal adaptations, this notation makes it possible to specify interesting types of changes in a generic way. Our *Evolyzer* system (see Section 3.2) provides an efficient implementation of SPARQL that is adequate for this purpose.

The final step involves postprocessing of the change data obtained in step 3 in order to prepare the results for final display. One important purpose of this step is to allow for applying specialized comparison algorithms to particular model elements. For example, changed text descriptions in the V-Modell can be compared using a word-level, LCS-based algorithm to determine which words were changed. We also use this step to generate a variety of textual and graphical representations of change data.

One important limitation of the *DeltaProcess* approach is the fact that it requires that entities have unique identifiers that are consistent in all of the compared model instances. Otherwise, it would be impossible to reliably compare the resulting statements. Although this limitation may appear at first sight to be very onerous, our experience shows that, in practice, most modeling notations actually contain the identifiers, and most modeling tools do a good job of keeping them among versions. The V-Modell is not an exception, since its entities are always given a universal, unique, aleatory identifier at creation time.

3.2 Implementation

Our current implementation, *Evolyzer,* (see Fig. 1) was especially designed to work on large software process models, such as the V-Modell and its variants. Nevertheless, since the comparison kernel implements a significant portion of the RDF and SPARQL specifications (with the remaining parts also planned), support for other types of models can be added with relatively small effort.

The current implementation is written completely in the Python programming language, and uses the MySQL database management system to store models. Until now, we have mainly tested it with various process models, including many versions of the V-Modell (both standard releases and customized versions.) Converted to RDF, the latest released version of the V-Modell (1.2) contains over 13.000 statements, which describe over 2000 different entities. A large majority of the interesting comparison queries on models of this size (e.g., those used for producing the results presented in Section 4) run in less than 5 seconds on a modern PC.

3.3 Related Approaches

A number of other approaches are concerned with identifying differences in models of some type. [7] and [8] deal with the comparison of UML models representing diverse aspects of software systems. These works are generally oriented towards supporting software development in the context of the Model Driven Architecture. Although the basic comparison algorithms they present could also be applied to this case, the approaches do not seem to support the level of difference analysis we require.

[9] presents an extensive survey of approaches for software merging, many of which involve a comparison of program versions. Some of the algorithms used for advanced software merging may be applied to the problem of guaranteeing consistent results after a model merge operation, but this is a problem we are not yet trying to solve.

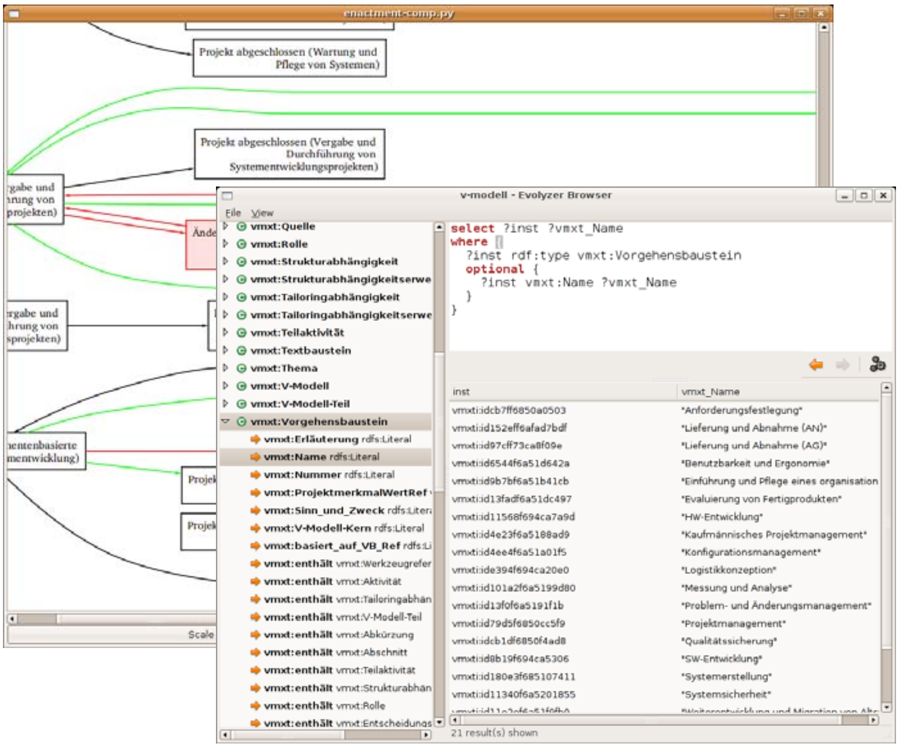

Fig. 1. The *Evolyzer* tool working on the V-Modell XT

[10] provides an ontology and a set of basic formal definitions related to the comparison of RDF graphs. [11] and [12] describe two systems currently under development that allow for efficiently storing a potentially large number of variants of an RDF model by using a compact representation of the differences between them. These works concentrate on space-efficient storage and transmission of

difference sets, but do not go into depth regarding how to use them to support higher-level comparison tasks.

Finally, an extensive base of theoretical work is available from generic graph comparison research (see [13]), an area that is basically concerned with finding isomorphisms (or correspondences that approach isomorphisms according to some metric) between arbitrary graphs whose nodes and edges cannot be directly matched by name. This problem is analogous in many ways to the problem that interests us, but applies to a separate range of practical situations. In our case, we analyze the differences (and, of course, the similarities) between graphs whose nodes can be reliably matched in a computationally inexpensive way (i.e., unique identifiers.)

4 An Alignment Viability Analysis

As part of our ongoing case study, we performed an analysis aimed at determining the viability of aligning the company's customized process model with the V-Modell, by incorporating a subset of the changes that occurred in the V-Modell between versions 1.1 and 1.2. In order to perform this assessment, we decided to count the number of entities, entity attribute values, and relations affected by certain types of changes. The purpose of these measurements was to obtain a general impression of the number of separate changes that need to be considered by the process engineers while doing the alignment work.

In order to obtain the values, we defined a change pattern query for every change type, and used the *Evolyzer* tool to execute it and count the results. Although we are only presenting consolidated numbers, the individual changes are available from the tool and could be used by a process engineer as input for the actual alignment task. Regarding effort invested into the analysis, it was performed by one engineer in a single day, with the models having been imported previously into the tool's database.

The table below summarizes our results. The first column numbers the rows for reference, and the second column contains a description of the analyzed change type. The columns labeled “Entities”, “Attributes”, and “Relations” contain the respective counts of affected model elements. When a change type does not affect a particular type of model element, the corresponding cell remains empty.

#	**Change Type**	**Entities**	**Attributes**	**Relations**
1	Total entities in the V-Modell (1.2)	2107		
2	Total entities in the tailored model	1231		
3	Entities present in both models (common entities)	789		
4	Changed entities in the V-Modell	536	670	
5	Common entities changed only by the V-Modell	96	99	
6	Common entities containing conflicting attributes	180	210	
7	New entities in the V-Modell	286		
8	New entities in the V-Modell that are contained in preexisting entities	150		
9	New entities in the V-Modell that are contained in entities still present in the tailored model	109		
10	Entities deleted from the V-Modell that are still present in the tailored model	0		
11	New entities in the V-Modell that reference preexisting entities	170		393
12	New entities in the V-Modell that reference entities that are still present in the tailored model.	100		189

#	Change Type	Entities	Attributes	Relations
13	Preexisting entities in the V-Modell that reference new entities	81		109
14	Entities still present in the tailored model that reference new entities in the V-Modell.	26		41
15	New relations between preexisting entities in the V-Modell			67
16	New relations in the V-Modell between entities that are also present in the tailored model			7
17	Deleted relations (between preexisting entities) in the V-Modell			127
18	Relations deleted in the V-Modell between entities still present in the tailored model			1
19	Entities in the V-Modell moved to another position in the structure.	86		
20	Entities still present in both the V-Modell and the tailored model, which were moved by the V-Modell but not by the tailored model	14		
21	Entities moved to conflicting positions in the structure by the V-Modell and the tailored model	0		

Rows 1 to 3 present the total entity counts involved. It is clear that the tailoring process deleted a significant portion of the original. Another important observation is that 64% or about two thirds of the entities in the tailored model are still shared with the V-Modell. This portion seems large enough to justify attempting an alignment.

Rows 4 to 6 count the number of changed entities (defined as entities with changed attributes). Lines 5 and 6, in particular, count entities changed by the V-Modell that are still present in the tailored model. The count in 5 (96) corresponds to entities without conflicts, whereas the count in 6 (180) corresponds to entities with conflicts. The sum (276) is the total number of changed entities to consider. Notice that this number is about one half of the total of entities changed by the V-Modell (536). The difference (260) is the number of changed entities that do not have to be considered because they were deleted from the tailored model.

Rows 7-18 try to quantify the size of totally new additions present in the V-Modell. 7 and 8, respectively, count all new entities (286) and new entities contained in preexisting entities. The latter is probably the most relevant count, because the remaining entities are subentities of other new entities, and will probably be considered together with their parents. The subsequent rows try to determine whether it is possible to filter some of these new entities by analyzing their relations to preexisting entities. The resulting values suggest that this is possible, and that a significant number (40 to 50%) can probably be discarded because they have no connections to any of the entities in the tailored model. Line 10, in particular, contains good news: no entity deleted by the V-Modell is still being maintained by the tailored model.

The last three rows (19-21) are an attempt to measure a particular type of structural change, namely, movement of entities in the containment hierarchy. From 86 total changes in the V-Modell, only 14 affect the tailored model, and there are no conflicting changes.

Without historical effort data, it is difficult to produce an exact estimation of the effort involved in performing a model alignment. However, a few conclusions can be extracted from this data. First, integrating the changes done to existing entities (lines 1-3) is probably possible with relatively little effort. Informal observation of the versioning changelogs tells us that many of the changes are small grammar and spelling corrections, but to confirm this, we would need to exactly measure the extent of the changes done to text attributes.

Second, although integrating the new V-Modell elements is likely to take more work, it is also probably viable in a few days time, because the number of entities to consider is relatively small (around 100). Finally, the analysis shows that in this case, the total number of model elements to consider for alignment can be reduced to about half by filtering those elements that were already deleted from the tailored model or that are not connected to elements in the tailored model. This fact alone represents a significant effort saving, which is not achievable with any other method we are aware of.

5 Conclusions and Future Work

Organizations trying to document their software processes for the first time may greatly benefit from adopting an existing process standard and customizing it. However, since both process standards and the models derived from them evolve over time, sooner or later they diverge to a point where their lack of alignment becomes problematic. Realigning large process models, however, is a complex problem. Manual alignment is tedious and unreliable, and automated tool support for this task has been insufficient.

Our *DeltaProcess* approach and its *Evolyzer* implementation are a first step to remedy this situation. They provide a framework for identifying changes in process models and for analyzing these changes in order to support particular tasks. The implementation works efficiently on models of the size of the German V-Modell XT.

As the analysis presented in Section 4 shows, our approach can be used effectively to identify relevant changes and filter irrelevant changes when trying to align large process models that were changed independently from each other for an extended period of time. We have not yet started doing the actual alignment as part of our current case study, but expect to be able to attempt it in the following months. A complete experience report will be produced from that effort.

We are also working on extending our tools, which currently concentrate on change analysis, to also support altering the analyzed models. This way, we expect to make it easier for process engineers to work on complex model alignment tasks, by being able to move seamlessly from the change data to the actual model contents.

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Analysis of Most Common Process Modelling Mistakes in BPMN Process Models

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Abstract. The purpose of this article is to present the most common patterns of mistakes and misunderstandings together with proposed solutions, which resulted from the analysis of more than two thousand process models designed using BPMN notation.
The approach, used in our research was a multiple case study of graphical process models drawn using Business Process Modelling Notation (BPMN), created by students of information systems study programme. Most important finding of our research is that we have identified 15 most common BPMN process model anti-patterns. Most of them represent wrong usage of BPMN's connecting objects. Less notable is wrong usage of other BPMN's objects.
Results of our research could have direct positive implications on learning habits of process analysts and on faster learning of correct process modelling. Findings could also be used for the improvement of process modelling tools and finally to improve the students skills. The findings are useful for all types of stakeholders in education and businesses, who deal with business process management.

Keywords: business process modelling, BPMN, process patterns, case study.

Introduction

Business process modelling is becoming increasingly important activity in all types of organisations, especially as a part of larger initiatives - Business Process Management. One of main purposes of process modelling is to ensure at least repeatability of organisation's processes [1].
Process modelling is especially valuable and unavoidable when implementing quality management systems in organisations. In addition, it can be extremely useful as a part of software development cycle, especially in early phases of software development projects, where behaviour of target domain is analysed and requirements are being gathered.
Latest information technology evolution is heading towards process models as the core drivers of the distributed computing [2]. In addition, the web services technologies stack contains process modelling and synchronisation (choreography) languages on its highest level [3].
Until now, the business process modelling was often neglected, mainly due to the gap between business requirements for information systems (process models) and inability of automated execution of the process models. The development of the latest XML based languages for process description [4] and execution [5] and process engines is enabling the execution of the business process models already.
Nevertheless, information system developers and business analysts do not have sufficient knowledge about the detailed process modelling, because in the last decades, there was the need only for rough process models, which were performed manually.

It is well known, that poor quality of process models can cause poor quality software requirements resulting in a poor information system. Therefore, greater emphasis on the business process modelling education should be put.
In the recent years, many modelling techniques were used for process modelling and many of them were not appropriate as a teaching method for process modelling. The process modelling technique, which is appropriate for students, should be easy to learn, it should hide the unnecessary details of process model and it should be broadly accepted. At University of Maribor, newer process modelling techniques such as BPMN [6] were introduced in the curriculum of Information Systems course [7].
Students at the Faculty of Electrical Engineering and Computer Science are taught how to model business and software processes. The goal of practical lectures of process modelling is to teach students how to design business and software development process models. In the last six years, many experiences about process modelling were gathered.
The BPMN notation was chosen for theoretical and practical lectures for classes "Standards and quality" and “Organisation and management of information systems projects”, because it offers a graphical notation with the support of all important process concepts (process, activity, event, routing, merging, synchronisation, messages, roles and so on), which can be used to model various kinds of discrete processes. Another reason for choosing this notation was that the specification of the notation defines standardised mappings to the process execution languages, currently for BPEL4WS [5] and XPDL [4].
Currently, there are many commercial tools being developed, which shows the overall adoption of the notation in the industry is increasing. Although BPMN notation is ontologically most complete notation currently available [8,9], it does not prevent us to design bad process models, including syntactical, semantic and pragmatically errors. During last six years, we were gathering most frequent mistakes, which were created by students. We have analysed over two thousand process models and extracted 15 most important and frequent process anti-patterns and proposed solutions for them.

Similar work

The term anti-pattern is not new. It is often called a pitfall, or, set of classes of commonly-reinvented bad solutions to problems. They are studied as a category so they can be avoided in the future, and so instances of them may be recognized when investigating non-working systems [10].
Similar definition has been used in a book [11]: Anti-patterns are commonly repeated bad practices, or, roadblocks, which prevent successful delivery and are directly caused by lack of understanding of the problem.
To our knowledge, currently no such work described here can be found in accessible literature. Other researchers describe process patterns from different contextual and abstraction levels.
For example, a great work of authors [12] identifies a set of generic workflow patterns, which can be used to test the capability and completeness of process modelling languages or tools regardless of the notation used. Those patterns are grouped as control flow patterns, resource patterns, data patterns and exception handling patterns.
Our work differs from mentioned that we identified process modelling anti-patterns, which are specific to the BPMN notation and often occur when an inexperienced analyst uses a tool without the verification capabilities.
Nevertheless, our anti-patterns are somehow similar to control-flow and data patterns [12], because most of our anti-patterns describe incorrect connectedness of activities, events and organizational structures.
Other authors, such as [13,14] describe possible process management pitfalls, which should be avoided. In the context of process modelling, the author warns the analysts not to exaggerate with the details and completeness of the process models. Author's work describes pitfalls from the human resources point of view and does not identify mistakes in the process models.
Other patterns, found in the literature, such as design patterns [10], are not directly related to our work.

Research method

In order to answer the stated research question "What are the most common mistakes when modelling business process diagrams using BPMN notation?", we decided to perform a multiple case study research based on data collected during the curriculum. The process models, designed by students were gathered and systematically analysed from 2002 to 2007. Corresponding to data collection and data analysis, exploratory research approach was chosen, which allows collecting the data prior to the definition of the research question [15-17].

Within the curriculum, the process models are designed during practical lectures by students of fifth (higher programme) and eighth semester (university programme) of information systems study programme. Total duration of Information systems study programme is six (higher programme) or nine semesters (university programme). Students in both groups receive equal knowledge about the BPMN topic. The learning process of BPMN includes the following steps.

Students learn about the theory of process modelling during theoretical classes. The practical lectures take 45 hours. Based on textual requirements, each student designs five process models using computer aided software engineering tool. This tool (Microsoft Visio or Dia plug-in) allows students to design process model. However, neither of the tools syntactical or semantically validate created models. Additionally, students design process models during the exam. The models are stored in a configuration management system, which simplifies evolution of models and identification of plagiarism. The quality of designed models is validated by teaching assistants using rules defined in BPMN 1.0 specification. Finally, the validated and updated versions of process models are committed back in configuration management system. There are roughly 30 students for each class for each year, which makes totally around two thousand process models designed in last six years.

To ensure validity of the case study, the triangulation principle [15-17] should be used: The case should be examined by multiple observers, data sources and theories or methods. Corresponding to the triangulation principle, process models were analysed by two teaching assistants and one assistant professor. Additional, multiple process models were analysed, which ensures data sources validity. The study (analysis of process models) was repeated multiple times in each study year, after each process model finished by students.

The validity of our case study could only be threatened by the fact that the case should be observed from different viewpoints (theories or methods) and we are fully aware of this issue.

The study followed the procedure: After each process model designed by students, the process model was inspected and problematic patterns were identified and recorded. This step was repeated for each process model.

Wrong usages of the BPMN notation were classified as syntactical mistakes. Process models with wrong meaning were classified as semantically mistakes. Process models, which were not understandable or ambiguous, were classified as pragmatic mistakes. 'Anti-Patterns' evolved when similar mistakes repeated over multiple cases of process models. Those patterns were incrementally added to the 'Most common process modelling mistakes' document, which will be used in next year's curriculum to prevent most common mistakes.

Findings - Most common anti-patterns of process modelling and proposed solutions

Improper use of BPMN syntax rules and general modelling principles can cause low process modelling performance in the sense of correctness.

During the practical lessons of process modelling we noticed that some process model patterns cause problems and are not used in the right way. Most frequent patterns of such mistakes were gathered and are presented in this chapter.

Each process pattern is described in the following way: first, problem is formulated in a form of process anti-pattern and classified according to the type of mistake. Type of mistake can be syntactical, semantic or pragmatic. Second, the severity and implications are discussed. Implications can be deadlocks, un-reachability of some process parts, unnecessary complications and so on. Third, the solution is proposed in a form of correct process pattern.

Examples are drawn using BPMN notation. Patterns represent only parts of process models. Dots (...) represent hidden parts of the process models, which are not necessary for pattern understandability.

Patterns from 1 to 8 represent improper use of BPMN's connecting elements. Patterns from 9 to 15 represent improper use of other BPMN's elements, such as events and activities.

Pattern 1. Activities in one pool are not connected

Problem: A common mistake in this case is that activities in one pool are not connected with sequence flow (see Pool B on Fig. 1). When multiple pools are modelled, only message flows can be used to connect different pools. Within each pool a separate flow should be defined. Most frequent reason for this type of mistake is that students perceive multiple pools as one process or dependent processes and think that message flows between pools can be used instead of sequence flows.
Possible practical impacts: In the organization, which is represented by Pool B (Fig. 1) the dependency of the activities is not defined. These could lead to non-performing of the task D. In case that there are several non-connected activities, the sequence of performing them is also unknown.

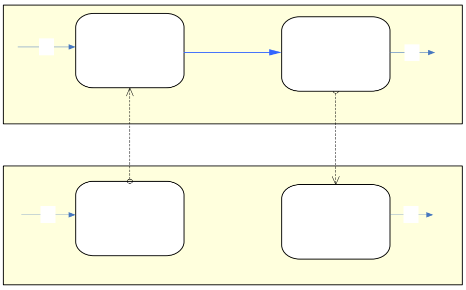

Fig. 1. Anti-pattern: Activities in one pool are not connected

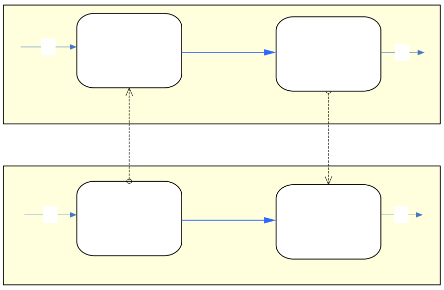

Fig. 2. Correct pattern

Type of error: This is a syntactical error and pragmatic error; students think that sequence flow between task C and task D is not required.
Implications: Process model is not valid. Direct implication of this mistake is that part of the process model is not reachable (Activity D).
Proposed solution: The modelling should be performed in a way that pools are modelled independently, without thinking about the connection between pools. All process elements in one pool should be fully connected using sequence flow, according to the BPMN specification. This step should be repeated for all pools.
Lastly, message flows, intermediate message events and data objects should be added. Example of the solution is presented below (Fig. 2).

Pattern 2. Process does not contain a start event

Problem: Although start event is optional (according to BPMN specification), its usage is recommended, especially for complex processes, where it is difficult to localize process starts (Fig. 3).
Possible practical impacts: If the starting event is missing most probably in an organization it will be unclear when or where to start performing the process. It could happen that the process is not performed at all.

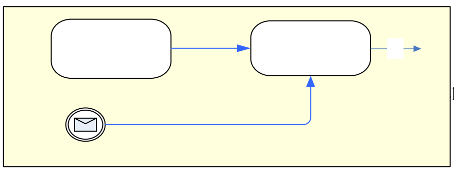

Fig. 3. Anti-pattern: Process does not contain a start event

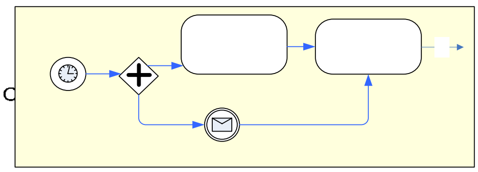

Fig. 4. Correct pattern

Type of error: This is pragmatic error, not syntax error, according to the BPMN specification.
Implications: The understandability of the process model is lowered, because it is not clear where the process starts.

Proposed solution: The start event should be added (Fig. 4), to make the understanding of the process model easier. If necessary, a combination of routing elements should be added also. If the pool contains sequential and simple process then the start event is not needed.

Pattern 3. Process does not contain an end event

Problem: If the process doesn't contain an end event, it is not clear when the process ends, for example: Does the process on (Fig. 5) ends when Task B and C are finished? The answer is "probably, but not necessary".
Possible practical impacts: In an organization, process performers' work may stall, because they don't know how to react when tasks B and C (Fig. 5) are finished. Other dependent processes may be delayed also.

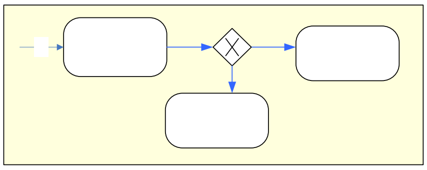

Fig. 5. Anti-pattern: Process does not contain an end event

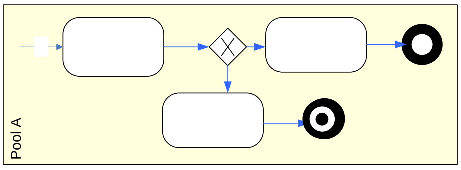

Fig. 6. Correct pattern

Type of error: This is a pragmatic error, because it is not clear when the process in Pool A ends.
Implications: The understandability of the process model is lowered, because it is not clear when the process ends.
Proposed solution: Process ends should be explicitly modelled to specify when the process ends. For example, the whole process on (Fig. 6) ends when the task C is finished (see terminate event).

Pattern 4. Sequence flow crosses process boundary

Problem: The sequence flow crosses sub-process boundary. Inexperienced analysts often don't perceive sub-processes as independent units.
Possible practical impacts: In an organization, sub-process is often treated as 'batch of activities', which is started at the first activity, which is treated as the beginning, not in the middle of the sub-process. In case of following incorrect sequence flow, process performers might skip the task C (Fig. 7).

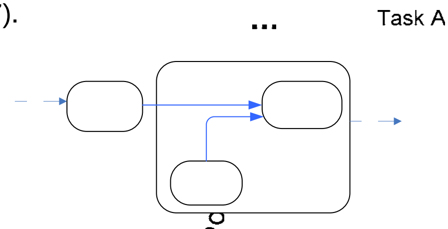

Fig. 7. Anti-pattern: Sequence flow crosses process boundary

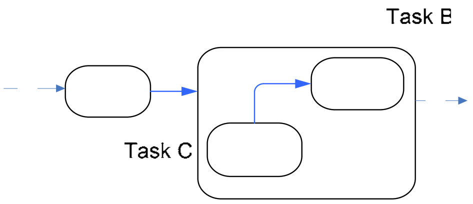

Fig. 8. Correct pattern

Type of error: This is a syntax error, according to the BPMN specification.
Implications: Process model is not valid. There are no other serious implications, but understandability is lowered and process model does not conform to the specification.
Proposed solution: Re-combine activities and connect wrong sequence flow to the boundary of sub-process (Process X Fig. 8). When teaching students process modelling, comparison with Java programming language methods is useful and helps students to understand the proposed solution. When programming in java, calls of the statements within the class' methods are not allowed also, only calls to the whole objects' methods.

Pattern 5. Sequence flow crosses pool boundary

Problem: Improper use of flow objects often occurs in combination with pattern 1. In this case (Fig. 9), activities from different pools are connected with the sequence flow, which is not allowed in this case. Interaction between pools should be designed using message flows only.
Possible practical impacts: The process performer from the Pool A might think that for passing the control to the organization B, no action is needed, for example sending documents, emails, contracts and so on. This situation can cause the Task F is not performed at all.

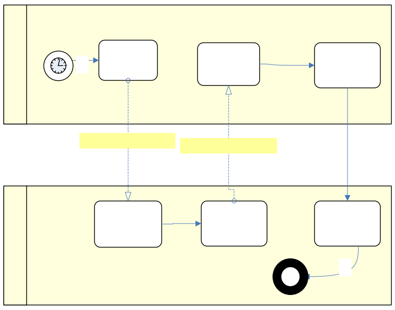

Fig. 9. Anti-pattern: Sequence flow crosses pool boundary

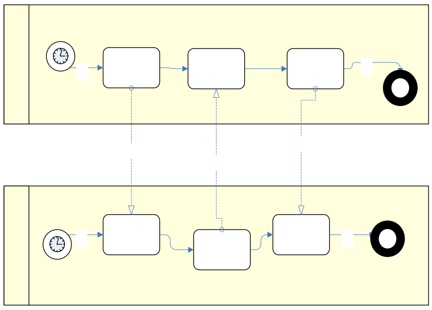

Fig. 10. Correct pattern

Type of error: This is a syntax error, according to the BPMN specification.
Implications: Process model is not valid. Two independent processes are being made dependent using sequence flow.
Proposed solution: The message flow should be used instead of sequence flow (Fig. 10).

Pattern 6. Gateway receives, evaluates or sends a message

Problem: A common mistake when using gateways is that a gateway receives or sends a message (Fig. 11). The most common cause for this type of error is that it is wrongly assumed that the incoming message influences the decision and that a gateway alternative or output can directly result in a message flow. However a gateway cannot produce, receive or evaluate data, which is also evident from BPMN's Message flow rules. A similar mistake appears when association flows are used.
Possible practical impacts: Process performers may think that messages can trigger the decisions or can be result of the decision, which is wrong. Direct impact could be unwanted waiting for the message before the decision is taken during the process execution.

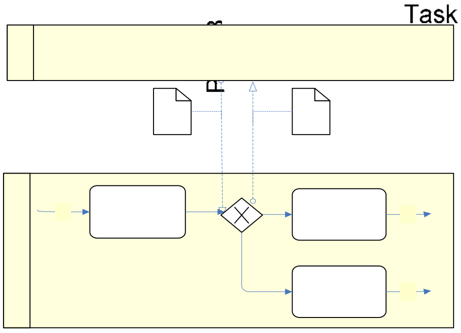

Fig. 11. Anti-pattern: Gateway receives, evaluates or sends a message

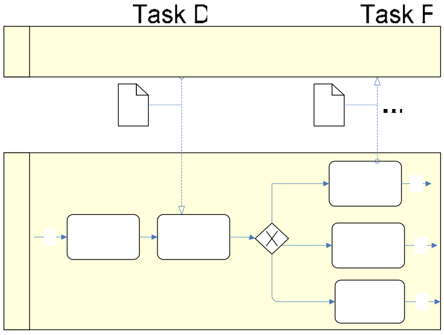

Fig. 12. Correct pattern

Type of error: This is syntactical error and semantic error; students think a gateway can receive and produce messages.
Implications: The most critical implications of this anti-pattern are missing activities which should receive or produce messages. Beside, while gateway alternatives are not modelled correctly this usually implies further sequence flows.

Proposed solution: New activities should be included in the model, which receive, evaluate or produce messages (Fig. 12).

Pattern 7. Intermediate events are placed on the edge of the pool

Problem: Students often model pool interfaces as intermediate events placed on the pool's boundary, which is not correct (Fig. 13).
Possible practical impacts: Process performers may think the intermediate message events can be triggered anytime during the process, which can cause unwanted execution of the activities in the process.

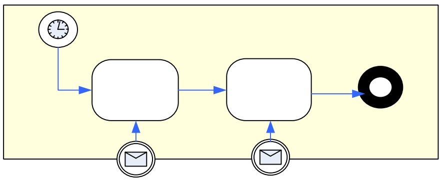

Fig. 13. Anti-pattern: Intermediate events are placed on the edge of the pool

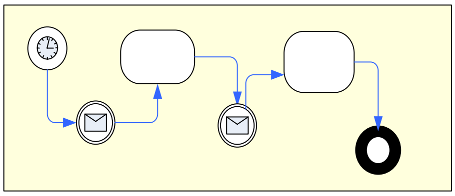

Fig. 14. Correct pattern

Type of error: Syntactical error.
Implications: Event is not reachable within the pool.
Proposed solution: Intermediate events should be modelled within the pool and fully connected (in and out sequence flows). Only then they are reachable and represent delays in the process (Fig. 14).

Pattern 8. Hanging intermediate events or activities

Problem: Activities or events within the pool do not contain incoming sequence flows (Fig. 15).
Possible practical impacts: Some activities in the organization may never be performed. Triggering of the intermediate events can cause unwanted performing of activities.

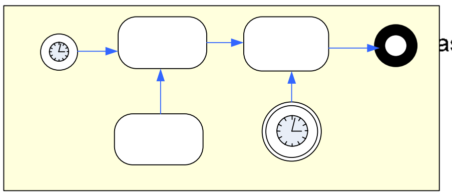

Fig. 15. Anti-pattern: Hanging intermediate events or activities

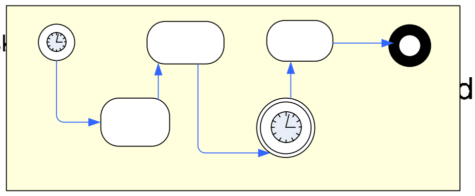

Fig. 16. Correct pattern

Type of error: This semantic mistake leads to the non-reachability of the activities.
Implications: Activity is not reachable.
Proposed solution: The process model should be rearranged and fully connected (Fig. 16). The meaning of the process should be examined when rearranging sequence flows.

Pattern 9. Each lane in the pool contains start event

Problem: Although this situation is allowed (according to BPMN), we've found that it can cause a lot of ambiguity when reading the process model (Fig. 17).
Possible practical impacts: Process performers may think the processes in the organization are independent, which may not be true. The processes can also be started at the wrong time.

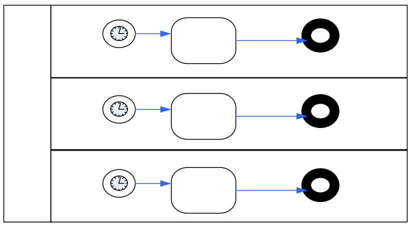

Fig. 17. Anti-pattern: Each lane in the pool contains start event

Type of error: This is a pragmatic error.
Implications: The model is ambiguous.
Proposed solutions: There are more possibilities how to resolve this case. First possibility (Fig. 18 - left) is that the process includes only one start event and sequence the activities. Second possibility (Fig. 18 – right) is that the process includes one start event, event based decision, intermediate events and parallel activities. Or, the processes in lanes can be modelled as processes in separate and independent pools. The correct solution depends on semantics of the process model.

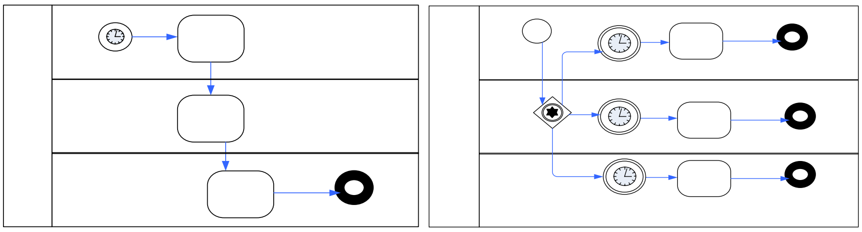

Fig. 18. Two possibilities of correct patterns

Pattern 10. Incorrect use of time events

Problem: Intermediate time events have two basic purposes - acting as a delay mechanism when used between sequence flows and acting as an exception (duration) when attached to the boundary of task or sub-process (Fig. 19). These two purposes are often interchanged.
Possible practical impacts: Process performers may interrupt the execution of the activity at the wrong time, or, the execution of the next activity may be delayed.

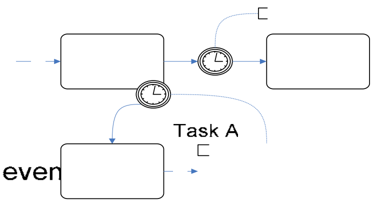

Fig. 19. : Anti-pattern: Incorrect use of time events

Type of error: This is a pragmatic error; students want to model a duration mechanism, but they model a delay instead; and opposite.
Implications: The most critical implication of this anti-pattern is unwanted delay in a business process.
Proposed solution: There is no recipe for solving this type of problem because both types of models are syntactically correct. The students should learn how does the meaning of the intermediate event changes when using in different locations in the process model.

Pattern 11. Sequence and message event represent data flow

Problem: Similar to time events, intermediate message events are used as delay or synchronisation mechanism. When an intermediate message event is placed within a sequence flow it will continue when a message (explicit or implicit) arrives from a participant and triggers the event. However, students often wrongly use intermediate message event as a mechanism for sending messages (data) from previous task to following task (Fig. 20).
Possible practical impacts: In the organization, if process performer follows wrong process model, the execution of some activities may be delayed and document, which should flow between the activities may not be created at all.

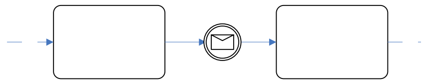

Fig. 20. Anti-pattern: Sequence and message event represent data flow

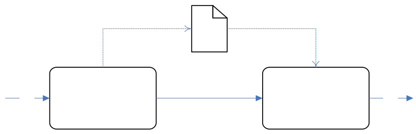

Fig. 21. Correct pattern

Type of error: This is a semantic error; students think to model a message or data flow. Instead, they model a delay mechanism.
Implications: The process if forced to stop. Therefore a part of the process will not be able to execute until the message arrives.
Proposed solution: Instead of using intermediate message event, the document or data flow as presented below (Fig. 21) should be used.

Pattern 12. Event is used as a message flow source

Problem: Events are often used as sources of message flows. According to BPMN message flow rules this is wrong and can be explained with the fact that only activities can produce messages (Fig. 22).
Possible practical impacts: In the organization, the process performer who follows the incorrect process model may think that he or she should produce a document at some point in the process, instead of waiting for the message. The situation can cause ambiguity and unnecessary work of the process performer.

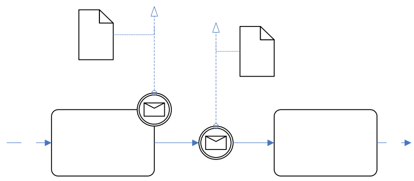

Fig. 22. Anti-pattern: Event is used as a message flow source

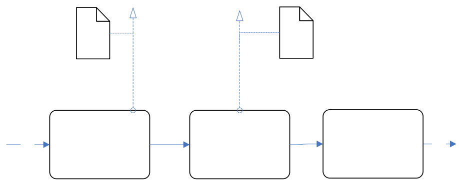

Fig. 23. Correct pattern

Type of error: According to BPMN specification, this is a syntactical error.
Implications: Missing activities which actually produce messages.
Proposed solution: If message event is placed on the activity boundary it should be deleted. The message should be connected directly to the activity. If message event is placed between the sequence flows it should be replaced with an activity (Fig. 23).

Pattern 13. Improper use of flow elements

Problem: Different states of the activity are often incorrectly modelled as separate activities. This includes the receiving of the messages. However these types of activities usually complicate the process (Fig. 24).
Possible practical impacts: In the organization, the process performer who follows the incorrect process model may be confused, because states of the activity are represented as separate activities.

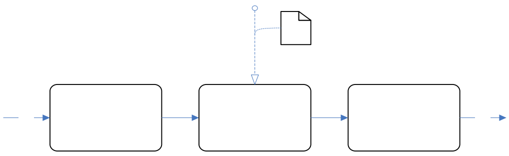

Fig. 24. Anti-pattern: Improper use of flow elements

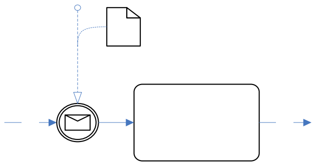

Fig. 25. Correct pattern

Type of error: The anti-pattern represents semantic and pragmatic errors. The models are often confusing and complex.
Implications: Non-understandable models.
Proposed solution: The states of an activity are not required because the sequence flow indicates if an activity starts (incoming sequence flow) or ends (outgoing sequence flow). To model intermediate message events explicitly is a better solution. In case of multiple incoming message flows the event based gateway and the appropriate combination of intermediate events should be used. (Fig. 25).

Pattern 14. Starting timer placed instead of intermediate timer

Problem: This is a small but very frequent mistake using starting timer instead of intermediate one. We believe that time events are often misused because of the inner circle which represents the clock symbol (Fig. 26).
Possible practical impacts: Because this is syntactical error, we think that it would not cause any significant problems during process execution.

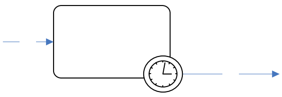

Fig. 26. Anti-pattern: Starting timer placed instead of intermediate timer

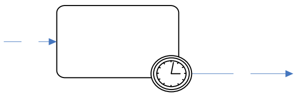

Fig. 27. Correct pattern

Type of error: This is a syntactic error.
Implications: Syntactically wrong model.
Proposed solution: Start timer should be replaced with intermediate timer event as presented on Fig. 27.

Pattern 15. Exception flow is not connected to the exception

Problem: Analysts often model task exception using intermediate event, but the sequence flow remains connected to the task, which is syntactically correct, but semantically wrong, if we want to represent the activity, which is performed after the exception is triggered.
Possible practical impacts: This type of process model mistake could cause serious problems in the organization. If the activity which is currently performed is interrupted, no compensation activity would be performed because of wrong connections.

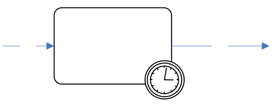

Fig. 28. Anti-pattern: Exception flow is not connected to the exception

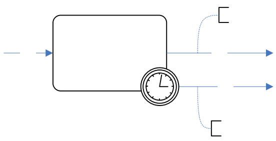

Fig. 29. Correct pattern

Type of error: This is a semantic error.
Implications: Wrong meaning of the process model, especially if read by other person than original author. Also, it is not clear if a sequence flow is missing or it is just wrongly connected directly to the activity.
Proposed solution: Correct flow should be modelled. If the analyst wants to represent the exception flow, then the sequence flow should be connected to the intermediate event (Fig. 29).

Conclusions

In this paper we presented unique collection of most common process modelling mistakes or anti-patterns which occurred most often within the process models designed by a large group of information system students.
If the process models with identified anti-patterns would be performed in the organizations, several implications could occur. These practical implications include unwanted delays in the process performance, non-execution of the activities or simply ambiguity which could hinder the process performers at their work. Therefore, process modellers should have knowledge about anti-patterns, which would prevent their appearance in the process models.
Results of our research leaded to the following activities. Firstly, the learning materials for students are being improved, where examples of mistakes in process models are emphasized. A one page (A2) poster, containing BPMN symbols and anti-patterns has already been designed[1], as a kind of student's 'cheat sheet', to prevent the process modelling mistakes in the first place. Second, the results of our research can also indicate how inexperienced process analysts perceive BPMN notation and process modelling principles. This could lead to further improvements of the BPMN and other business process modelling notations.
Another insight that we gained is that the anti-patterns should be implemented in the process modelling tool as 'on-the fly' verification and validation mechanism of process models. Verification of syntax-checking mechanisms is not difficult and it is implemented in many existing modelling tools. Bigger problem, which remains still an open issue in the research domain is, how to check the semantics and understandability of process models.

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Establishment of a Performance Driven Improvement Program

Gunther Spork, Uwe Pichler

Abstract

This paper summarises the results of an improvement program at Magna Powertrain. Magna Powertrain belongs to one of the largest automotive suppliers in the world. Magna Powertrain develops mechatronic (mechanical and software) systems primarily for the all wheel drive sector.

The improvement program related to the improvement of the systems and software engineering processes is based on ISO 15504 / Automotive SPICE and the safety related standard IEC 61508.

Systems have been improved and implemented to control the processes based on so called performance trends.

Keywords

Process improvement, assessment, ISO 15504, performance trends

1 Introduction

Magna Powertrain has a long tradition and is one of the world's leading firms in delivering systems for the powertrain. In the last years the systems became more complex and developed from mechanical to mechatronical units including software based intelligence. At the beginning of this shift the mechatronics and software scope was purchased, especially the software engineering. Due to the increasing importance it was decided to establish an internal software development department. At the same time a key customer made an initial assessment according ISO TR 15504 "SPICE" referring to the HIS scope. The software related processes were assessed at the software supplier.

This first assessment resulted in the kick off of an improvement project. The aim of this project was to establish processes and to create a working environment to be able to fulfill the requirements of SPICE.

The improvement project has been based on a new product which included safety critical features. Thus the organization had to additionally fulfill the IEC 61508 "Functional Safety of electrical/electronic/programmable electronic safety-related systems" standard. It was decided to integrate the requirements of IEC 61508 into the processes to be established for ISO 15504, which led to an extension of the existing improvement project.

This paper describes the major steps of the improvement project with the main focus on the engineering process group. It describes the process definition, why and how specific supporting tools have been implemented, and how measurements are used to create a performance driven quality organization.

2 Improvement Program

The improvement program (Figure 1) establishment started in 2005. A first analysis showed that for the implementation of ISO 15504 a professional requirements management strategy is needed. This resulted in a set of requirements for tools and methodologies to be used, and the selection and pilot implementation of requirements tools. Finally a specific tool has been selected.

In parallel to the tool selection a requirements and development workflow has been agreed with the development, see Figure 3.

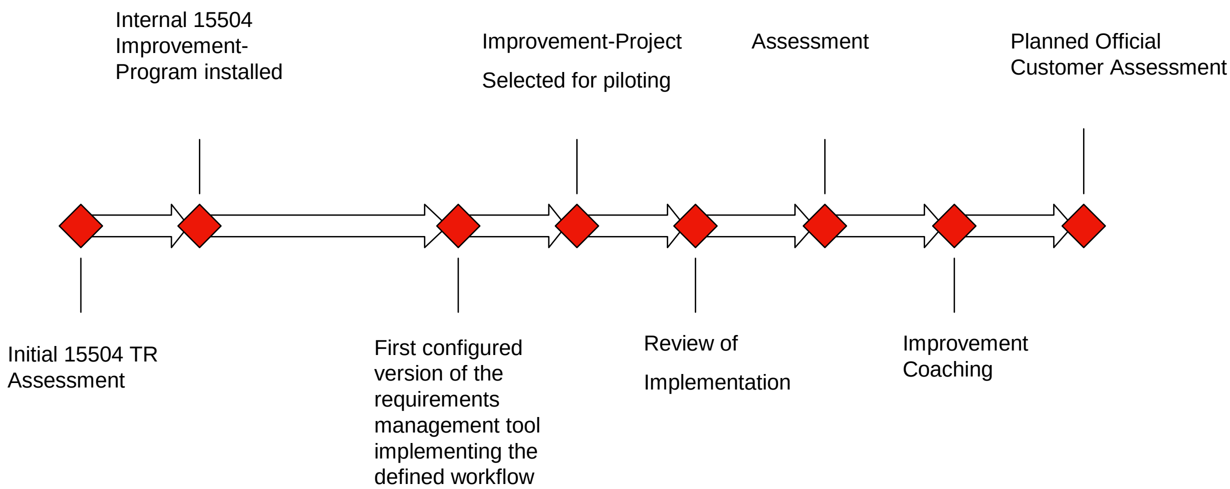

Figure 1: The improvement program at Magna Powertrain

Then a pilot project has been selected to implement the requirements management workflow and to install necessary plans required by ISO 15504.

Project Management Plan

This plan describes the project objectives, the general set of work packages, the team structure, the processes used for cost estimation, project tracking, and status reporting.

Test Plan

This plan contains a description of the test strategy, concepts about how to achieve a requirements and acceptance criteria coverage, test phases, test methods and descriptions of test tooling environ-ments. See the integration phases in Figure 5.

Configuration Management Plan

This plan contains a description of the configuration management strategy, a list of all configuration items, a description of the software integration processes, a description of the configuration manage-ment systems for documents and software, a definition of the project release, etc.

Quality Plan

This plan describes measurable objectives per process. It contains a definition for each of the processes in form of a detailed workflow with role and task descriptions, a set of quality status reporting requirements and a detailed review checklist for reviews of results of the different development processes.

Quality Attribute	Quality Goal	Measurement
Completeness of the system requirements analysis ENG.2 – Automotive SPICE	> 86% of all functional customer requirements are mapped onto system requirements which contain defined acceptance criteria (= Test issues) > 86% of all system requirements are mapped onto sub-system requirements which contain defined acceptance criteria (= Test issues) Additional for safety relevant requirements: 100% of all system requirements which are classified as safety critical must contain acceptance criteria (= test issues). 100% of all sub-system requirements which are classified as safety critical must contain acceptance criteria (= test issues).	All coverage reports are automatically generated through the standard queries which have been implemented on top of the Requirements Management tool set.

Figure 2: Extract from the quality plan at Magna Powertrain

During the pilot project specific quality control metrics have been used which illustrate the trend of the project performance.

- Requirements coverage trend per requirement level
- Test coverage trend per requirements level and hardware sample or prototype
- Test matrix reports illustrating the test completeness

A standard quality report format based on the 10 most important metrics has been agreed for the pilot project.

In the middle of the improvement pilot implementation an external assessment took place to assess the achievements and illustrate further potential improvements. This formed the basis to plan a coaching phase which has currently started to create a critical mass of impact and to later roll out the experiences to other projects.

3 Requirements Management Concept

Customer requirements are evaluated concerning their feasibility. If they are feasible a system specification will consider the customer requirements, and system requirements are derived from the customer requirement. Each system requirement is described with acceptance criteria and a set of so called test issues. Test issues are mapped against test phases in the test plan and specific test specifications. This way a test coverage can be demonstrated.

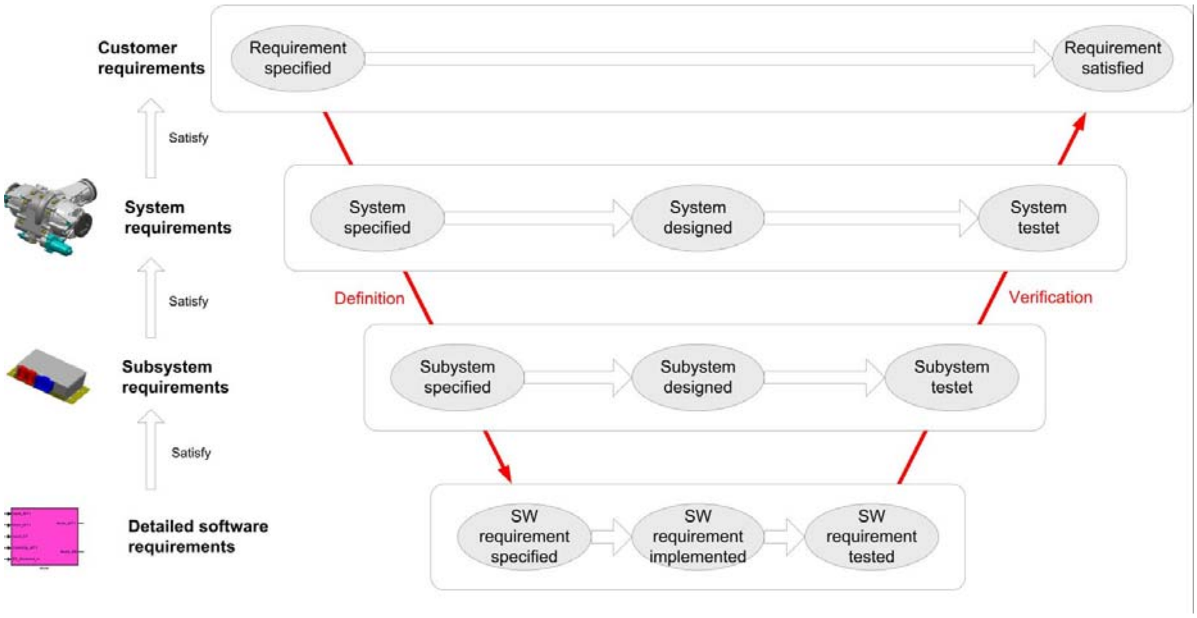

Figure 3: The requirements workflow at Magna Powertrain

Customer requirement

A customer requirement represents a functional or non-functional customer wish which needs to be analysed by the system team. Inside Magna Powertrain there are specific roles such as the *Mechatronics Coordinator* responsible for leading such an analysis.

System requirement

The system requirement is planned for a specific release/sample/prototype and is described in a specification document (technical solution) and inside the requirements management tool with a description, title, priority, acceptance criteria, etc. and a related test is defined (= test issues for the system test).

Sub-system requirements

Once the system requirement has been planned for a specific release/sample/prototype the system analysis by the system team (led by the *Mechatronics Coordinator* and the *Technical Project Manager*) decomposes this system function into tasks for each of the sub-systems. This leads to a set of sub-system specification documents and a set of sub-system requirements which are described inside the requirements management tool with a description, title, priority, acceptance criteria, etc. and a related test is defined (= test issues for the sub-system test).

Please note (see Figure 3) that the operating software and the application software represent different sub-systems (SW sub-systems developed by separate teams). This way inside Magna Powertrain the ECU, the operating software and the application software have unique version numbers.

Detailed software requirements

The sub-system requirements for the application software and the software sub-system specification are used to implement software modules inside a design tool which generates the code. The implementation of software functions is assigned to software developers who produce a module design and a set of module specific detailed software requirements. These are described inside the requirements management tool with a description, title, priority, acceptance criteria, etc. and a related test is defined (= test issues for the module test).

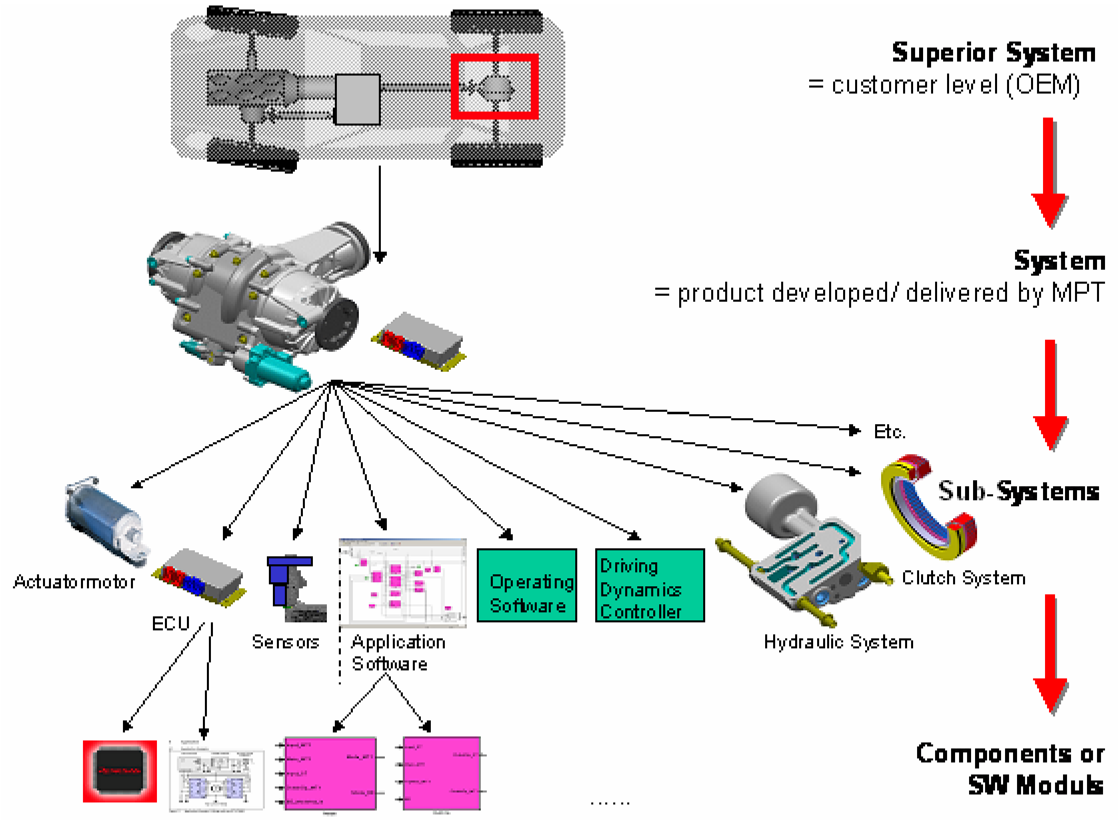

Figure 4: Requirement levels and types at Magna Powertrain

In a system development there are approx. 150 – 200 system requirements, approx. 800 – 1000 sub-system requirements and additional detailed software requirements. Each of the requirements has associated acceptance criteria and test issues. And for each test issue there are a number of test cases. This finally leads to a huge number of test cases and test reports and without a systematic approach it would be very hard to evaluate the requirements coverage in the test.

To do this requirements coverage analysis by hand and Excel would be extremely time consuming and so the idea at Magna Powertrain was to automate this coverage analysis as much as possible.

Also, comparing this approach with other industrial approaches, all has been implemented in one tool with a central database so that queries can be done across all requirement levels from the customer requirements down to the detailed software requirements. This allowed the implementation of a set of standard queries that illustrate the performance data at different development departments and management levels in the same way.

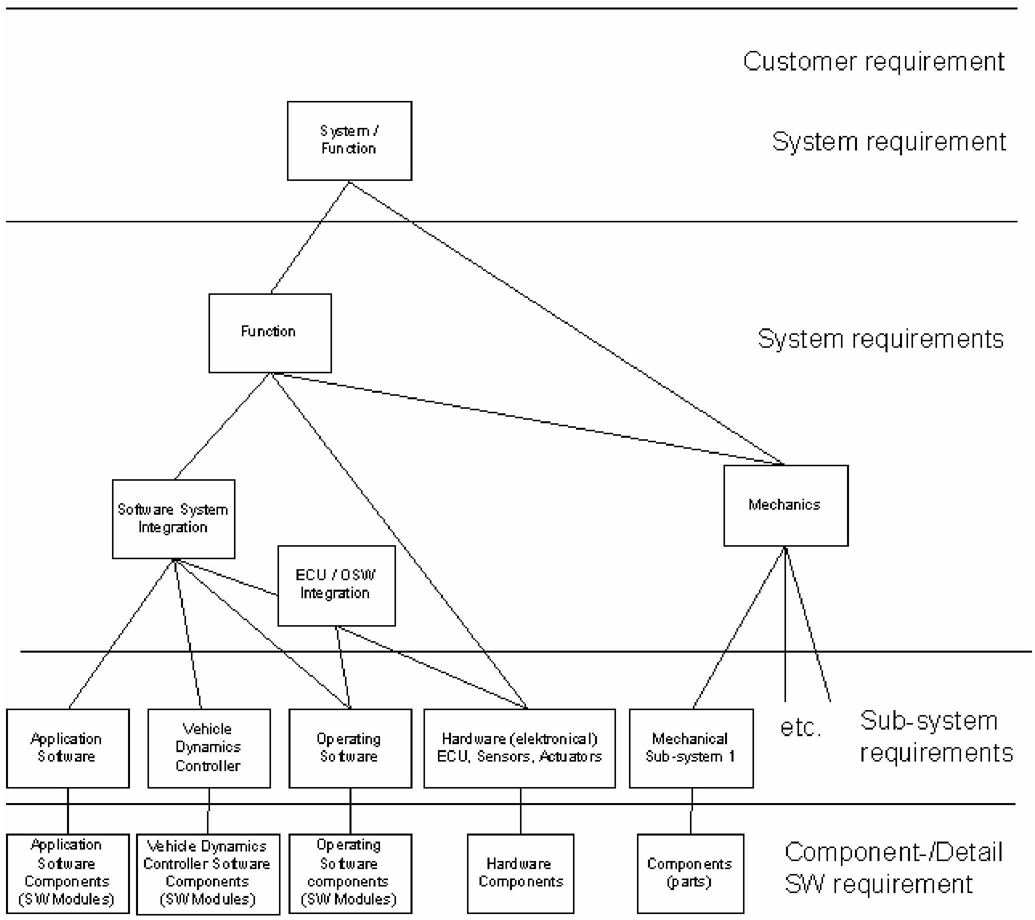

Figure 5: Integration and Test Levels at Magna Powertrain

Based on the requirements system according to the test plan test reports, so called DVP&Rs, are generated (see Figure 6). These DVP&Rs are structured into

- Test levels: examples are system test, sub-system test (SW is one of the sub-systems), module/component test
- Test groups: examples are mechanical test, software integration test, software functional test, etc.
- Test class : This includes a further refinement of the test group , e.g. software integration for the diagnosis functions.
- Test methods: examples are Matlab simulation with state flows, test bench test, HIL (Hardware in the Loop) test, etc.

The DVP&Rs contain a line for each requirement including the following information

- An assignment to the above mentioned test levels, groups and methods
- The acceptance criteria
- The SIL Level – Safety Integrity Level
- The linked test issue in the requirement management system.
- The status of the requirements and related test issues.

As long as the requirements management tool is completely filled the reports will demonstrate the actual status. The original idea was that each developer enters the requirements by himself and the *Technical Project Manager* and *Mechatronics Coordinator* would control that via the system. The experience in the pilot project showed that a consistent requirements handling calls for a *Requirement Manager* role at least at the system requirement level to achieve a consistent description and linking.

Test Item Classification					System/Subsystem Requirements					
Level	Group	Class	Method	ID	ID	Summary	Acceptance Criteria	Milestone SIL	Type	State
Subsystem Integration	Software Integration	Diagnosis tests	HIL / White Box	6337	6249	Sicherheitsdiagnosen (Ebene L2)	Alle Diagnosen und Fehler in der "Diagnosen QHCU Steuergerät" - Liste sind bezüglich ihrer Auslösebedingung und Fehlerreaktion zu testen. Auf System-Ebene ist der gesamte Diagnosefluss (Eintrag im DMS, Schutzfunktionen und Ersatzprogramme, die vom Fehlermanager aus beim KR, FDR, oder der generellen Zustandsmaschine gestartet werden) zu testen.	PT1/B/B3 SIL 2		
					7717	Der Druck im Zylinder wird sicher gemessen	Review auf Erfüllung der SSR	PT2/B4/B4 SIL 2		
					6335	Offsetabgleich failed (Diagnose des Abgleichbereiches)	Der Komponentenregler wird sicher abgeschaltet (siehe "Diagnosen QHCU Steuergerät" - Liste (EasyDMS-Nr: 100000011976))	PT1/B/B3 SIL 2		

Figure 6: Test matrix report at Magna Powertrain

4 Workflow of Requirement Management System

To be able to track the progress in the project a specific workflow for requirements and test issues has been established.

The status definitions used in the workflow are:

Status	Explanation	Responsible
New	Minimum information like title, project, requirement type is filled in.	Requirements manager

Status	Explanation	Responsible
Specified	The requirement has been specified with acceptance criteria and measurable test issues.	Requirements manager with tester
Specified Reviewed	Review if requirements are completed and can be tested.	Review team
Designed	The requirement can be traced between the design documents and the requirements tree (link is traceable).	Requirements manager and systems and software designer
Designed Reviewed	Complete design to fulfil all technical needs of the superior requirement.	Review team

The status of test issues linked to requirements is traced by the following status definitions:

Status	Explanation	Responsible
New	Minimum information like title, project is filled in and the associated requirement has defined acceptance criteria.	Requirements manager
Specified	A detailed test specification is available in a configuration management system and linked to the test issue.	Tester
Test Case Reviewed	The test specification has been reviewed.	Quality manager, tester, requirements manager
Completed	The test has been successfully completed.	Tester
Completed with Restrictions	The test has been successfully completed with minor deviations.	Tester
Failed	The test has failed.	Tester
Retest Completed	The re-test has been successfully completed.	Tester
Retest Completed with Restrictions	The re-test has been successfully completed with minor deviations.	Tester
Retest Failed	The re-test has failed.	Tester

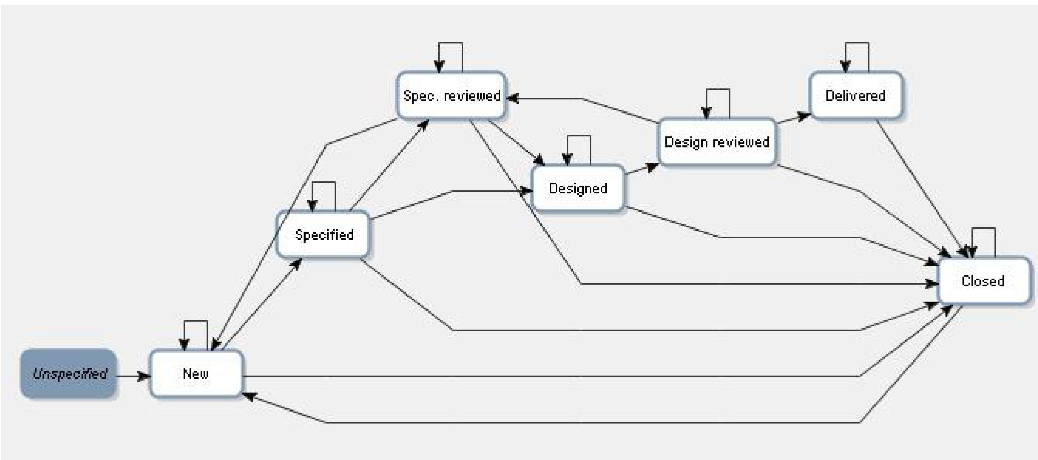

Figure 7: Workflow of requirements

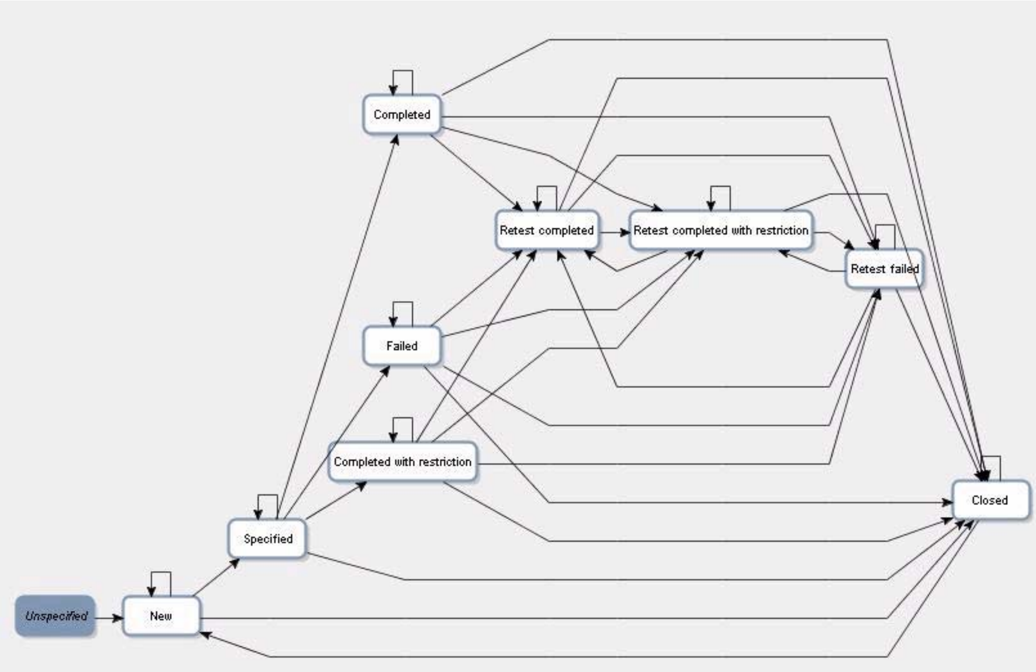

Figure 8: Workflow of test issues

The workflows in Figure 7 and Figure 8 are managed in three basic steps.

1. The requirement is tracked from status new to the status design reviewed (left part in the V-model).
2. The linked test issues are tracked from the status new to the status completed (right part in the V-model)
3. Once all test issues are completed and the requirement has been delivered in a release, the requirement achieves the status delivered.

By purpose the number of different status were kept at a minimum to keep the administrational effort as low as possible and to be able to avoid inconsistencies. Because requirements and test issues are stored in the same database the status integrated, for instance, can be derived through a query which analysis the status of the linked test issues which relate to integration tests.

4.1 Safety Critical Requirements

Based on the same processes and tools the workflow of the requirements management system was amended to ensure conformity with ISO IEC 61508. Safety critical requirements are classified, can be tracked and filtered, and safety critical requirements trigger safety reviews. If these reviews are mandatory and have to be done in a formal way depends on the fact if a requirement is safety critical or not, see also Figure 9.

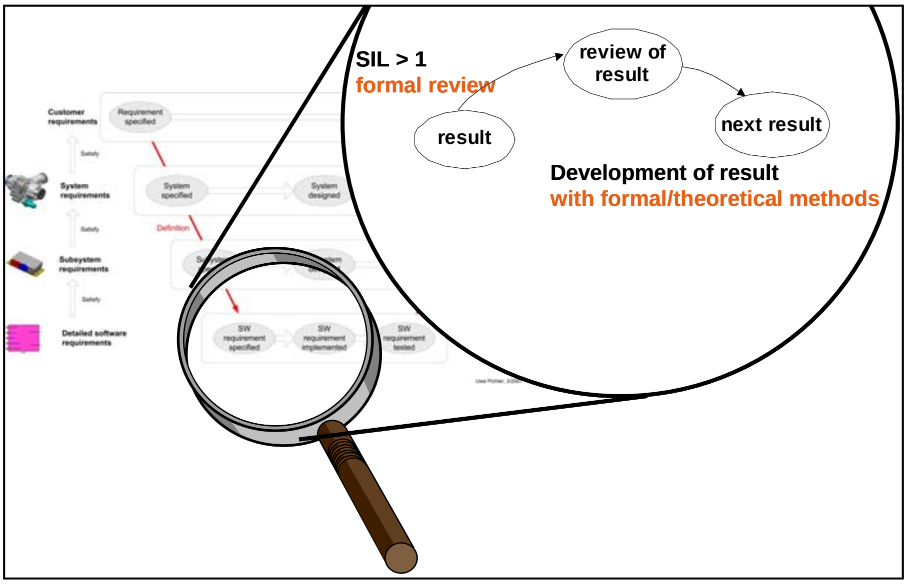

Figure 9: Additional review steps for safety critical requirements

You can see in the Figure 6 that reports for SIL classified requirements can be generated and tracked.

5 Quality Measurement Driven Development

As already explained all processes have specific, measurable quality goals. The minimum coverage of 86% has been derived from ISO 15504 where a rating fully is achieved only if a minimum coverage of 86% can be demonstrated.

In addition to this standardized goals there is the strict objective to have evidence, that 100% of all safety requirements are fully accomplished. Starting from the level of customer requirements, mapped over system requirements and sub-system requirements onto the detailed component requirements all requirements have to have defined acceptance criteria and linked test issues. The different levels are connected by links, which help to identify affected issues in case of any change.

The key measurement indicators are produced by the quality department each month. Most of the indicators are delivered by standard queries in the requirements management tool and compiled to trend charts in a quality report. Each quarter the quality report is additionally presented to the steering committee.

The quality department controls the project progress and target achievement. If necessary, the quality department initiates reviews or starts an escalation process.

The quality report is standardized regarding content and layout and includes the following ten key measurement indicators:

- System requirements coverage (automated out of requirements management system)
- Sub-system requirements coverage (automated out of requirements management system)
- Software requirements coverage (automated out of requirements management system)
- Problem trends (automated out of requirements management system)
- System test coverage (automated out of requirements management system)

- Sub-system test coverage (automated out of requirements management system)
- Software test coverage (automated out of requirements management system)
- Milestone charts (self developed monitor tool)
- Resource trends (self developed monitor tool)
- Open Issue Trends (automated out of requirements management system)

The large number of ten KMIs is due to the fact that the progress of the project regarding all affected departments has to be monitored.

Figure 10 shows an example of a trend chart of the quality report. In this chart the coverage of the safety critical sub-system requirements is displayed. The requirements are additionally dedicated to a specific release or classified as unspecified if the release is not yet defined.

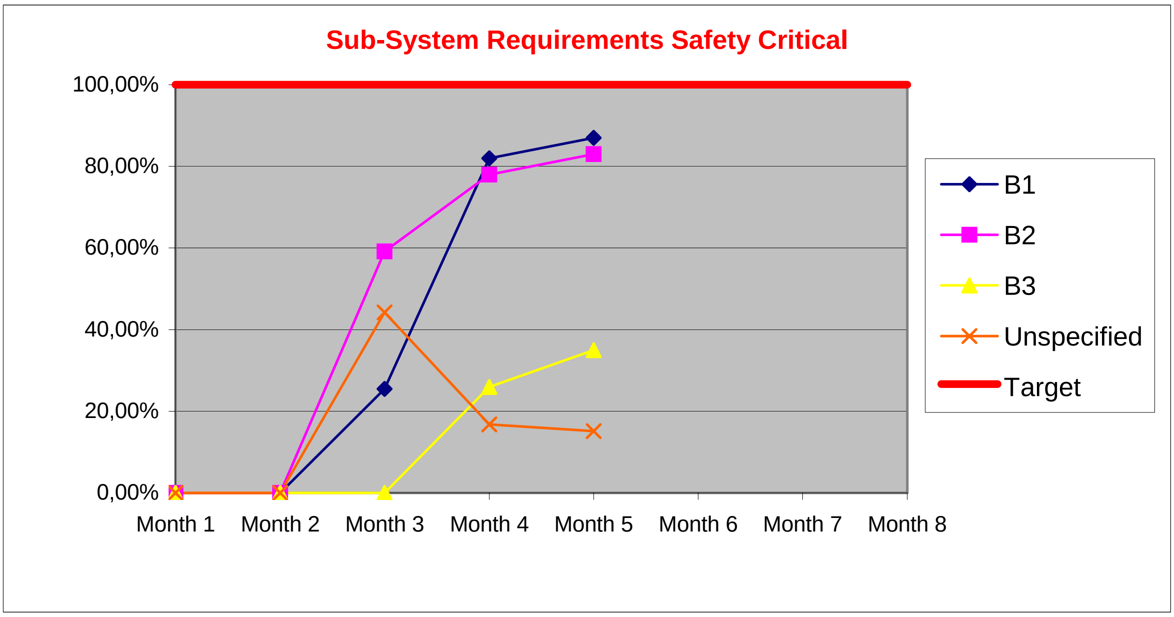

Figure 10: Trend chart sub-system requirements

6 *Lessons Learned*

Although the paper is referring mainly to processes and tools people are for sure at least as important as the described working environment. Of course there was a focus on the empowerment and motivation of the employees during the whole improvement project. The highlights listed in this chapter take also into account what should be considered regarding the human factors.

- A training of all involved staff at the start of such an initiative is of critical importance, otherwise you loose a lot of time in discussions.
- The requirements architecture with customer, system, sub-system and module requirements has been very effective to create a common understanding between the engineering departments. However, such a requirements tree structure needs a requirements manager coordinating the different inputs and ensuring the consistency between the requirements.
- Originally it was tried to put all documentation into the tool and link the parts of the documentation. However, this resulted in an inflexible approach where any line change in a document led to requirements changes. Thus we decided to create a requirements tree with more generic requirements with references to design documents and linked test issues creating a test

scope. This resulted in a situation where a small change in a document did not lead to a change in the requirements any more. Please note that there are limits in how to describe generic requirements (they should not become too general as well) so that we used minimum input fields and demanded acceptance criteria and test issues for each requirement. This leads to kind of test driven specification.

- A strategy has been elaborated about how to classify safety critical requirements. The requirements tree helped to identify contradictions and inconsistencies and to create a reviewed and consolidated safety concept.
- At the beginning the usability of the requirements system was a big topic. However, one has to be aware that the process and the understanding is more important than the tool. Once we reached a critical mass of understanding and of requirements in the system, the people accepted the tool even if some GUI issues remained solved not totally satisfying.
  - It is important to demand a participative approach where users are just coached and need to work in the system themselves.
  - Once certain contents (e.g. signal lists, interface functions reports, …) can be automated, the support for requirements management increases dramatically.
- Another important experience was that it makes no sense to have a safety concept separate from the functional design. The requirements tree helped that the safety manager and the systems designer agreed on one consistent approach covering both, safety and functional aspects.
- To consider human motivation aspects we created an internal award where the employees receive scores every week and the people with the three highest scores will receive presents. We also created a small award for all who manage to achieve a minimum score of support. This playful - but still a little competitive - aproach pushed the collaboration in the team.

7 Magna Powertrain committed to performance trends

The actual activities to fulfill the requirements of ISO 15504 and automotive SPICE have already led to organizational changes within Magna Powertrain. The usage of many improvements is independent whether a project has to be developed according SPICE or not. Several improvements can also be used for projects which even do not include software or mechatronics.

Therefore a lot of the new developed tools and techniques will support all future projects within Magna Powertrain. Furthermore, in preparation to automotive SPICE Magna Powertrain is aiming to expand the SPICE processes to parts of the development to which the actual ISO 15504 does not refer.

More and more people get involved with the results of the improvement project. They get used to the new way of development and contribute to a further optimization of processes and the usability of tools by bringing in new ideas.

The possibility of reuse of certain parts of software, software modules or mechatronical components also depends on development processes and tools which are capable to deliver work products in the expected quality. Thus it is essential to roll out the improvement to the whole organization. Together with the already provided new tools and techniques Magna Powertrain will continue to make a better product for a better price.

8 Abbreviations

HIS	Hersteller Initiative Software, group of German automotive OEMs

DVP&R	Design Verification Plan & Report
SIL	Safety Integrity Level according IEC 61508
KMI	Key Measurement Indicator

9 Literature

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10 Author CVs

Gunther Spork

Gunther Spork has a Master of Science degree in mechanical engineering from the Technical University at Graz.

He started as manufacturing engineer at VA TECH Hydro for the generator division. In 1998 he joint a Six Sigma Team which was responsible for deploying a Six Sigma pilot structure. As certified Master Black Belt he was also responsible for the Six Sigma training program and trained colleages from 3 continents.

In 2001 he started to work for Magna Powertrain in Lannach and was responsible for the Management System according ISO TS 16949 and Six Sigma. Later he took over the responsiblility for engineering processes and development methods. In this function he, as a certified ISO 15504 assessor, is also responsible for the implementation of SPICE.

Uwe Pichler

Uwe Pichler has a Master of Science degree in Mechatronics and received a doctor’s degree in the field of smart structures incorporating piezoelectric sensors and actuators from the Johannes Kepler University in Linz. During and after his studies he worked as an engineer in the field of FE calculations and simulation of closed-loop controlled systems for companies like Voest Alpine AG and VA TECH Industrieanlagenbau.

In 2005 he started to work for Magna Powertrain in Lannach as an system architecture engineer. He was a core member of the ISO 15504 (SPICE) implementation project in which he was responsible for system requirements analysis and the implementation of the integrated requirements management tool presented in this contribution.

Since March 2007 Uwe Pichler is now responsible for the business development of Magna Powertrain’s mechatronic business unit in Asia.

Experiences and Results from Tailoring and Deploying a Large Process Standard in a Company

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Abstract

With increasing process maturity of the software-developing companies, an increasing interest in standardized processes can be observed. Company-specific standards are often derived from reference standards such as ISO/IEC 12207 or the German V-Modell XT. Developing and deploying a (new) company-wide standard is a challenging task with many obstacles. Many efforts in defining and deploying standard processes in a company do not result in sufficient adherence between the defined and the lived (i.e., the enacted) process. Such situations have severe consequences, e.g., it is not possible to measure processes. Published experience with process definition and deployment projects is often anecdotal or incomplete. This paper describes the adaptation of a generic process standard to an organization and its deployment to daily practice. In this article, the approach taken for adapting and deploying the V-Modell XT in the data processing department of the German Josef Witt GmbH is described. Additionally, effort data and lessons learned with respect to these activities are given. Finally, effects visible so far are sketched.

Keywords

Process definition, process standard, process adaptation, process deployment, experience, lessons learned, success factors.

1 Process Standards in Industry

In recent years, the trend of introducing and optimizing defined process models for developing software-intensive systems in companies and other organizations has gained momentum. This is motivated by a plethora of different reasons working alone or in combination. These reasons include, in particular, (1) the increasing maturity of companies, which – for a certain level – demand defined processes, (2) the need for defined and possibly certified processes to acquire external orders and to prove the quality of development processes, (3) the increasing complexity of real-world development processes, especially in terms of interdisciplinary development with other disciplines such as mechanical engineering, (4) the increasing (global) distribution of development processes, which demand a coordinated approach, especially at the interfaces.

Potential advantages of defined processes in organizations include – among others – high development productivity, the ability to (better) plan development projects, usage of experience from past projects, and support regarding the coordination and cooperation of developers. Apart from this, explicit and instated process models are a necessary prerequisite for continuous, metric-based process improvement, because only such process models allow for instrumenting processes with process metrics.

Since development processes are mostly human-based and, in the software area, depend strongly on the development context, there are no ideal or commonly applicable development processes. Selecting suitable processes normally depends on the respective development context and project goals. For example, the criticality of the software to be developed and its maintenance period have a distinct impact on the development documentation necessary. According to this, it is important to carefully distinguish the different process models, e.g., in terms of agility or discipline. Likewise, when introducing such a process model, it needs to be adapted to the development context. Furthermore, it is necessary that defined processes are followed and improved continuously. In practice, this means that existing and often implicit processes need to be changed gradually towards defined target processes, which poses great difficulties, because with this task comes the necessity to change human behavioral patterns. Simply prescribing pre-defined process standards has not been successful in practice.

There are different ways to establish a defined and followed development process within an organization. For one, this depends on the goals of the organization with regard to process management. Another important point is organization maturity. Three substantial goals concerning process management measures are *improvement, certification,* and *process harmonization.* If *improvement* is the goal, then the interest in process models is usually triggered by acute problems with the daily business, e.g., many defects surfacing after delivery or many late requirements changes. If *certification* following a standard is the goal, several reasons may be identified as triggers. For example, certain certifications are often necessary prerequisites to acquiring an order, for example, a SPICE certification within the automobile industry, or its equivalent for the V-Modell XT in the German public administration. Certifications may also be actively used as a recommendation for certain tasks, because a certification identifies (or rules out) potential weaknesses compared to a reference model. Finally, *process harmonization* often seeks to integrate different organizational units and to facilitate their cooperation. This may be the case after acquisitions or following quick growth. A uniform understanding of the process and a uniform vocabulary enable these units to work together effectively.

Organization maturity considerably influences the approach of introducing and evolving a process: for example, if a new development branch is set up within an organization, or if organization maturity is so low that even implicitly followed processes do not exist, it may be wise to use a domain-specific process template as a starting point, adapt these processes, and then use the adapted variant of the standard within the organization. Such process templates may be ISO/IEC 12207 or the V-Modell XT. In case the templates do not fit the organization's domain, one may still use the process architecture (i.e., the meta-model) without the concrete processes, in order to achieve a common notation to describe process entities and their interaction. More mature organizations with defined and established processes usually cannot be improved by simply modifying their processes towards a prescribed, external process model. This approach only makes sense in some exceptional cases, e.g., concerning standards for process interfaces. For example, changing from one development technique to another may pose substantial risks. If a mature organization is forced by external powers to comply to some standard, there normally exists the possibility to provide a mapping between the organization-specific processes and the ones of the standard, thus demonstrating a sufficient equivalence between both and thereby proving process conformity.

Depending on the goals of process management and organization maturity, different measures are necessary to introduce defined and followed processes into an organization. Particularly if process standards external to the organization are to be introduced, such measures have been found to be extremely important. An unadept approach will almost certainly lead to negative provisions with developers concerning usage of the processes, and have a lasting negative effect on the success of the measure.

This article describes a two-phased approach to adapt the German V-Modell XT [Koo06], a process standard supported and demanded by the Germany government, and introduce it into industry practice. The experience gained shows that it is by far not sufficient to systematically develop a company-tailored variant of the standard, but that equal efforts need to be invested into getting the organization to use the tailored standard.

The paper is structured as follows. Section 2 gives some related work. Section 3 explains the adaptation of the process standard and its subsequent deployment at Witt. Section 4 describes lessons learned during the project, and Section 5 discusses the experience and gives an outlook on the process future at Witt.

2 Related Work

In a five-year study conducted at Ericsson AB (Sweden), 18 process improvement projects were accompanied [BM04]. The main influence factors on project success identified were *process push,* which originates from the process deployment group, and *practice pull*, which comes from the people who execute the process. [KK00] presents a framework for process deployment used by Nokia. lists as one important success factor a helpdesk facility for employees who have difficulties with the new process. [O'H00] stresses the importance of early and active involvement of the affected employees, as well as their continuous mentoring during and after process deployment. The meaning of strong management commitment and a high level of transparency and employee involvement when designing and deploying new processes is reported in [HA05]. presents five major influence factors with high relevance as a result of a comprehensive literature study concerning influence factors on organizational change during software process improvement programs.

[Bec04] describes a method for the systematic elicitation and documentation pf process knowledge in descriptive process modeling. A common overview of software process modeling is given in [CKO92]. Finally, new processes are often based of or replace already existing ones. An approach to automatically compare old and new processes in order to identify changes is described in .

3 Selecting, Adapting, and Deploying a New Process Standard

3.1 Goals and Context

Josef Witt GmbH is a medium-sized (2.200 employees) mail order business in the clothing domain within the Otto group (123 companies, 55.000 employees). IT services are an integral part of the group – outsourcing IT to external service providers would only be possible to a limited extent because of the necessary flexibility and detail of knowledge of the business processes. Therefore, most of the development work is done internally. The Datenverarbeitung (data processing) department consequentially performs about 60 projects every year with 80 employees. These projects are in the range of 20 to 2000 person days. Besides projects, a multitude of so-called “Tasks” are realized. Every year, about 200 of such mini-projects are executed, covering all kinds of maintenance work. Tasks have two distinct features: low estimated effort (up to 10 person days) and low complexity.

For several years, the V-Modell 97 (the predecessor of the V-Modell XT) has been used for all projects. During this time, this has proven to be the source of a number of problems. Since the V-Modell 97 had been created mainly for development work for public clients, it was suitable only partially for typical Witt projects. For example, many project types common for Witt (e.g., infrastructure projects of the systems department) were not covered at all by the V-Modell 97. At the same time, the tailoring abilities of the V-Modell 97 are not exactly great, either, so that a lot of effort is required either for adapting the V-Modell 97 or during project execution with a suboptimal approach. Because of these problems, the search for a new process standard was started in 2004.

The goal was not certification according to a specific standard, but to find a stable basis, onto which a Witt-specific process standard could be developed. While the V-Modell 97 lacked the required features, its successor, the V-Modell XT, provided them, in particular through its good support for tailoring the process. The V-Modell XT is a process model for planning and realizing (software) development projects. It is designed as guidance for planning and executing development projects, considering the entire system life cycle. It defines the results to be achieved in a project and describes approaches for developing these results. In addition, the V-Modell specifies the responsibilities of the participants. Thus, the V-Modell describes in detail "who" has to do "what" and "when" within a project [Koo06].

At the same time the decision in favor of the V-Modell XT was taken, Witt joined the BMBF-funded research project V-Bench [Fra06], which concentrates on the adaptation of the V-Modell XT and its application in industrial contexts. This way, Witt profited from the direct interaction with the V-Modell XT project team, e.g., for model adaptations and coaching purposes. For the V-Modell XT project team, on the other hand, Witt provided valuable data concerning the usability and quality of the V-Modell XT. Further goals of the new Witt-specific process standard, besides the optimal support of Witt projects, were the adaptation of the existing tool landscape for project management, configuration management, and software modeling to the current project situation. In addition to that, all tools should work in a V-Modell XT-aware manner, i.e., support the creation of the necessary documentation. One major goal throughout the entire project was to ensure user acceptance of the V-Modell XT in order to really use the new process standard, and not to produce a big book that nobody ever reads.

The V-Modell XT is neither an assessment standard, nor a capability maturity model. Therefore, the goal of the Witt V-Modell XT project was not to become a certified Level-3 company. Its intention was purely to create and deploy a company-wide standard software process. Likewise, measurement issues besides effort and duration were mostly neglected and will be addressed in future stages.

The project was controlled through a series of Jours Fixes, where the complete project team would meet and discuss work done so far, identify problems, devise solutions, and fine-plan the increment until the next Jour Fixe. Another important topic was to process the problems and suggestions list. About 20 Jour Fixe dates were fixed at project start, taking into consideration the fact that the concept and process design phases required more coordination than the later phases.

3.2 Creating a Custom Process Standard

This chapter describes the steps taken on the path from the generic standard as provided by the V-Modell XT to the Witt-specific process standard (see Figure 1). The steps are explained in the following sections.

3.2.1 Analysis Phase

During analysis of the current working procedures, projects of the past five years were analyzed for repeating, similar parts

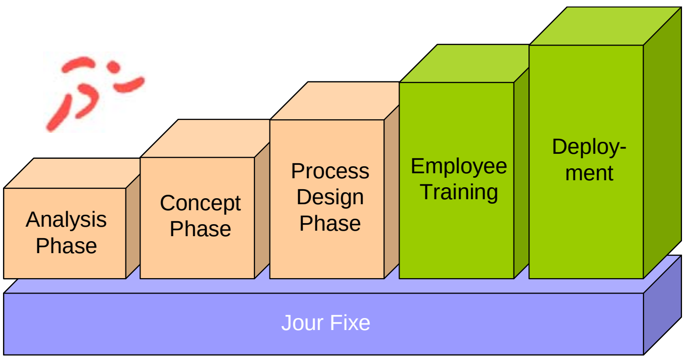

Figure 1: Project Structure

and for variations. The results of this analysis were used later in the definition of the Witt-specific project templates. Data collection was done by means of questionnaires that were filled in by Witt employees, by interviewing key personnel, and through discussions within the Witt V-Modell XT project group. In total, 15 questionnaires were filled in by 25 people. Interview partners were mostly project managers and software developers. One major output of the analysis were the strengths and weaknesses of the current development approach within Witt. This output was later used to incorporate improvements into the new process standard. For example, one weakness identified was project manager overload with too many and too unspecific tasks. Other weaknesses included too little quality assurance at some points and sometimes different considerations of projects of different departments.

In a second step, the generic V-Modell XT was analyzed for features that depicted the current approach at Witt. The features identified were marked for direct transfer to the Witt-specific model, while features with no direct match were evaluated as to whether they were necessary or could be left out. Finally, necessary changes to features were identified. The whole analysis phase took about five months.

3.2.2 Concept Phase

The goal of this phase was to model the new Witt processes and to create a mapping to V-Modell XT concepts and terminology. The starting point was the identification of the project types relevant for Witt. Besides client-server-development projects, these were projects concerned with mainframe development, system operation projects, and projects for the introduction of new technologies and methods. Except for the client-server-development projects, which were widely equivalent to V-Modell XT's software development projects, none of the project types relevant for Witt were foreseen within the V-Modell XT standard. Thus, creating them was necessary.

The project types were created according to the V-Modell XT rules. Quite a number of work products required by the V-Modell XT were already instated in some form or another at Witt. Therefore, wherever possible, the existing products were used and/or adapted, in order to facilitate the transition to the new processes for the developers. All conceptual work was done in the form of workshops. Participants in the workshops included – depending on the project type being discussed – the future users, management, the coaches from TU München [TU 07] and MID GmbH [MID07], and Witt's V-Modell XT project team. Only by incorporating all these stakeholders into the efforts could it be assured that all parties had a common understanding of the new processes and therefore would fully support them. This phase took about three to four months, during which time a two- to three-day workshop was held about every other week.

3.2.3 Process Design Phase

The initial process structure in the form of V-Modell XT process type descriptions created during the concept phase was filled with life during the process design phase. For example, descriptions for all concerned process elements (products, activities, roles, milestone plans, …) had to be adapted or newly created. This work was mainly carried out by the future users of the respective elements. For example, members of the system operations group were responsible for the elaboration of the activity "hardware exchange", while "software development" was elaborated by the software developers of the data processing department. The core activities (project management, quality assurance, configuration, control, and change management), on the other hand, were copied mostly unchanged and only partially adapted or expanded, to suit Witt's needs.

During process design, the future users of the process were explicitly included in the ongoing work. This was done to achieve better identification with the new processes and thus, better acceptance of the new process as a whole. Another step into this direction was the decision not to use V-Modell XT's project assistant's ability to generate document templates, but to create Witt-specific templates based on Word and Excel. The goal behind this was to create more user-friendly templates than the somewhat limited abilities of the project assistant would allow. For example, the standard V-Modell XT templates for product descriptions were amended with tables, macros and fields. Experience collected during process deployment later showed that these individually crafted templates had a major influence on V-Modell XT's acceptance.

Problems encountered. The only serious problem during process design was to maintain a uniform look and feel of the many descriptions, despite their many different editors. In order to achieve this, a style guide was developed in advance to mitigate this risk. The style guide described the structure and format of all texts developed and was applied consistently throughout the phase. Because of the many editors who had to be coordinated, the process design phase was the most effort-prone phase of process adaptation. It took about five to six months to complete.

3.3 Deploying the Customized Process Standard

3.3.1 Employee Training

Since the newly defined Witt process meant major changes in many daily activities of the data processing department, a detailed concept for training and deployment was devised. This included information events before actual deployment, “guided tours” through the new process for all employees, as well as role-specific training units for certain groups of employees. During these training units, nine different roles were educated in terms of methodology and (new) tools used. Special trainings addressed the tools INNOVATOR [MID07], Dimensions [Ser07], Augeo , and QA-Center [Com07], and were held for specific employees, in cases where the common or role-specific trainings did not contain the respective parts. In addition to the data processing department trainings, all affected departments within Witt that were taking on the customer role were informed about the new process and trained as well. A supplementary newsletter was established, keeping all Witt employees posted about new developments and “breaking news” in the Witt-V-Modell XT area.

The training measures required significant effort to be spent. In numbers, 56 person days were spent for the common information events and the guided tours. Role-specific trainings required about 140 person days, and the additional tool trainings consumed another 42 person days. In total, 238 person days were spent to train about 80 data processing department employees and the required personnel in the (customer) departments of Witt (about 20 additional people). The training phase took nine months to complete and was held in parallel to process design and process deployment.

3.3.2 Process Deployment

Deployment of the new process was achieved in a project-based manner. This means that new projects starting after an appointed date were carried out using the new process, while already running projects were not converted. This approach minimized friction losses during deployment and, at the same time, ensured consistent application of the new process. Especially during the first weeks and months of using the new process, many questions surfaced amongst the affected employees. This was anticipated, because it was clear that the trainings dispensed the formal knowledge required, but its application in the daily project business was not always easy. To cope with this, a helpdesk service was provided from the first day, which could be addressed in case of any questions and problems with the new process. The helpdesk service was provided by the V-Modell XT development team and thus had expert knowledge about the new process. At the same time, a problem and suggestion list was established, where any employee could add problems, inadequacies, and unclarities sensed within the V-Modell XT, and also make improvement suggestions. The list was processed at every Jour Fixe, so that every employee got timely feedback to his or her list entries.

Both offers – helpdesk service and problem and suggestion list – were accepted right away by the employees, and used intensively. The collected feedback suggests that because of these two measures, employees never had the feeling of being left alone in front of a pile of new concepts. At the same time, integrating employees into process customization through the problem and suggestion list provided valuable improvement feedback, which already led to significant enhancements of the originally devised process. Both helpdesk service and problem and suggestion list have been continuously supported in the stabilization phase (since April 2006), whereas helpdesk usage has been continuously declining with increasing employee routine.

4 Lessons Learned & Success Factors

4.1 Overcome Resistance

At the beginning of the project, many employees were skeptical concerning the new process. Often, changes were opposed with statements such as “the V-Modell XT does not fit our situation”, “everything is different here”, “why change anything, it is working all right”. This fear of the unknown, respectively of changes, was not unexpected, but partly surprising in its intensity. Eventually, these fears were removed through a combination of different measures with the goal of maxing out the transparency of the changes that were going to happen. For example, information concerning upcoming changes was dispensed to employees constantly, during the process customization phase as well as during deployment. At the same time, employees from all departments were integrated into the different project phases all the time, so that the new process also was a result of their efforts right from the beginning.

4.2 Ensure Support Services

Providing contact persons for questions and problems at any time turned out to be another important success factor. The trainings provided knowledge about the “tool” V-Modell XT and a “user manual” for its application all right, but actual usage in daily business turned up many stumbling blocks. In the end, most of these stumbling blocks were removed only through intensive mentoring of all affected employees. Mentoring was done through various means: A “V-Modell XT fibula” provided help in a number of everyday situations. In addition to that, a helpdesk service was established, which provided a V-Modell XT hotline for answering questions and providing further assistance in case of problems. This support ranged from pointing people to suitable templates to assistance in creating a (new) document for the first time.

4.3 Keep Proven Concepts

A third significant success factor was to not replace everything by default, but to always keep the benefit in focus. For example, it was necessary to unify role definitions across the entire Witt data processing department in order to reach the goal of implementing consistent project execution, leading to major changes in some areas. On the other hand, the document templates provided by the V-Modell XT, resp. its tools, were not transferred to Witt, because the templates already in use were more comfortable to use. Rather, the existing templates were cautiously adapted where necessary, without altering the look & feel known to everybody. This led to a high rate of recognition amongst employees and, as a consequence, better acceptance of the partially new templates.

4.4 Management Commitment

Last but not least, string and continuous management commitment was another decisive factor for the success of the V-Modell XT project at Witt. In the end, the project consumed more than marginal effort (see Figure 2). The support demonstrated by management made the importance of the project visible to the employees on the one hand, and on the other hand, relieved the project team of unnecessary financial fights, distracting it from its real duties of designing and deploying a new standard process. The key was trust: The management trusted the project team that it would do their job properly, and the project team trusted the management that it would get the needed resources.

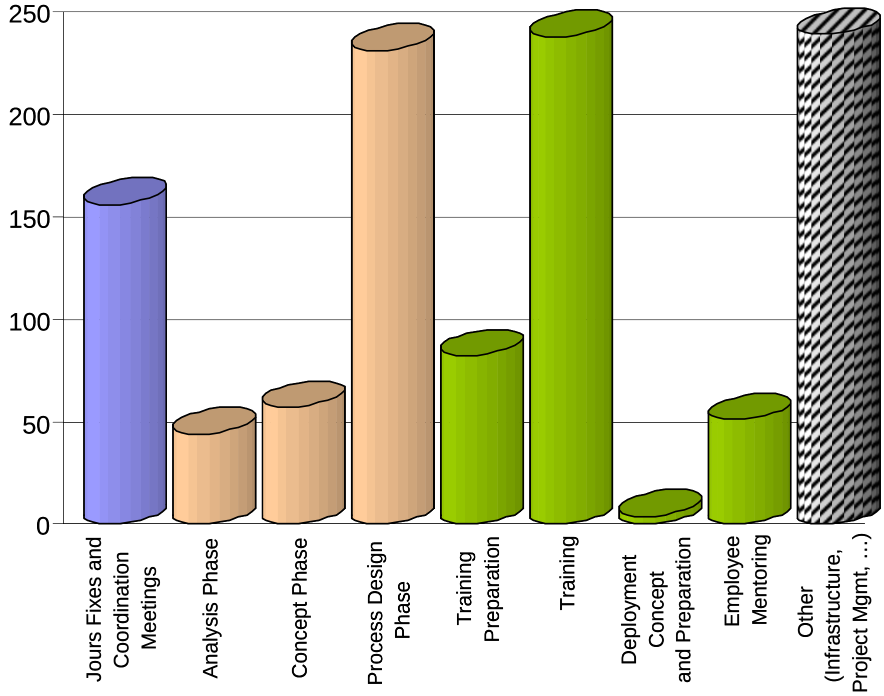

Figure 2: Effort spent

5 *Discussion and Outlook*

The main advantage Witt gained through its specific V-Modell XT instance is the unified, consistent process applied throughout all projects. Every project uses the same terms, document templates, role names and definitions, etc. – this started saving enormous maintenance and communication effort right after the deployment of the new process. In addition to that, all people involved profit from the clear (process) interface definitions that clearly describe all activities. The precise definition of the customer/supplier interface especially helps to make the Witt-internal relationship of the departments to data processing explicit and unambiguous. Since the V-Modell XT prescribes the documentation of all activities, this documentation has stopped to depend on the respective person carrying out the activity. This led to every project being documented similarly, simplifying cooperation amongst different groups and departments enormously, as well as facilitating the management of these projects.
Alltogether, the following reports gathered from literature could be confirmed during development and deployment of the Witt-specific process:

- At the beginning, many people have a skeptical to negative attitude.
- This problem may be remedied with lots of information, transparency, and especially contact persons in case of problems.
- Active involvement of employees in process changes yields valuable information for further improvement and, at the same time, helps to reduce resistance.
- A goal-oriented approach that only changes things if this is definitely beneficial for reaching the goals helps to reduce the number of changes and increases their acceptance.

- Management commitment throughout the whole process definition and deployment project is essential for the success of the project.

Currently, the project is in its stabilization phase. Therefore, not all benefits expected from using a standard process model have set in with full effect. Nevertheless, the following benefits have already surfaced:

- The binding character of the new process model helps in many project situations. This applies to the flow of activities as well as to the perception of the defined roles. This helps to reduce unnecessary and time-consuming coordination activities.
- Currently, projects are running as fast as before the process changes. Nevertheless, the improvement potential is clearly visible and is being systematically exploited.
- Identification of employees with their roles is already clearly visible.
- Project quality has clearly improved already. Project and product documentation are both much better than with the old processes.

Besides the benefits gained through the new process, it has become apparent that the ability to leverage these benefits strongly depends on the employees' acceptance of the new process. The heavy focus on the deployment aspect (as can be seen by the effort spent during the different phases in Figure 2) throughout the whole project has proven to be the right decision, and has led to a smooth transition to the new processes. Taking a close look at Figure 2, it becomes apparent that the effort for training and deployment (green columns) exceeds the effort spent on process analysis and design (orange columns). In fact, training and deployment consumed about 370 person days, whereas analysis and design required about 330 person days. These numbers average to about 3.7 days of training, deployment, and mentoring effort per person affected, including the effort for both "teachers" and "students". Considering total effort, about 5.5 person years were spent to develop and deploy the new process for 100 affected people.

After about one year of doing project work with the new process, almost all employees are convinced of the benefits of the new process and do not want to go back to the old processes. The Witt-internal project "V-Modell XT" has been completed in the meantime. A maintenance project for the process, which evolves and further optimizes the process, has been started and attached seamlessly. There still comes in a constant stream of improvement suggestions from employees, which are regularly evaluated and implemented. Just like the software systems developed and maintained by the data processing department at Witt, the process also lives. And like the software systems, the process also must be adapted to new challenges, in order to ensure the current level of performance and to improve it in the future.

Current activities, besides systematic adaptation and maintenance of the company process, focus on the definition, collection, and usage of measures in order to gain quantitative insights into the (new) process. We will report on this in a future paper.

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7 Author CVs

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Ove Armbrust received his Diploma in Computer Science from the University of Kaiserslautern, Germany in 2003 and has been working at Fraunhofer IESE's Process and Measurement department since then. He collected experience in process modeling and definition in projects with a variety of mid-sized and larger companies. His research interests include process modeling, process compliance, and process evolution.

Jan Ebell

Dipl. Ing.-Ökon. Jan Ebell is head of the department of Tools and Standards at the Witt Group. He has been working at Witt Weiden's data processing department since 1992. In this function, he is responsible for the central software architecture, for the choice and use of development methods and standards, and for administrating the enterprise database- and middleware-systems. Before heading the Tools and Standards department, he worked as a software developer for Unisys mainframes and client-server systems, and as a database administrator.

Ulrike Hammerschall

Ulrike Hammerschall received her Diploma in Computer Science from the Technical University in Munich in 1999. For three years, she worked as a senior software developer at sd&m and went back to university in 2003. Currently, she is earning her doctorate at the chair of Professor Broy (TU München). Her research interests include process models and methodologies, but she is also active in the field of middleware and application servers. In 2005, she published a book about distributed systems and middleware (Verteilte Systeme und Anwendungen, ISBN 978-3827370969) and held lectures on middleware at the University of Applied Sciences in Augsburg. During the last years, she has been member of the development team of the V-Modell XT and supported companies in the adaptation and implementation of the V-Modell XT. Currently, she is participating in the redesign of the V-Modell XT meta-model.

Jürgen Münch

Jürgen Münch is Division Manager for Quality Management at the Fraunhofer Institute for Experimental Software Engineering (IESE) in Kaiserslautern, Germany. Before that, Dr. Münch was Department Head for Processes and Measurement at IESE and an executive board member of the temporary research institute SFB 501 at the University of Kaiserslautern, Germany, which focused on software product lines. Dr. Münch received his PhD degree (Dr. rer. nat.) in Computer Science from the University of Kaiserslautern, at the chair of Prof. Dr. Dieter Rombach. His main industrial consulting and research activities are in the areas of process management, goal-oriented measurement, model-based project management, and quality assurance. Dr. Münch has significant project management experience and has headed various large research and industrial system engineering projects, including the definition of international quality and process standards. He has been teaching and training in both university and industry environments. Dr. Münch has co-authored more than 60 international publications and will serve as program co-chair for the PROFES 2007 conference and the ESEM 2008 conference.

Daniela Thoma

Daniela Thoma joined Witt in 1997 as a software developer. Before that, she worked as a trainer at a private school for office education. Since 2005, she has been project coordinator at Witt, responsible for inter-department project management.

Practical Experiences on Using SPICE for SPI in an Insurance Company

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Abstract

Software process assessment using models like SPICE or CMMI is a common way to improve the capability of the selected processes. Models not only support in pointing out the weaknesses of the processes but also give a roadmap to developing the processes further. Process assessments enjoy a contradictory reputation; some see them as time consuming consultation which doesn't give any concrete results for the sponsor of the assessment, while others see them as a well defined way to bring up improvement ideas both inside and outside the company.

In this paper we describe how process assessments were used in an outsourced IT department of a Finnish insurance company. We also take a look at how the attitudes and motivation of managers and software professionals changed over the 5 year period of the assessments, and present some results on how the assessments were used to improve processes and how the improvement was seen from business metrics point of view.

Keywords

Software Process Improvement (SPI), SPICE (ISO15504), Software Process Assessment

1 Introduction

Pohjola is a Finnish insurance company. In the time period of this presentation Pohjola's ICT was organized into a subsidiary company, Pohjolan Systeemipalvelu (later referred to as “the company“). The organizing enhanced budget responsibility and clarified customer and supplier relationships.

Ms Heidi Wegelius is a Senior Systems Analyst employed by the company. She has been actively involved in Spice assessments.

Mr Mika Johansson is an independent consultant. He has done external assessments for the company, in the beginning as an assessment team member and later as the lead assessor.

The aim of the research was to find out what kind of benefits process improvement has brought to the company and also to collect assessment related experiences from individuals. The authors chose customer satisfaction to substantiate the benefits. Some, but not too many, similar studies are available [1], [2].

The results presented in this paper are the joint findings of the authors.

2 Company Background

The company had about 200 employees maintaining and developing circa 100 software systems of varying sizes and ages. The oldest systems are perhaps 20-year-old mainframe systems. Client-server systems were developed during the last decade. Developing web systems and buying software packages are all the rage nowadays.

All software developing, including software maintenance, is done in projects. Development projects are divided into manageable subprojects with a time span of a year or less. In maintenance there are usually two or three releases per year. In maintenance project tasks tend to change during releases, but all changes are managed through change request management.

To check the quality of our performance the company made customer satisfaction studies of every project. It amounted from 80 to 100 studies per year. The company used SPICE to evaluate the capability levels of processes. Some five or six of development and version projects and three to five SPICE processes were selected every year for assessment by the top management.

SPICE evaluations have been a major factor in the development of processes. The company formed a quality team. This team made checklists for various processes and a process for gathering best practices and evaluating them yearly. The company has systematically developed systems processes. Every year one or two processes have been developed, and the changed processes have then been taken into the next SPICE evaluation. The latest major development was done to change request management.

3 FiSMA Gnosis SPI Method

Finnish Software Measurement Association, or FiSMA for short, is a non-profit organisation which is on national level responsible for software and systems engineering standardisation. One of these standards is ISO15504, in the development of which FiSMA key persons have been involved from the beginning. FiSMA also supports companies to deploy and utilise these standards by developing methods and tools and distributing knowledge among its members.

FiSMA Gnosis is an assessment method which is based on the idea that a single model usually cannot fully satisfy all the SPI needs a company might have. Currently it integrates ISO15504 and CMMI models, and during the spring 2006 it extends from software and systems engineering IT service management (ISO20000).

FiSMA Gnosis is a tool-supported process and it is available to FiSMA member organisations in different forms, depending on the organisations' needs. Originally it was delivered as Office document templates but there is also a family of continuously evolving tools.

FiSMA Gnosis assessment phases are based on [3] and [4]:

- Planning of the assessment.
- Briefing of the participants.
- Data collection. The first part of the data collection is to identify and classify relevant work products. Usually this collection is done by the organisation's quality manager, based on instructions given by the assessor team. Collected work products are documented in a list, and a preliminary mapping to processes and capability attributes is done. Strengths and weaknesses of the work products are documented. After document collection the rest of the data is collected in interviews.
- Data validation. Validation is done in a couple of phases. Documents found in interviews are validated. The next validation is done in rating sessions, where the assessment team goes through its findings. The final validation is done after the reporting sessions, when the interviewees can comment on the assessment result and present additional evidences.
- Process attribute rating.
- Reporting.
- Initiating SPI program. Since FiSMA Gnosis is more SPI oriented than capability level determination oriented, after reporting session and final results there are additional sessions for going through the actual findings. The weaknesses found in the assessment are analysed and prioritised for business goals. The idea is that by implementing only a number of relevant actions from the business point of view the organisation can maximise the results and minimise the resources needed. The results of this phase depend on how well the business goals are mapped to Spice or CMMI processes. This mapping is mainly based on the assessor's expertise, but a general level base mapping was made in X-Item project [5].
- Re-assessment. Re-assessment is done every one or two years to validate that improvement has actually taken in place.

ISO15504 defines achieved capability levels for processes. Since the level is a rough metric, FiSMA has developed a detailed index to show process improvement called capability index. The idea is simple: instead of a four point scale N, P, L or F a number between 0-100 is used. The average of practice (GP) ratings is calculated for each process attribute (PA), after which the average of process attributes is calculated for each level. Finally the indices of each level are summed. See examples in Tables 1 and 2.

PA / GP	NPLF rating	% rating
3.1	**L**	**73**
3.1.1	F	100
3.1.2	L	67
3.1.3	L	67
3.1.4	F	100
3.1.5	P	33
3.2	**L**	**61**
3.2.1	L	67
3.2.2	P	33
3.2.3	L	67
3.2.4	F	100
3.2.5	L	67

3.2.6	P	33

Table 1: An example of capability index. Process attributes 3.1 and 3.2 are rated, capability index for level 3 is (73+61)/2 = 67.

Process attribute	NPLF rating	% rating	Capability index
1	L	78	78
2.1	L	80	
2.2	F	92	
2			86
3.1	L	67	
3.2	P	40	
3			54
Achieved level / Capability index	1		2.18

Table 2: An example of capability index. SPICE rating gives 1 as the official achieved level, but capability index 2.18 shows "more capability".

4 Making Assessments in the Company

SPICE assessments were began with a trial run in 2002, and have been made yearly after that. All assessments have been made by external professional assessors using FiSMA's methods.

As in every new thing the beginning was obscure. The company's staff was very sceptical about the benefits of such assessments. In order to enhance the company's knowledge of SPICE assessment some of employees have studied SPICE. They formed a SPICE team to help with the assessments.

The team translated SPICE into Finnish integrating the company's own processes into SPICE processes, and introduced the translations to all employees.

The team prepares folders for assessment materials to ease gathering of the needed documents and prepares the chosen projects for the assessments by introducing SPICE processes to the participants and interviewing them before the final assessments. Should the need arise the team also asks for additional documents and participants. During SPICE assessments the team collaborates with the assessors by organizing the assessment meetings and helping in the analyzing phase. A major function is to act as translators from SPICE to Finnish. After the assessments the team gives detailed feedback to the participants.

When SPICE assessments were begun employees were very sceptical about Spice assessments. They considered the assessments insignificant. Neither did they think the assessments would be of any use in their own work or work processes. Participants thought the gathering of the documents was too time-consuming. But worst of all people didn't understand what the assessors were asking, i.e. question and answer didn't meet.

As knowledge of SPICE and the assessments has spread, attitudes have undergone a great change. The changes have come about probably for various reasons: people have taken part in more than one assessment, word has spread and the team has done their part.

Nowadays attitudes could still be described as sceptical in some sense, but people are surprised at how easily the assessments have been performed. It is acknowledged that the assessments have been and, in reality, are beneficial for work processes. There is still some feeling that the gathering of documents takes time, but participants are happy because assistance has eased the work.

5 *Benefits and Results of Assessments*

The assessment results in graphical form are presented in Figure 1. Not all of the processes have been assessed every year; the missing values are simply copied from the previous year.

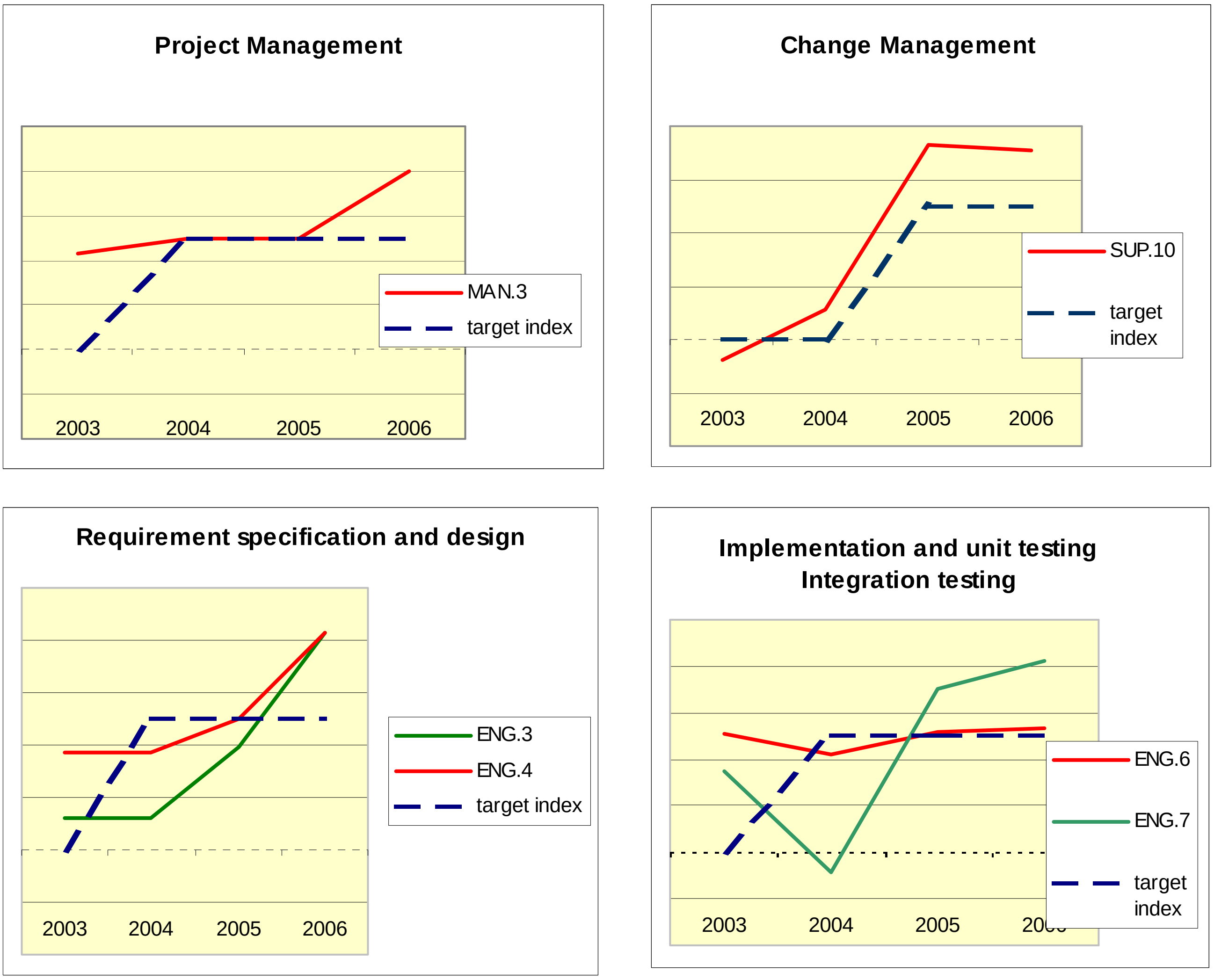

Figure 1: The development of capability indexes of the assessed processes. The dotted line indicates the baseline set in 2003. The scale of horizontal lines is 0.2.

The target was originally set at a realistic level and raised steadily after that.

5.1 Customer Satisfaction Studies

Customer satisfaction study is a major factor in assessing the quality of the company's performance. Studies were made of all projects amounting from 80 to 100 per year. The study consisted of seven categories: technical solution, functionality, cooperation, time schedule, leadership, delivery capability and change request management. The grades were given in Finnish school grades 4 - 10, 10 being the best. The medium grade was set to 8. If the performance was more than satisfactory the grade was advised to be more than 8, and less if the work was unsatisfactory.

The yearly average target was set to 8.75. The company always achieved the set target. Because of the grade's high level the average customer satisfaction response did not rise very much. That in itself is not very interesting, but what is interesting is that the variance has become dramatically smaller and also that the low grades have come up as the process capability indexes have increased.

The following table shows how the deviation has changed in the set time period. The grade is the overall result of single survey, calculated as the average of seven categories listed in previous chapter. The number of datapoints is between 80 and 100 each year.

Grade / Year	< 8,50	8,50 - 9,00	> 9,00
2003	28 %	34 %	34 %
2004	24 %	55 %	21 %
2005	18 %	53 %	29 %
2006	8 %	62 %	30 %

Table 3: Customer satisfaction survey results.

Our conclusion is that the company's own development of processes and the use of SPICE assessments are major factors decreasing the variation of customer satisfaction survey results.

6 Conclusions and Experiences

Assessment experiences from the company's point of view

- It is advisable to have a (virtual) SPICE support group within the company, supported by top management. Assessments can be made on a yearly basis, but the processes must be developed at the same rate and the processes to be assessed should vary from time to time.
- In order to get better results employees should be encouraged to give feedback on processes.
- Employees need not have in-depth understanding of the SPICE method, but they should be taught the basics of SPICE before assessments
- The overall results should be published within the company, and detailed results only for the project team.
- Best practises found during assessments are very useful in developing processes. See also [6]

In addition to collect experiences of process improvement, the other goal of the study was to validate if SPICE based process improvement has been useful. Based on customer satisfaction survey results, there is a clear correlation between process capability and customer satisfaction.

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Multiplying Knowledge in ISO/IEC 15504 Based Improvements

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Abstract

When the Capability Maturity Models, such as SPICE (ISO/IEC 15504), Capability Maturity Model Integrated (CMMI) and Bootstrap are being applied by assessors, they mostly assess projects and establish project specific action plans. If organisations are very experienced they establish company wide improvement projects to exploit synergies. This exploitation of synergies helps to achieve improvements in a company wide manner much faster. For the multiplication of improvement knowledge organisations need to invest into knowledge management strategies and infrastructures. This paper also describes a sample implementation of such an approach inside industry. The development of an example knowledge based learning infrastructure has been funded under the EU Plato E-Learning project.

Keywords

Process Improvement, Knowledge, Synergies, Learning Organisations, PLATO

1 Introduction

1.1 ISO 15504

In 2003 – 2006 the SPICE project results have been published as the 5 parts of the ISO 15504 standard. The new standard is a complete rework of the technical report from 1998. The standard describes an architectural framework to assess projects in organisations based on two dimensions, the process and the capability dimension. The process dimension bases on a selected process reference model (processes and their outcomes) and on elaborated indicators to assess if a process fulfils its purpose. The capability dimension bases on 6 capability levels (0-5), process attributes to assess the achievement of levels, and generic practices to assess the achievement of process attributes.

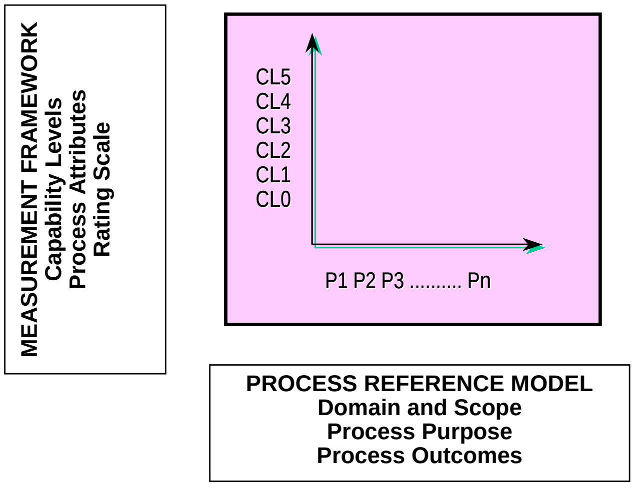

Figure 1: ISO 15504 Assessent Framework

In the following we will presume basics knowledge of that model because the ISO 15504 standard is well known and numerous papers have been published about it.

1.2 Knowledge and Knowledge Management

Davenport and Prusak (1997) proposed that knowledge is “a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information”. This definition cover our understanding, as knowledge can be either “tacit” or “explicit” (Nonaka and Takeuchi, 1994). Tacit Knowledge refers to an individuals Knowledge which is created by personal experience and is difficult to express in words, or as Hahn and Subramani (2000) state “the deeply rooted know-how”. On the contrary explicit Knowledge is the Knowledge that can be “extracted” from individual knowledge, be stored (documented) and shared.

Knowledge Management can be defined as the management of “processes by which Knowledge is created and applied” (Paulzen and Perc, 2002) though there is not a commonly agreed definition.

Organisations try to gain business advantage by using Knowledge Creation processes (KC) in order to “capture” Knowledge and use it to make wiser decisions about strategy, competition, products, production and service life cycles (Davenport and Prusak 1997), as well as to improve its effort in today's very competitive and uncertain environment. Organisational Knowledge is created by an organisationally specified systematic process for acquiring, organising and communicating both tacit and explicit knowledge of employees so that other employees may make use of it in order to be more effective and productive (Alavi and Leinder, 1999). This experience is documented and stored in a Knowledge Management System (KMS) preparing the organisation to react on the future, based on the Knowledge that is acquired from its own organisational experience.

1.3 Concept and Approach

A most recent definition of knowledge generation in firms is the creation of organisational learning cycles, involving both, the staff and the organisational level. Improvement knowledge and best practices should also become part of such a learning cycle to allow

1. An exploitation of synergies across the organisation (distribution and leraning on the staff level)

2. A regular improvement and development of the knowledge item which needs to be distributed and exploited.

For the multiplication of improvement knowledge organisations need to invest into knowledge management strategies and infrastructures.

In his paper we plan to give a short overview of the potential knowledge items and provide examples of how to build learning cycles inside the organisation. This paper includes a sample implementation of such an approach in the LATO project .

2 Knowledge Re-Use Potentials per Capability Level

The below table describes per capability level a set of potential knowledge re-use pattern. This evaluation is performed only up to a capability level 3. Levels 4 and 5 describe generic patterns of how to measure and control and continuously innovate the created improvement knowledge.

<table>
<tr><th colspan="2">Specific Process</th></tr>
<tr><td colspan="2">• Re-Use of know-how
i. To perform specific practices
ii. To create specific work products
iii. To use specific tools to perform practices to create the work products
iv. To involve specific expertise and functions to perform the practices</td></tr>
<tr><th colspan="2">Capability Level 2</th></tr>
<tr><th>Process Attribute 2.1 – Performance Management</th><th>Process Attribute 2.2 – Work Product Management</th></tr>
<tr><td>GP 2.1.1 Identify the objectives for the performance of the process.
• Re-Use of know-how
i. The selection of objectives and measures used to analyse their achievement
ii. What 5 most important objectives shall be represented in ach report ?
iii. The use of specific tools which allow to automatically generate the achievement of objectives representations.
GPI 2.1.2 Plan and monitor the performance of the process to fulfil the identified objectives.
• Re-Use of know-how
i. The implementation of specific requirements based work flows.
ii. How to plan releases based on a requirements based work flow and the assignment of releases.
iii. The use of specific tools which allow to automatically generate a status and plan.
GPI 2.1.3 Adjust the performance of the process. Process performance issues are identified.
• Re-Use of know-how
i. The implementation of spe-</td><td>GPI 2.2.1 Define the requirements for the work products.
• Re-Use of know-how
i. The review criteria used for the process results.
ii. The templates used to ceate the process results.
iii. The content / development guides used to create the process results.
GPI 2.2.2 Define the requirements for documentation and control of the work products.
• Re-Use of know-how
i. The typical results per process which are put under CM (Configuration Management) control in CM plans.
ii. Typical CM plans content, structure, and guidelines .
GPI 2.2.3 Identify, document and control the work products. The work products to be controlled are identified.
• Re-Use of know-how
i. Experiences with the use of specific CM systems .
GPI 2.2.4 Review and adjust work products to meet the defined requirements.
• Re-Use of know-how
i. The typical review plans.
ii. The review model and techniques applied.</td></tr>
</table>

<table>
<tr>
<td>cific requirements based work flows which allow to generate a status information.
ii. The use of use issue tracking systems which allow to generate a status overview automatically.
iii. The use of reports which allow to analyse the achievements and compare with the objectives.

GPI 2.1.4 Define responsibilities and authorities for performing the process.
• Re-Use of know-how
i. The use of specific roles to implement the process.

GPI 2.1.5 Identify and make available resources to perform the process according to plan.
• Re-Use of know-how
i. The typical resources and the tools needed to implement the process.

GP 2.1.6 Manage the interfaces between involved parties. The individuals and groups involved in the process performance are determined.
• Re-Use of know-how
i. The typical team structures and communication flows needed to implement the process.</td>
<td>iii. Experiences with the use of systems to document and track the review results.
iv. Experiences with tailoring of reviews (what falls under review ?).</td>
</tr>
<tr>
<td colspan="2">Capability Level 3</td>
</tr>
<tr>
<td>Process Attribute 3.1 –
Process Definition</td>
<td>Process Attribute 3.2 –
Process Deployment</td>
</tr>
<tr>
<td>GPI 3.1.1 Define the standard process that will support the deployment of the defined process.
• Re-Use of know-how
i. The modelling notation used to describe the processes.
ii. The tool used for process modelling.
iii. The experiences with tailoring processes for e.g. small projects.

GPI 3.1.2 Determine the sequence and interaction between processes so that they work as an integrated system of processes.
• Re-Use of know-how
i. The detail description of process steps and how they interface.
ii. Typical process flows.</td>
<td>GPI 3.2.1 Deploy a defined process that satisfies the context specific requirements of the use of the standard process.
• Re-Use of know-how
i. The experiences with tailoring processes for e.g. small projects.
ii. What specific tailorings made processes much more practical for projects to implement ?

GPI 3.2.2 Assign and communication roles, responsibilities and authorities for performing the defined process.
• Re-Use of know-how
i. Experiences with the defined roles and what needed to be adapted to make it really practical for projects.</td>
</tr>
</table>

GPI 3.1.3 Identify the roles and competencies for performing the standard process. • Re-Use of know-how i. The typical roles applied. ii. The competence and knowledge profiles of the roles. **GPI 3.1.4 Identify the required infrastructure and work environment for performing the standard process.** • Re-Use of know-how i. The typical tools and infra-structures used to support the processes. ii. Experiences with specific tools. **GPI 3.1.5 Determine suitable methods to monitor the effectiveness and suitability of the standard process. Methods for monitor-ing the effectiveness and suitability of the process are determined.** • Re-Use of know-how i. The typical measures used to compare the efficiency of processes across all pro-jects. ii. How feedback cycles typi-cally are managed.	**GPI 3.2.3 Ensure necessary competencies for performing the defined process. Appropriate competencies for assigned personnel are identified.** • Re-Use of know-how i. Experiences with skills gaps based staff planning in the project (comparing with the defined competence profiles of roles). **GP 3.2.4 Provide resources and information to support the performance of the defined process.** • Re-Use of know-how i. Experiences with the typical resources and information needed to efficiently perform the process. **GPI 3.2.5 Provide adequate process infra-structure to support the performance of the defined process.** • Re-Use of know-how i. Experiences with the tools and infrastructures used to support the processes. **GP 3.2.6 Collect and analyse data about per-formance of the process to demonstrate its suitability and effectiveness.** • Re-Use of know-how i. Experiences with the use of process efficiency measures and how the project com-pared itself with others (any typical trends) in the organi-sation.

Figure 2: A Short Overview of Sample Re-Use Potentials per Capability Level

3 An Example Implementation of a Learning Cycle

When it comes to knowledge management in combination with ISO 15504 a learning cycle is usually built around a set of assessments.

Since 2003 a group of major firms (see note below) started using a knowledge based assessment portal system in which the assessment results of all projects and divisions are stored in a central multi-user portal system (www.soqrates.de). From there so called knowledge links point to specific best practices inside projects which shall be multiplied in the organisation.

Note for SOQRATES: *The referred web site is still reflecting the first funding year from 2003 where it started with coaching middle sized companies. Since 2004 other companies joined and different task forces work together in cross-company working groups. The current members are – Continental TEMIC, Continental TEVES, ZF Friedrichshafen AG, T-Systems MMS, Siemens AG, Panasonic Automotive Systems Gmbh, Giesecke & Devrient, One Vision, Telelogic, MKS, Methodpark, IMBUS, EDV Team Süd, Artisan, SW Factory, ISCN, etc.*

Expert linking and team learning facilities have been added, so that projects which have weak areas can find expert projects (who were strong in this area) inside the corporate firm. Also it is possible to use team learning and training portals so that if a project is weak in a certain area it can enter a virtual training room for upgrading the skills in this area.

Also the projects work through a defined online infrastructure where results of the projects are documented so that the expert links can address re-usable information.

The following documentation refers to the results of an EU project PLATO (the virtual campus and learning organisation) and the usage of parts of that system in medium sized and large industry.

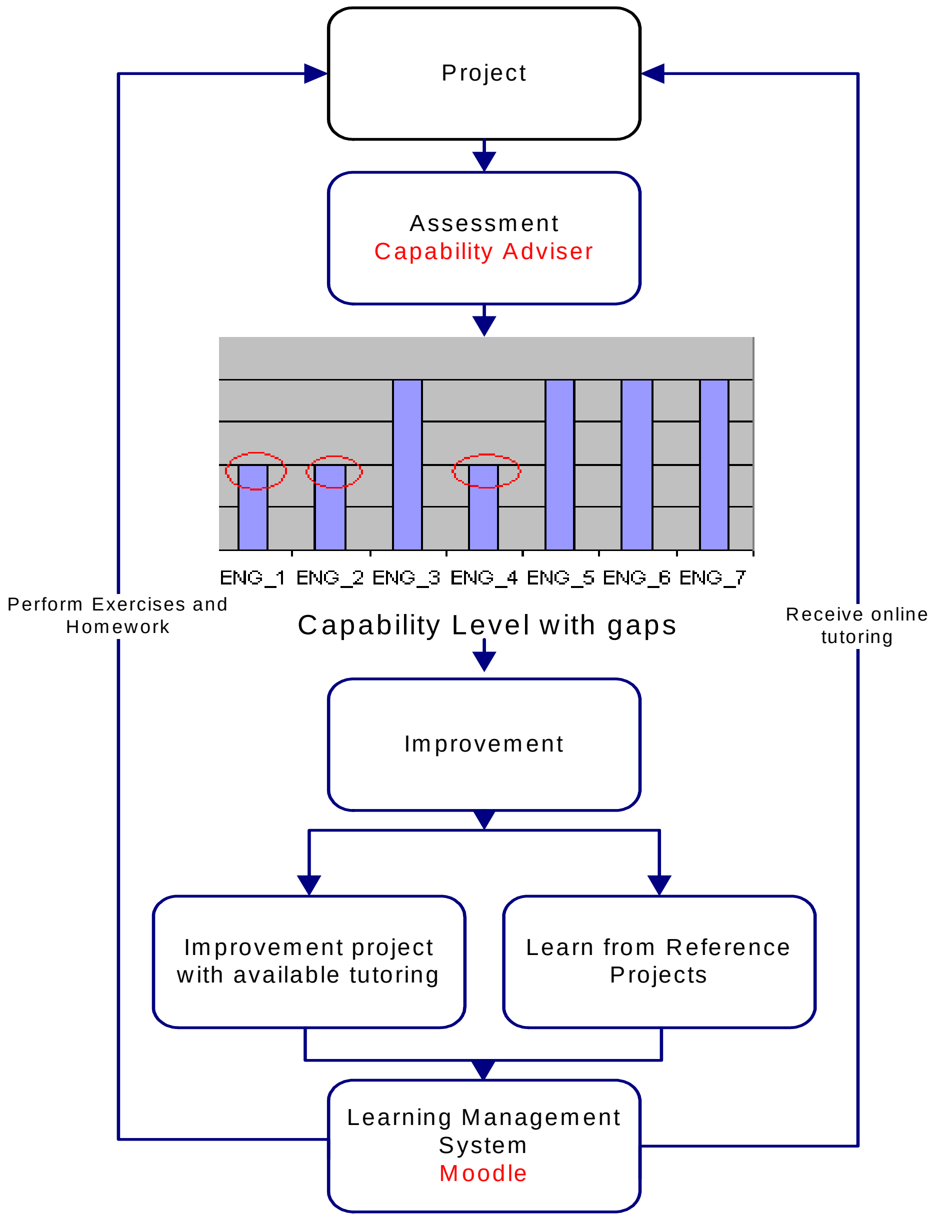

Figure 1: Assessment and Knowledge Management Cycle

The Knowledge Retrieval (Synergy Exploitation Strategy)

In the above Figure 1 we describe the knowledge retrieval cycle. Processes in projects are being assessed against the previously described capability levels. In a central knowledge repository we store the capability profiles and related information of all projects. A project can then in weak areas (a) get access to materials of highly rated projects (learning from best practice examples, and (b) attend courses in an online environment where bext practices have been collected in form of training materials. Tutors are the so called process experts / owners.

Moodle – This is a web based learning management system which is public domain available. (www.moodle.com)

Capability Adviser – This is a web based assessment portal system with a defined interface database to connect the systems. (http://www.iscn.com/projects/piconew/).

The Knowledge Generation – Best Practices Pool

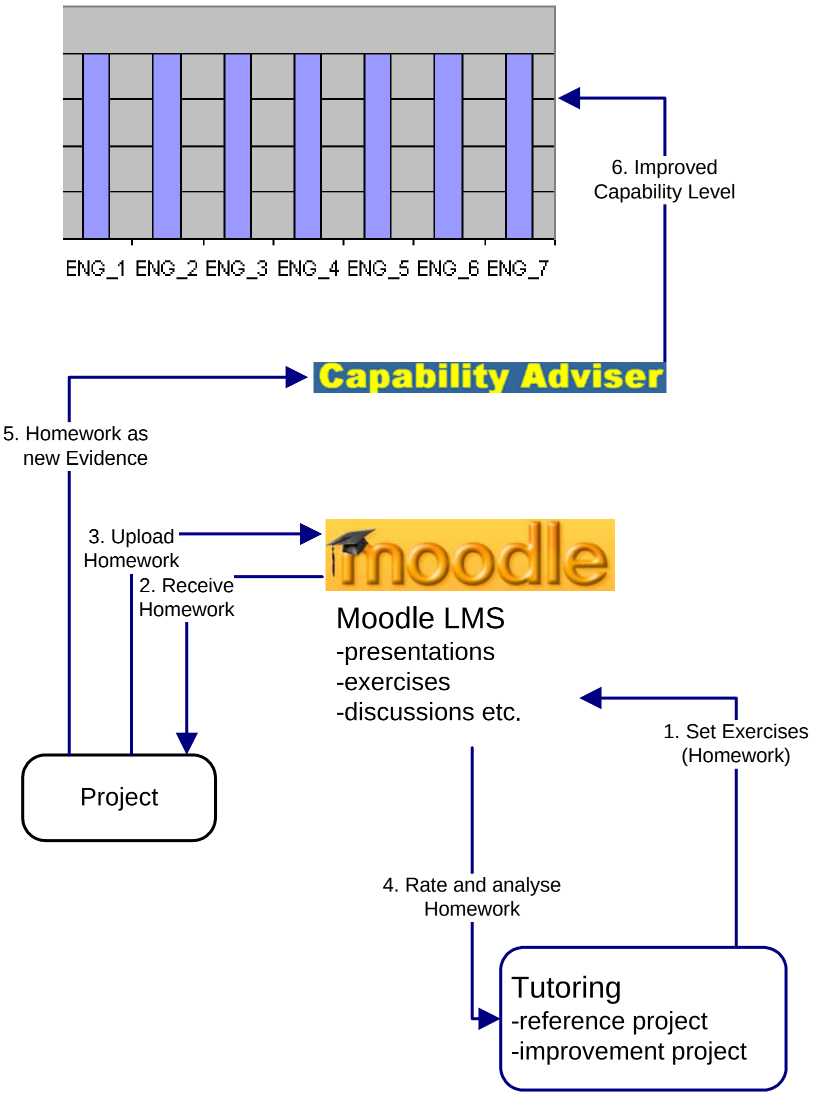

Figure 2: Generating a Learning Pool Used for Tutoring Knowledge

When applying ISO 15504 you need to invest into improvement programs. The improvement programs develop best practices for specific engineering and management practices and processes. The results of the improvement projects are piloted in real projects and lessons learned are documented for all projects.

In the system which is developed by the EU project PLATO (http://deis.cit.ie/plato/) and parts of which are used for the support of learning initiatives like SOQRATES, S[2]QI, EQN (www.eu-certificates.org) the best practice with lessons learned are being configured in a learning platform.

The Knowledge Generation – Structured Knowledge Pool

Figure 3: Knowledge Query of Development – Example – Problems with bar chart before

When applying ISO 15504 a defined level 3 all projects document their results and experiences in a standard way. If for this a defined e-work based infrastructure is being used, this allows to share all content related issues across projects. Figure 3 shows the result of such a knowledge query used in a knowledge management system based development documentation of the Capability Adviser development project.

4 Impact on Level 4 and Level 5 Thinking

Most metrics on capability levels 4 and 5 refer to

- Productivity measurement
- Complexity / size measurement and related trends
- Requirements based trends
- Effort trends
- Cost trends
- Error trends
- Etc.

However, if we apply the principles of a learning organisation we would need learning oriented metrics.

- Effort saved by re-using a pattern of work (comparing projects)
- Effort saved by re-using functions.
- Trend of new improvement patterns integrated into the projects
- Trend of projects offering best practices to other projects

This learning strategy would be perfectly aligned with the original meaning of levels 4 and 5. It helps establishing a continuous improvement cycle based on identified and proven in field/ measured best practices and success.

5 The Advantages and Future Perspectives

The advantages are significant. Projects that have to achieve a level 3, if they properly are supported by already learned best practices in the corporate environment, achieve higher maturity grades in half the time.

The time to find problem solutions by doing queries (see Figure 3) was reduced in development teams by more than 2 thirds.

The team learning factor is a major driver to create a company mission and then has a big impact on the social factors and employee motivation.

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He is the editor of a book "Better Software Practice for Business Benefit", which has been published by IEEE (www.ieee.org) in 1999 (the leading research publisher in the USA). He is the chairman of the EuroSPI initiative and chair of the programme committee of the EuroSPI conference series.

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Human Resources Based Improvement Strategies – the Learning Factor

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Abstract: Processes usually are defined according to underlying standards (ISO 15504, ESA ECSS, ISO 9001, …) and are described with process steps to be performed by roles and producing results (outputs) from well defined inputs, methods and tools to support the process steps, and activities to be done and skills to be covered by roles [5]. Assessments and resulting improvement initiatives very much focus on the processes and less on the human resources based strategies.

In this paper we want to emphasise that both issues are of equal importance, the processes and the highly skilled human force. We also highlight a currently running European strategy (European Qualification Network) and a funded technology project PLATO which support the establishment of such a human resource and learning strategy in Europe.

1. Motivation

European studies (1998 – at 200 firms [7], 2002 – at 128 multinational firms [8], 2003 – in 59 networked European organisations [1], [2], [3]) illustrate that the success of an innovation or improvement is not just dependent on the correct technical approach. A lot of learning strategy related aspects influences the success. See Figure 1.

Beside top management support the study outlined a positive learning culture (learning from mistakes, team learning, knowledge sharing, etc.) and a supporting organisational infrastructure which helps with the implementation of the learning organisation [8].

Please note that we regard human skills as a complementary set needed in addition to qualified processes to be successful on the market.

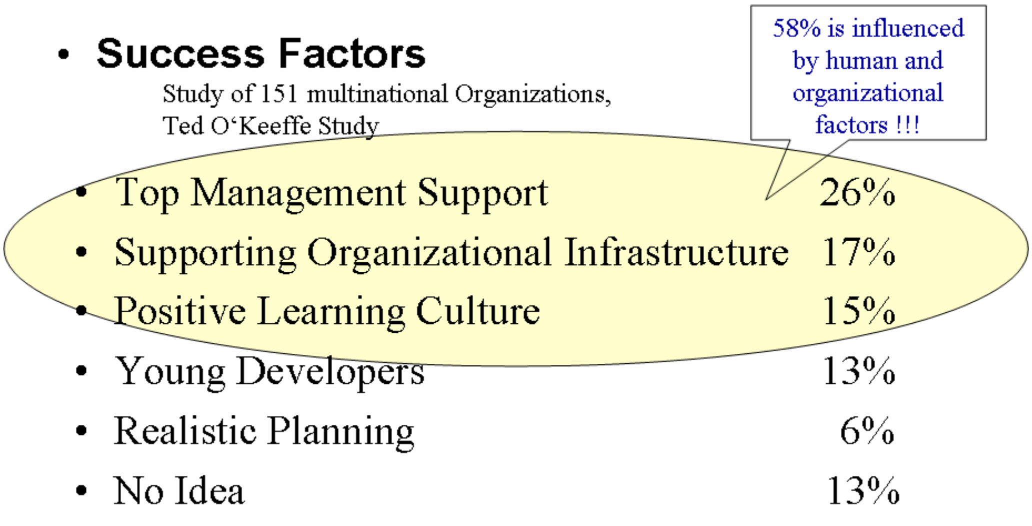

Figure 1: Success Factors Influencing the Implementation of Innovation and Improvement

2. What is a learning organisation?

A learning organisation [6],[7],[8],[10] creates a positive learning culture and enables team learning and synergy exploitation in an organisation. By team learning knowledge is spread much more quickly and a high level of a skilled human force is maintained.

Typical examples of failure are

- You recognise that for the implementation of a new product or new processes you lack specific skills and have no chance of acquiring them in time.
- You recognise that departments inside the company have the knowledge but do not want to share it with other departments.
- You recognise that your competitors have formed a group to share knowledge and jointly compete against you on the market.
- You recognise that some of your management staff does not fully understand the mission.
- You recognise that someone in your firm bought a knowledge management system but none uses it.
- Etc.

Typical examples of success are

- You linked in time yourself to experience partnerships and training networks and can react on the market immediately with any skills required.
- You manage that knowledge and team learning is used in a synergy approach between the departments and teams.
- You were the one who formed the group that jointly learns and shares knowledge and collaborates against your competitors.
- You ensure that the mission is a goal which binds everyone to a big picture.
- You analyse the core knowledge (the one that differentiates you from the competitors) and build all knowledge management strategies around that core (=realistic and not holistic knowledge management!).
- Etc.

In learning organisations there is an infrastructure in place which enables the team learning and the spreading of knowledge and team communication.

Ted O'Keeffe described such a learning organisation model which was published in the Journal of Industrial Computing in the EU. [8]

3. The Relationship Between Processes, Job Roles, and Skills

From the European studies you can see that above 58% of the success factors to implement learning organisations depends on human factors. Figure 2 illustrates that processes require roles and roles need specific skills to efficiently perform the job. In ISO 15504 a capability level 3 would, for instance, require the definition of competence criteria per role.
Combining this approach with the learning organisation related approach leads to a framework (see Figure 1) where it becomes extremely important to think in terms of job role based qualification and skills.

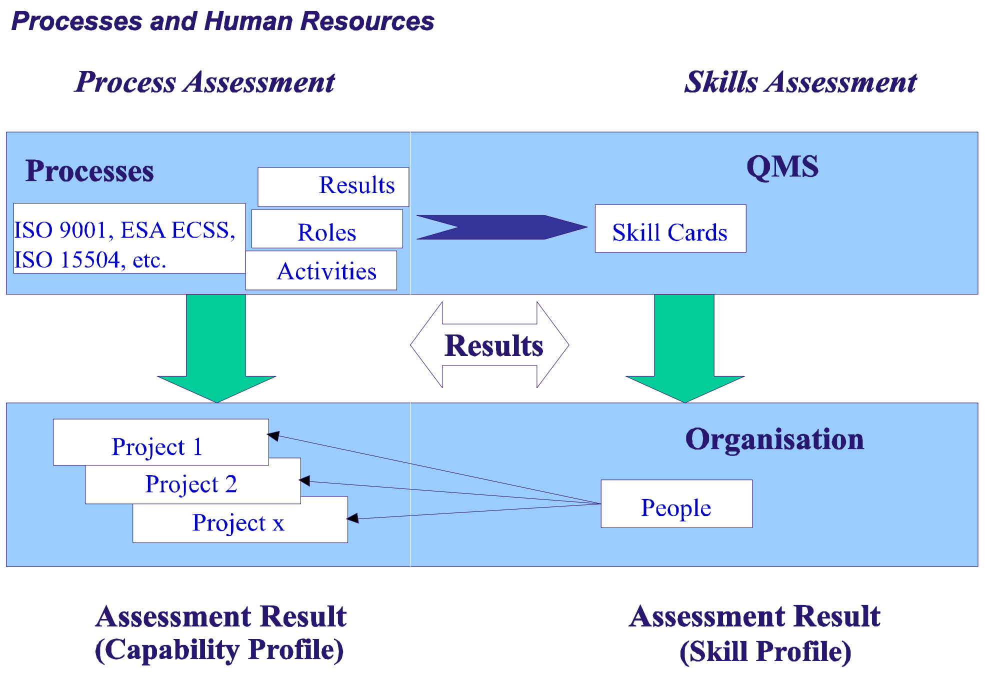

Figure 2: Processes and People – an Interrelated Framework

This is the reason why the following skills acquisition strategies base on specific job roles and their qualification needed to efficiently manage the development (e.g. job roles SW project manager, SW architect, etc.) and enable learning (e.g. job roles innovation manager, SPI manager, etc.)

4. The Skills Acquisition Strategy

European Level

We have set up a partnership of experienced partners in 18 European countries to create a pool of knowledge for specific professions. This pool can be extended to further professions.

If there is a need a person can attend a course for a specific job role online through an advanced learning infrastructure. See Figure 3.

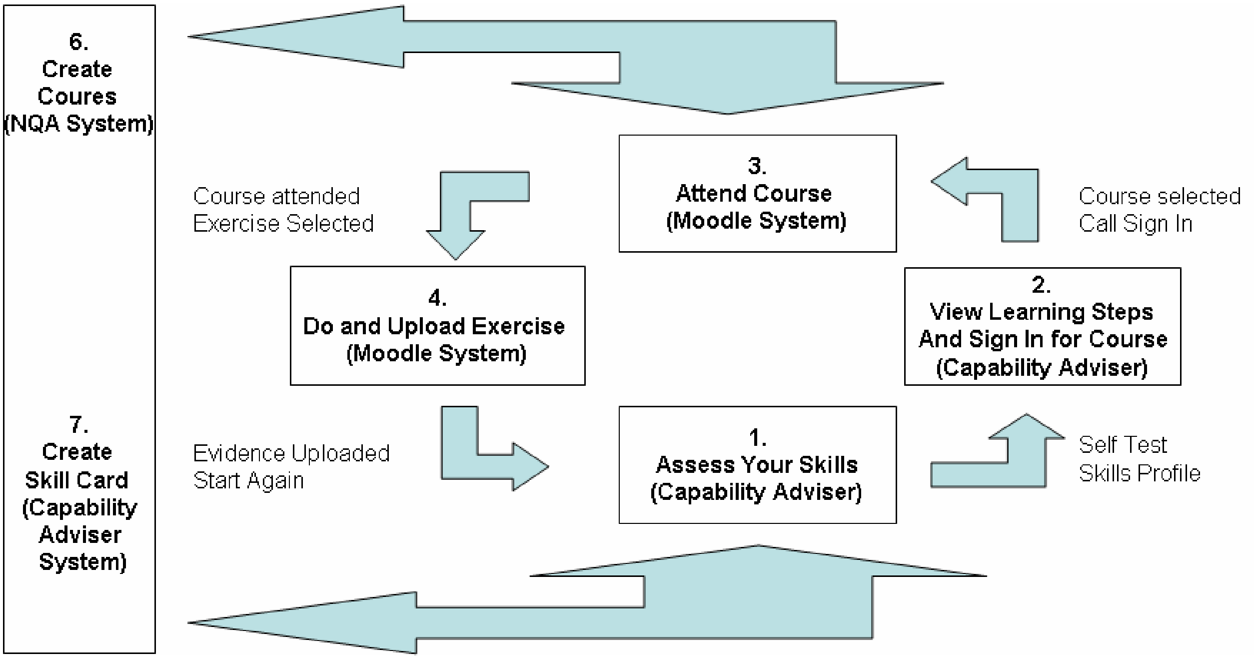

Figure 3: The Integrated European Skills Acquisition System

You start with a self assessment against the skills [2], [5], [12]. Then you can sign into an online course. Here you are guided by a tutor and do a homework which is being corrected by the tutor. Finally the homework and real work done in your project is sufficient to demonstrate the skills.

Moodle – This is a web based learning management system which is public domain available. (www.moodle.com)

Capability Adviser – This is a web based assessment portal system with a defined interface database to connect the systems. (http://www.iscn.com/projects/piconew/) [12]

NQA – Network Quality Assurance – This is a web based team working tool which was developed in the EU IST 2000 28162 project. [5]

So far the following profession have been configured –

- Software Process Improvement Manager
- Software Architect
- Software Project Manager
- IT Consultant
- EU Project manager
- Innovation manager
- Security Manager
- Configuration Manager
- Internal Financial Control Assessor
- Etc.

See www.eu-certificates.org

Company Level

We started installing similar platforms and strategies in multinational organisations so that their process related training programs can be delivered in this advanced form of human skills acquisition management (either at central sites or learning centres).

5. The Skills Provision Strategy

European Level

On an annual basis the existing platform of knowledge will be enhanced. Existing skills sets are being reworked and new skills sets will be added. Joined knowledge is being configured in form of a job role with standard content structures [2],[5],[6],[12]:

- Skills set
- Syllabus
- Learning materials and online configuration
- A set of test questions

So called job role committees regulate the content for a specific skills set.

The job role committee for innovation manager, for instance, created a skills set of an innovation manager together with a set of online courses etc. People can register from the work place.

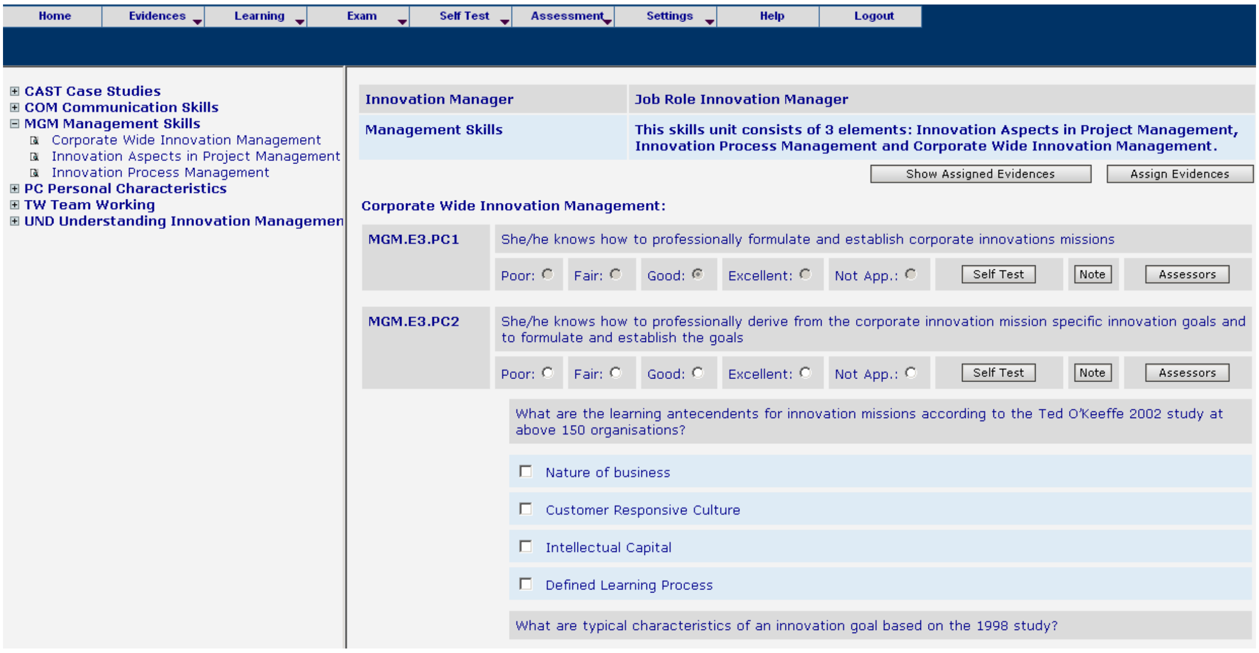

Figure 4: Skills Assessment

Show all courses

Please click one of the following units from the list below to display the available courses:

» Understanding Innovation Management

Unit/Element	Title	Course Start Date		
E: Introduction to Innovation Management	Public Introduction to Innovation Management Cours	2007-02-26	More Information	Sign In
E: Skills Management	La gestión de competencias profesionales	2005-11-01	More Information	Sign In
E: Customer Relationship Management	Customer Relationshih Management	2005-05-23	More Information	More
	Public Customer Relationship Management Course	2005-06-16	More Information	Sign In
E: Market Research	Spanish Market Research	2005-11-01	More Information	Sign In

» Communication Skills

» Management Skills

Figure 5: Sign Into Courses

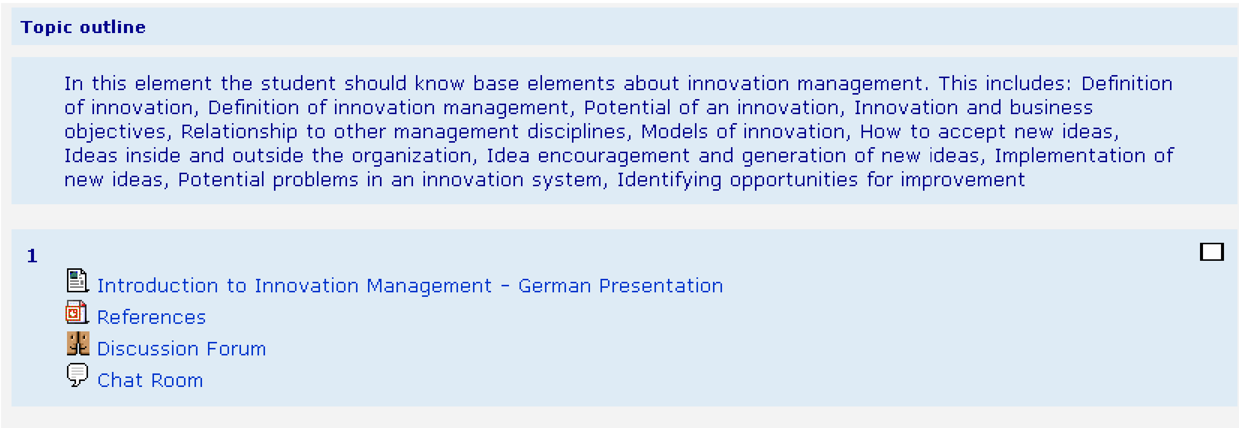

Figure 6: Online Course Attendance

Company Level

We started installing similar platforms and strategies in multinational organisations so that they configure the content with process and technology related skills sets and training materials. In the first run we use a combination of process assessment (weak processes areas) and the access to specific knowledge by training.

6. The Qualification Strategy

Nowadays it is important that training courses are really recognised and attendees receive a certificate valid for all European countries. As a backbone of the above described initiative the EU then supported the establishment of a European Qualification Network (EQN).

The overall objective of the project has been to establish an **EU Certificates Association** (www.eu-certificates.org) which supported by training organisations from European countries (currently organisations from 18 countries participate) installs a set of quality criteria and common certification rules which are applied across the different European regions in the Life Long Learning scope in the IT and services sector.

This results in a pool of professions in which a high level of European comparability has been achieved by a Europe wide agreed syllabus and skills set, a European test questions pool and European exam (computer automated by portals) systems, and a common set of certificate levels and a common process to issue certificates.

Quality Criteria: The partners collaborated on the development of the quality criteria comprising of: Quality criteria to accept new job roles in the EU Certificates Association, quality criteria to accredit training organisations and certify trainers promoted by EU Certificates Association, and quality criteria and test processes to certify attendees who have run through the raining of a specific job role.

EQN Certification Concept: The partners elaborated the whole set of necessary concepts and legal structures to start EU certificates. A founding conference at which 45 European training orgaisations from 18 countries have participated took place on 5 December 2006 in Krems (near Vienna), Austria. A second founding and Europe wide dissemination conference takes place in Budapest, Hungary, on 16. October 2007. From then on the European certificates and exam portals will be used by 18 countries applying the same quality criteria for training and certification Europe wide.

European Exam Portal System: The existing skills assessment portals (already used by approx. 4000 students in different learning initiatives) are extended to cover the new requirements of the ISO 17024 (General Requirements for Bodies operating Certification of Persons) standard. Especially the features how to run the tests have been improved. In 2007 already 12 European professions will be supported by the system. It is planned to support 18 EU professions from 2008.

The ISQI (International SW Quality Institute, www.isqi.org) is the German representative inside EQN.

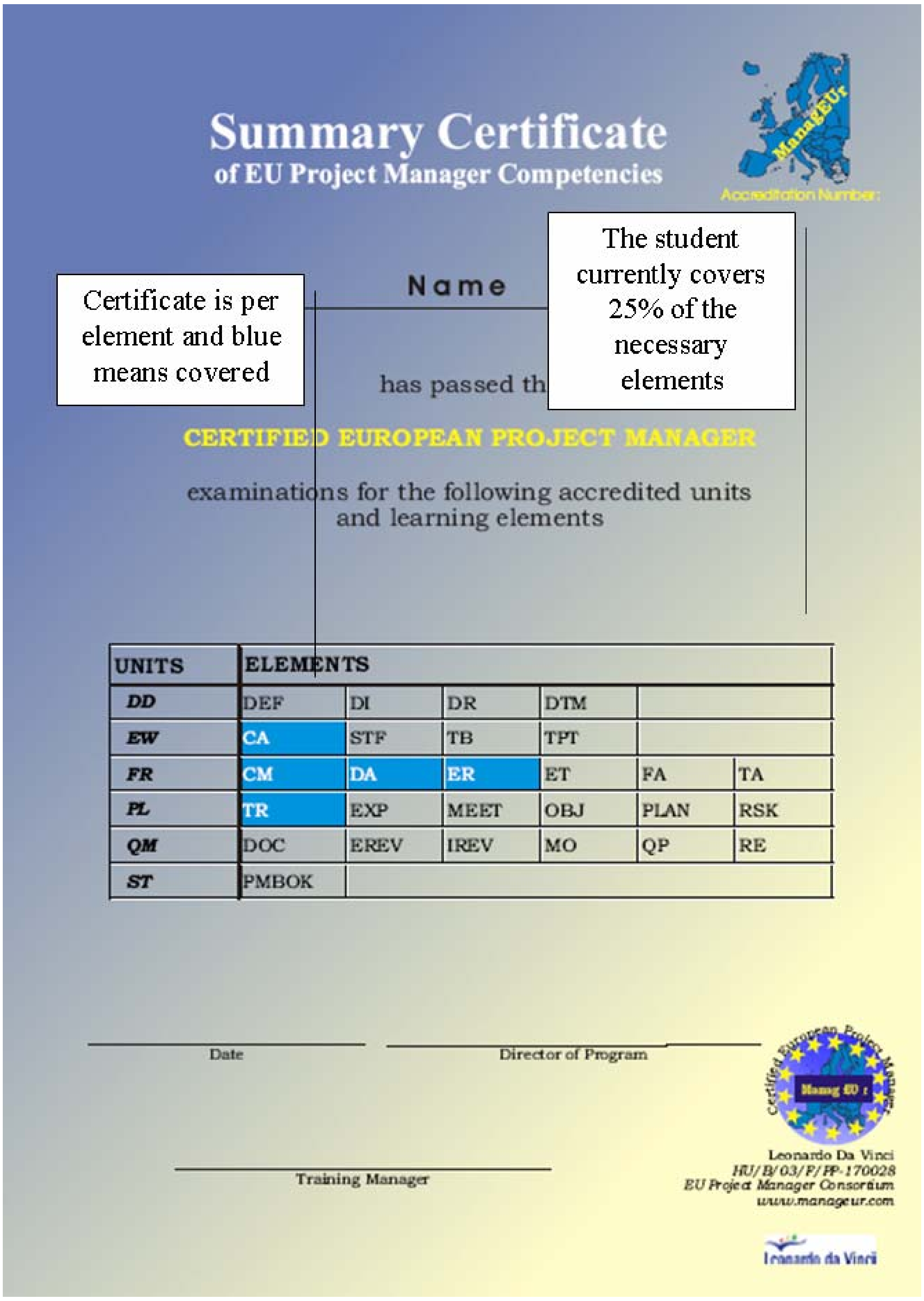

Figure 7: Example Certificate

The certificates are automatically generated by the system. This requires the participant to perform a computer based test.

7. The Platform Strategy - PLATO

The system is based on an integration of the Capability Adviser System (Skills and Process Assessment) and learning platforms such as Moodle. The interfaces are managed via a defined interface database system.

The system is being trialed with the support of the Danube (TU Vienna), Corvinus University of Budapest, University of Valladolid, and Cork Institute of Technology. It is being tested by the universities for work placements where students work inside firms.

ISCN is testing the system in related industry networks managed by ISCN (www.eurospi.net, www.eu-certificates.org, www.soqrates.de) .

8. Motivation

The innovation studies illustrated that to make process improvement strategies successful we need to consider the human skills and team learning factors to a large extent. How quick we can roll out a good practice to all teams is decisive about the time to impact and the time to success.

Advanced firms (e.g. the 156 multinational companies in the Ted O`Keeffe study) understand the need of such systems and beside top management support count most on the supporting infrastructure of team learning and knowledge sharing and the creation of a positive learning culture.

In such an environment we can (1) build a critical mass of joint certificates in Europe , and (2) use the advanced learning systems to install supporting infrastructures in the European firms.

If you are a training organisation and want to be joining EU Certificates Association and want to find out synergy options, please contact the coordinator Dr Richard Messnarz, rmess@iscn.com.

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Dr Richard Messnarz

Dr. Richard Messnarz (rmess@iscn.com) is the Executive Director of ISCN LTD. He studied at the University of Technology Graz and he worked as a researcher and lecturer at this University from 1991 - 1996. In 2 European mobility projects (1993 and 1994) he was involved in the foundation of ISCN, and he became the director of ISCN in 1997. He is/has been the technical director of many European projects:

PICO - Process Improvement Combined Approach 1995 - 1998,

Bestregit - Best RegionalTechnology Transfer, 1996 - 1999,

TEAMWORK - Strategic Eworking Platform Development and Trial, 2001-2002,

MediaISF - Eworking of media organisation for strategic collaboration on EU integration, 2001-2002

He is the editor of a book "Better Software Practice for Business Benefit", which has been published by IEEE (www.ieee.org) in 1999 (the leading research publisher in the USA). He is the chairman of the EuroSPI initiative and chair of the programme committee of the EuroSPI conference series.

He is author of many publications in e-working and new methods of work in conferences of the European Commission (E-2001 in Venice, E-2002 in Prague), and in the magazine for software quality (Software Quality Professional) of the ASQ (American Society for Quality).

He is a lead ISO 15504 assessor. He has worked as a consultant for many automotive firms, such as BOSCH, ZF TE, ZF N, Continental TEMIC, Audi/VW, etc. He is a founding member of the INTACS (International Assessor Certification Scheme) accreditation board, a founding member of the Austrian Testing Board, a founding member of the Configuration Management Board, and he is the technical moderator of the SOQRATES initiative (www.soqrates.de).

Dipl. Ing. Damjan Ekert

Dipl. Ing. Damjan Ekert is the chief developer of the Capability Adviser and EPI / Learning systems since 2003. He studied Telematics in Austria and finished studies with distinction. He is a certified ISO 15504 assessor and works in consulting projects for Magna. He is the project leader for software development inside ISCN.

Figure 8: EQN Founding Conference 2006

Reusable Project Patterns to enhance Software Process Improvement

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Abstract

Nowadays, performing software process improvement programs within n small software intensive organizations requires an expensive investment and, in many cases, these organizations cannot afford the improvement costs. In this paper, a new approach for enhancing the introduction of software project management practices based on Reusable Project Patterns (RPP) is introduced. Thus, the authors also present a software tool named PM-CAKE that has been developed to support the design of reusable project pattern and the management of a software project applying this approach. This work has been partially supported by the Spanish National Project "Software Process Management Platform: modelling, reuse and measurement" (TIN2004-07083).

Keywords

Software Process Improvement, Process Patterns, Experience Reuse

1 Introduction

Software Process Improvement is a well-developed and well-accepted domain for improving the performance of a software development organization increasing the quality of the products provided. The most popular strategy to introduce process improvements in a software organization is based on the incorporation of efficient practices proposed by reference model in the organization's day-to-day activity.

The introduction of this type of efficient practices in a software organization is complex due to the high initial investment required and the absence of personnel with required skills and experience. In case of large software development companies, this is a problem that has solution, but in case of Software Development Small and Medium Settings (SDSS) these problems usually suppose a barrier that impedes the starting of Software Process Improvement Programs.

The most part of software development and services are provided by small and medium companies. So, if European companies want to lead the software related market, an important and effective investment on improving the performance of SDSS must be fostered.

In order to reduce the complexity related to Software Process Improvement, there is a research area centered on the introduction of efficient practices in a software organization by means of process patters. Process patterns is a problem-solution pair where the problem is the use of a software development efficient practice and the solution is a set of activities, templates and guidelines that help software engineers to apply efficiently the mentioned practice.

Although the application of process patterns is a good strategy to introduce improvements in a software development setting, the benefits provided by them cannot be achieved by SDSS because:

- During our experience in several software process improvement programs, we have concluded that the activities related to process improvement deployment and training needs account for almost a third of the effort in the improvement project effort. This cost is not reduced by means of the use of process patterns as a SPI technique.
- In addition, most software organizations do not have the technology and the appropriate tools for process improvement deployment because many of the tools are completely new to the software engineers and do not integrate seamlessly with the knowledge enclosed by a process pattern.

Many SPI researchers and related organizations are in accordance with this point of view, so the tools used to deploy and use process patterns comprise an intensive area of R&D work related to software process improvement. Moreover, many Software Development Tools vendors are working on the new generation of this type of tools that provide a seamless and integrated access to the functionalities related to project management, domain modeling and design, components integration, software testing, quality assurance, configuration management, requirements management, and e-collaboration tools to implement distributed software engineering.

The problem related to an effective use of these type of tools is the absence of expertise and/or knowledge on how to adapt the efficient practices (in terms of process patterns) to an specific software development setting and the specific characteristics of a software project.

If reuse capabilities, automatic information indexing and advanced knowledge retrieval techniques and tools are added to process patterns, the effort and skills required to adapt and apply a software development efficient practice in a particular setting and project will be smaller, so the barriers that impede SDSS to begin a SPI will be reduced, facilitating the SDSS to access to the benefits provided by this type of programs.

In order to verify the previous hypothesis, the research objectives addressed by this paper are related to:

- Analysis on previous research works related to process patterns definition and use.
- Definition of improvements required by the related works studied in order to incorporate reuse and information processing capabilities.
- Adaptation of the process patterns concept in order to include reuse capabilities.
- Definition of a reuse framework (called PM-CAKE) that helps to use efficiently process patterns in particular development settings and projects and enables to:
    - Classify organization's efficient practices regarding to software development.
    - Search and reuse these efficient practices to instantiate organization's process in each software development or maintenance project performed.
- Validation of the reuse capabilities defined by means of the use of PM-CAKE in SDSS.

This paper is structured as follows; section 2 provides a brief summary of the most relevant research works related to software process improvement based on process patterns definition and use. Moreover, this section discusses improvements required to introduce reuse capabilities in this approach. Section 3 presents the concept Reusable Process Pattern that is an adapted version of process pattern concept presented in section 3 that includes reuse capabilities. Moreover, this section present the knowledge reuse employed to manage RPPs to help project managers to apply efficient practices in their projects. As well as, this section provides a brief summary on the way of using RPP to manage an specific software project. Section 4 provides the lessons learned by the authors during the use of RPP in several SDSS. Section 5 provides the conclusions and future works on the reuse of process patterns.

2 Related Works

This section presents a brief summary of the most relevant research works related to software process improvement based on process patterns definition and use. There are several meta-models designed for describing models of software development. A review of the most outstanding ones will be shown.

In 1999 Hajimu Iida offered the idea of Software Process Pattern (SPP) [3]. The idea of Hajimu Iida is to evolve a software development process using a SPP as a template. The main idea of this research work is to execute development processes with less effort applying pattern-based transformations to a primitive process. In this work Hajimu Iida offers a template for process pattern description: Problem (to be solved); Forces (restrictions); Initial Context (the original state before executing the pattern); Final Context (the final state after executing the pattern); Description (of the pattern in natural language); and Remarks (other comments).

In 2002 Traugott Dittmann, Volker Gruhn, Mariele Hagen proposed the Process Pattern Description Language (PPDL). PPDL is based on UML [4] and offer concepts, which are the explicit definition of the pattern's problem, the modularity of process patterns, the more formal definition of the pattern's process and relationships and the specializing of process patterns, they developed a language for describing process patterns in a more precise way. PPDL contains several approaches augmenting the expressiveness of process patterns as described beneath:

- Explicit definition of problems, PPDL defines a problem by its input and output:
  - A problem's input is the situation before the application of a solving pattern.
  - A problem's output is the situation after the application of a solving pattern.
- Modularity, a pattern solves certain problems; its initial and resulting contexts have to match input and output of the problem to be solved. So problem serves as an interface to all its solving patterns.
- More formal definition of processes; In PPDL is necessary to represent the solutions graphically and forces the documenter to a higher degree of formality. Also PPDL offer notations for modelling processes, such as activities, results of activities, objects, states, roles, parallel action and non-determinism.
- Specializing and generalizing patterns; there is more general patterns and more specific ones, thus PPDL suggest a relationship between more general and more specialized patterns solving the problem.

  PPDL offer a set of relationship, the most important ones are: Succession (the sequence between the patterns); Refinement (the specification form a pattern to another pattern); Usage, (a pattern as a sub-process of another pattern); Variance (explain when a pattern solves the same problem within the same context with mutual exclusive solutions of other pattern).

Later, they continue the previous investigation, thus in 2004, Mariele Hagen and Volker Gruhn suggested that process patterns should allow the modular modeling and adaptable application of business processes, but descriptions of process patterns show defects like non-uniform and unequivocal description forms and missing relationship definitions. This work warns that the actual process pattern descriptions and relationships are informal due to most of them use the natural language for representing its knowledge. They offer the PROPEL [1], [2] (Process Pattern Description Language) language for resolving these lacks. It provides concepts for the semiformal description of process patterns and relationships between process patterns. Using PROPEL is possible to design single patterns and relationship mechanisms to compose more complex patterns. PROPEL is an extension of UML [4], and defines a process pattern as a process, which solves a problem which has recurred in a certain context.

Hence PROPEL is composed by: A problem description (in natural language); A process, specifies steps which are necessary to solve the problem (PROPEL uses the metaclass "ActivityGraph" for modelling a process, and a process is a set of activities using the metaclass "ActionState"); Initial context (describing the initial state before executing the process); Final context (describing the final state after executing the process).

In 2005 Teodora Bozheva and Maria Elisa Gallo [5] propose a “Framework of Agile Patterns” to enhance the selection of most appropriate agile methods and techniques for a specific project. The key components of this framework are: *practices*, *concepts* and *principles.*

- Practice patterns; describe specifications that are performed in the whole process of software development. Each agile pattern is described using the next attributes: *Intent*, *origin*, *category*, *application scenario*, *roles*, *activities*, *tools*, and *guidelines*. This structure is closest to the one proposed by E. Gamma in [6].
- Concepts; are definitions of a class of items that consists of characteristics or essential features of the class.
- Principles; are a set of fundamental guidelines concerning the software development activities.

As a conclusion of an analysis of this state of the art, the authors have identified new research areas. Improvements related to the problem description are:

- An improved way to manage textual problem description based on a system of indexing and searching of the textual description of a problem based on advanced technique for text processing.
- A set of metadata that categorize a pattern for being able to make efficient searches on them.
- A set of requirements to accomplish for being able to execute the pattern (it would be considered as "input context"). The necessary requirements for fulfilling a concrete project are important information to study before undertaking the project; these requirements would be the minimal conditions to start the project execution.
- A set of risks inherent to the project execution. In every project execution a set of risk are always associated to the execution of itself. It is very important to advise the project manager about the possible risks in the execution; for guarantying a good product.
- A set of “To Do” items and other with “Not To Do” items, that provide the knowledge on the best practices, and the lessons learned obtained from the use of the pattern in concrete software projects.

New ideas for describing the solution should be proposed, concretely related to:

- A set of activities; for accomplishing the project development.
- A workflow describing the sequence between activities. For accomplishing a project with success it’s necessary to know what to do and when to do it. Offering a workflow, it’s the best way to inform what is necessary to do, and when is necessary to be done.
- A set of templates, products and guidelines that flow between the activities.
- A flow between the products, indicating which are the prior activities and successive ones. As well as offering a workflow for knowing the necessary activities to do, we suggest that is very important to offer the assets to help to carry out each activity, but the most important thing that we suggest is to give also the products´ flow between the activities i.e. the assets don’t live and die in a concrete activity, instead of this the completed assets in previous activity are the key for starting the next activities.
- Advanced algorithms to classify and retrieve solution information by means of indexing the information enclosed in solution activity diagrams. All the information is useless if there isn’t any kind of retrieval for it. We have developed algorithms able to index, classify and retrieve the solution information using any fields of the problem definition.

3 Reusable Project Patterns for Software Process Improvement

In this section we are going to show the main points of this investigation and its contribution. We are going to explain the metamodel developed for describing the Reusable Project Patterns, the framework developed for its management and the necessary steps for accomplish a project using the Reusable Projects Patterns, which are: diagnosis of current state, pattern adaptation and classification, process adaptation and Post-mortem reviews (all explained above).

3.1 Reusable Project Pattern Definition

A project pattern is a problem-solution pair [6]. The problem is used to describe the different kind of projects that can be developed using the corresponding project pattern solution. The solution condenses the best practices for software development, extracted from the globally recognized standards such as CMMI, RUP, PMI, etc. and from the own experience of the SDSS, this solution is represented by a set of activities grouped in a workflow, the assets flowing through these activities and the experience gathered during the execution of projects considered under the problem field scope.

PM-CAKE (Process Management Computer Aided Knowledge Engineering) is a framework for software intensive organizations that can be used by project managers, software engineers, process management groups, and managers of information technology units. PM-CAKE is a function framework, it is first state of developing and it is based in CAKE [7] technology. CAKE is a framework for knowledge management and reuse; it is a response for the need of knowledge reuse, offering the Incremental Reuse Method [8]. The PM-CAKE functionality will not be described in this paper; instead we are going to explain how to use the RPPs for software process improvement. We are going to use PM-CAKE screenshots for illustrate the most important step of the methodology proposed in this paper for SPI.

We illustrate the concept project pattern as well as its structure, using the interface of the PM-CAKE tool in Figure 1.

Currently, PM-CAKE tool provides capabilities related to:

- Define a project pattern from the scratch.
- Define a new project pattern modifying any other existing, or converting a concrete project into a pattern.
- Classify and query project patterns.
- Plan a software project instantiating a project pattern.
- Perform post-mortem reviews.

In order to introduce improvements in the practices currently used in SDSS that will enable to increase the organization’s effectiveness, efficiency and quality, we defined an “ideal” project pattern that is able to be applied in any software development/maintenance project. In this “ideal” project pattern, the problem description is very broad so it can be applied to any kind of project.

The skeleton for this ideal project pattern was obtained from the specific practices of the reference models (CMMI [9], ISO 12207 [11] or PMBOK [10]), joined the procedures and technical instructions coming from the most important existing software development methodologies as Unified Process [12]. The elements included in the ideal project pattern are, activities, products and practices related to: Project planning, Project Tracking and Oversight, Product and Project Quality Assurance, Requirements Engineering and Management, Technical Solution Development (Analysis, Design, Programming, Integration, Tests and Deployment), Configuration Management and Changes Management.

The ideal RPP must be customized to different contexts and needs of software development projects, i.e., specific approaches.

Along the development of several projects in small settings, we obtained new information and knowledge about products implemented and the list of “To Does and Not to Does”, these information have been incorporated in a new version of the ideal project pattern. Also we have defined a set of versions of the ideal project pattern to be used in specific technological environments, mainly for Web and Legacy Systems.

Reusable Project Patterns are a useful tool to manage software process improvement programs, because they help to perform several stages that are:

- Diagnosing Phase, because reusable project patterns help to establish current levels of process capability and initiate the action plan (see section 3.2).

- Establishing Phase because reusable project patterns help to establish goals and priorities and complete the action plan (see sections 3.2 and 3.3).
- Acting Phase whose objective is to research and develop the solutions to process problems (see sections 3.3 and 3.4).

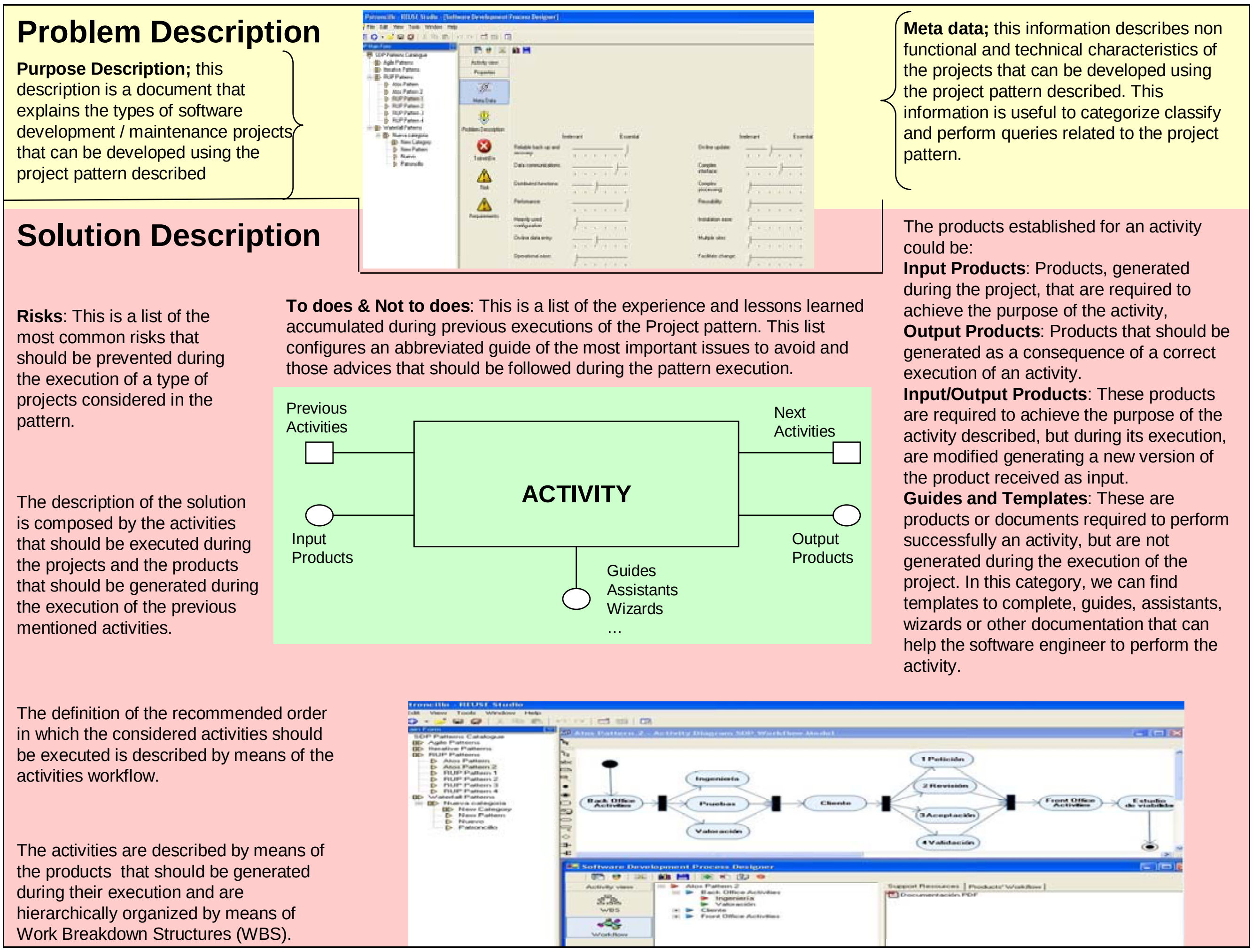

Figure 1: Project Pattern Description.

3.2 Diagnosis of current state using project patterns

In order to start an improvement activity in a software development small setting, the first step is to develop an evaluation of the current organization state, so the needs and improvement opportunities can be identified, as well as the quantifiable goals to be achieved once the specific improvement activities have finished. The steps to diagnose the current practice of a software company are:

- Identify the kind of work the company focuses on, this work can be usually classified as:
  - New development projects. A new project is a set of activities which goal is the development of a software system or the improvement, migration or reengineering of an existing system.
  - Maintenance projects. This is a set of activities which goal is the modification or extension of an existing and in use. Some kind of maintenances can be considered: corrective, adaptative, preventive and perfective.
- For each kind of work identified as potential for the organization, a project pattern is defined gathering information related with the way the organization develops its work. Usually, this step is deve-

loped through guided working sessions between external consultants and the internal team in charge of the improvement activities.

- The internal process improvement team (assisted by external consultants) analyzes all the knowledge and documentation gathered in the step 2, elaborating the organization's current project pattern. Depending on the organization needs one or more patterns can be defined.
- The study of the organization's current state finishes with a comparison among the ideal project pattern and the organization project pattern, identifying the improvement needs in terms of tangible organization's process assets to achieve.

The specification of the improvement objectives in this concrete way provides an extra motivation factor to the SDSS employees in relation to the improvement project, because they know the tangible results that must be obtained and they have an easy way to control the progress of the project.

3.3 Reusable project pattern adaptation and classification

Once the improvement goals have been established, the current project pattern is enriched with information and knowledge coming from an ideal project pattern. These improvement actions consist of enriching the organization's activity pattern with elements included in ideal project pattern (wizards, templates, guidance documents, activities, steps and examples).

The activities to adapt the ideal project pattern in a concrete organization require the most part of effort in an improvement program. The most part of this effort is related to the definition of products templates and the technical instructions that the software engineers should complete to execute correctly the project pattern activities.

In order to enable software engineers to find the correct pattern to apply in each case, these project patterns should by properly classified. The simplest way to classify a project pattern consists of identifying the type of work to which a concrete project pattern is applicable (new project, adaptive, perfective, preventive or corrective maintenance), grouping all the patterns of project of a same type in a same category. Nevertheless, in case that several patterns of project of a same type exist, this way of classification is inefficient.

In case of several project patterns in the same category, we can classify them by the content of purpose description field. This information can be indexed efficiently using, as a tool, predefined thesauri of the application domain and software engineering field. There are several software tools that allow creating a thesaurus of an application domain using the software requirements specification documents. In the software engineering thesaurus, this was generated from CMMI and ISO 12207 specifications that can be reused from one organization to another. PM-CAKE helps to perform this type of classification because it belongs to a knowledge management environment that has a documents indexer based on thesaurus concepts.

Finally, in case of an organization have several project patterns for very similar purposes and the same type of the work, but with non functional differences, such us the technological environment; we can use these non functional characteristics to classify the project patterns. The non technical characteristics that are used to differentiate project patterns of the same purpose and type are called project pattern metadata.

3.4 Process adaptation using project patterns

Using the reusable project pattern concept, project planning in a software development small setting consists of instantiating a concrete project pattern, so the first planning task consists of finding the correct project pattern to apply (see Figure 2).

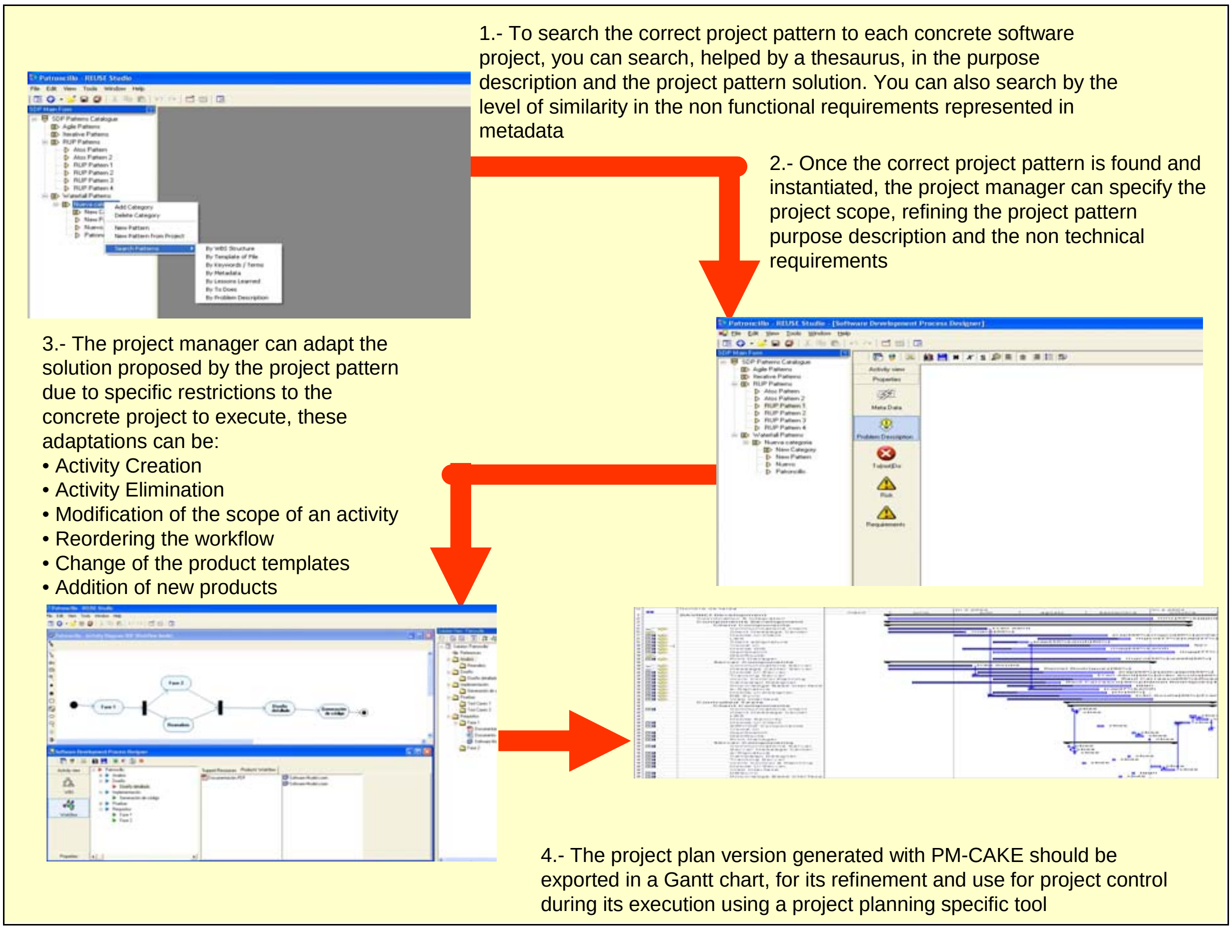

Figure 2: Project Planning by means of instantiating a project pattern.

3.5 Post-mortem reviews for continuous improvement

The ideal project pattern is intended to develop also post-mortem reviews, once the project has finished. The main topics to be taken into account in these reviews are the next:

- Modification, if needed, the project scope description and the metadata that defined the non-functional requirements of the developed project.
- Recording of the project pattern activities that have been actually performed and the corresponding effort.
- Recording of the project pattern activities not performed.

This information must be gathered to determine the adherence degree[1] of the projects developed with the selected project pattern. The study of the adherence values is very useful for us because when the adherence degree is high then project patterns are useful to guide the project staff to develop their responsibilities, so when the adherence degree is low the project pattern must be changed by:

- Adapting the definition of the ideal project pattern or even defining new project patterns.
- Improving the usability of the project patterns by integrating new tools to support this concept appropriately and improve the guides to use the activities and its product examples.

[1] The adherence degree measures the fidelity with which the projects are executed according to the description of the project pattern.

4 Lessons Learnt

During the application of RPP approach several software development small settings, authors found that this approach helps to solve several generic problems related to SPI programs execution. These lessons learnt are:

- When it is defined the processes and procedures to apply the best practices defined in improvement approaches like CMMI, a typical trend is the use of reference models skeletons to be implemented and next complete them with organization specific activities. This approach produces processes and procedures that satisfy the reference models but they are very bureaucratic and useless for software practitioners.

  Using RPP, the authors solved this problem because the ideal project pattern includes the activities of the main developed methodologies, with some added steps, verifications, records, work products, etc. This allowed the development of less bureaucratic processes.

- Many SDSS believe that the activity related to the real state assessment is useless and expensive in cost and effort, mainly because they think that their strengths and weaknesses are already known.

  Using RPP, the authors avoid the resistance to implement this activity by a clear communication of the added value provided by this activity, because its outcome is a set of tangible and measurable improvement goals and a set of precise activities to achieve these goals.

- In a traditional improvement program the first activity after the initial assessment is the construction of a process definition document. This kind of activity represents the most part of the total effort of improvement activities.

  With the use of our proposed improvement strategy this effort is distributed along the implementation of improvement activities, because project patterns are defined incrementally and this allows deployment of small changes that affect the most part of the organization, providing the benefits related to:

  - Visualization of early achievements related to the benefits of improvement programs
  - Increment of motivation of the personnel working (directly or indirectly) in the improvement project, increasing also the organization’s commitment, a critical success factor in software process improvement programs.

5 Conclusions and Future Research Lines

This paper has introduced the Reusable Project Pattern concept and a framework for its use in relation with software process improvement. As a consequence of its use in several improvement programs, the following conclusions are obtained:

- The Reusable Project Patterns reused and adapted by an SDSS permits to this type of software organizations to perform more easily software process improvement program by means of a reduction of the effort required to adapt a software process reference model to the operational characteristics of the organization
- The use of software tools to treat automatically the information enclosed in Reusable Project Patterns (and their instances) permits an easier and more productive access to the efficient practices to be used in each organization’s project. This more effective access reduces the difficulty and effort required to institutionalize software process improvements

The research and development lines that are currently ongoing or planned are:

- Elaboration of more Reusable Project Patterns.

- Improvement of the algorithms to treat automatically Reusable Project Patterns information, including ways to classify and recover graphical information enclosed in activity diagrams defining the solution of each Reusable Project Pattern.
- Investigation of more efficient ways to describe the types of projects solved by a specific reusable project pattern.
- Definition of interfaces (based on SPEM) that permit to reuse the information provided by other types of software process patterns or electronic software process guides.

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7 Author CVs

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He received an Engineering degree and PhD in Computer Science at Carlos III University of Madrid. He is software process improvement consultant in PROGRESION SMP. He has 9 years of experience as software engineer and consultant in public and private companies. He has participated in numerous research projects, financed with public (European and national) and private funds, in relation to software process improvement and its integration with the organizational business processes. He has published books and international scientific papers related to software engineering and collaborative working environments. His current research interest is formal measurement of processes improvement, ISO 15504 assessments, software capacity evaluations and audits and knowledge management related to software engineering.

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Integrated Process Improvement

Dr.-Ing. Dietmar Winner, Dr. Anne Kramer, Norbert Kastner

Abstract

The barrier to go for capability maturity models is high. CMMI or SPICE assessments are considered as time consuming and expensive. Also, they represent another process framework in addition to the standard ISO 9001 process. While the concepts and objectives of maturity models and ISO 9001 are similar, the application of the related procedures can differ considerably.

In our paper we present an integrated process improvement framework. Within this framework the preparation of ISO 9001 audit and SPICE assessment form an integral part of the company's internal quality assurance process. Considerable synergy effects between the SPICE assessment and the regular ISO 9001 audit are obtained. The approach also leads to lasting improvements and allows the company to develop important in-house expertise.

The model-based approach has been successfully adopted by TAW Cert GmbH and sepp.med gmbh in 2004. In this paper we present the method, our experiences with and the advantages that can be obtained from it.

Keywords

ISO 9001, ISO 15504, SPICE assessment, process improvement

1 The approach

While ISO 9001 [1] dictates the main frame for process improvements ("get better"), it does not prescribe in detail how process improvements shall be addressed. One possible way to identify process flaws or improvement potential is offered by capability maturity models such as CMMI or SPICE [2]. However, we recognize that companies are reluctant to introduce capability maturity models. Assessments, especially assessments that result in certified capability maturity rating are considered as being time consuming and expensive. This impression is intensified by the fact, that assessments are usually prepared and conducted by external consultants.

We state that this must not be true. The “integrated” approach presented in this paper combines the ISO 9001 standard process and incremental SPICE assessments. It is completely tool-based and relies on process modeling techniques. Most of the work can be done by the company itself.

As shown in figure 1, the company's process description (usually a part of the internal quality assurance manual) is used during preparation of both ISO 9001 audits and SPICE assessments. Audit and assessment are conducted simultaneously. The assessment results are used as input for the audit. Inversely, potential improvements identified during the SPICE assessment are mapped directly to the process description. Thus, changes will be immediately effective and lead to lasting improvements.

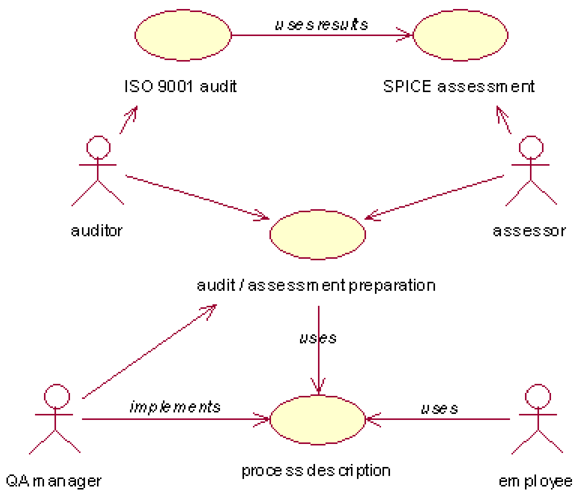

Figure 1: Using synergy effects between ISO 9001 audit and SPICE assessment

TAW Cert and sepp.med first adopted this approach in 2004. The sepp.med gmbh has specialized on IT solutions with integrated quality assurance in complex, safety-relevant domains (mainly in the medical device, pharmaceutical and automotive industry) [3].

sepp.med gmbh opted for the stepwise approach because it can be used to focus on specific domains, partly to prioritize problematic areas and mainly to become more attractive as supplier in well targeted domains (an aspect which is of particular importance for service providers). Moreover, SPICE offers the possibility to focus on parts of a process and, thus, to perform stepwise improvement including certification of sub-processes. The complete SPICE assessment of all processes is obtained over the years.

2 Process modeling

In the beginning, the process under consideration is modeled. This is done internally by the company as part of the quality assurance process. The resulting process model is not only used to prepare the assessment, but forms the basis of the internal quality assurance manual. In fact, the internal quality assurance manual of sepp.med is successively migrated to a model-based description.

The model-based process description has various advantages: it is understandable, structured and easy to maintain. Depending on the modeling tool, it may be possible to generate HTML pages and, thus, to navigate through the process description in the intranet. Also, templates can be linked to the activities they are required for. As a result, the quality assurance manual is no longer a heavy handbook, but a helpful tool for daily project work.

The process models are written using perspective oriented modeling language ([4], [5]). An example for a process model is given in fig. 2.

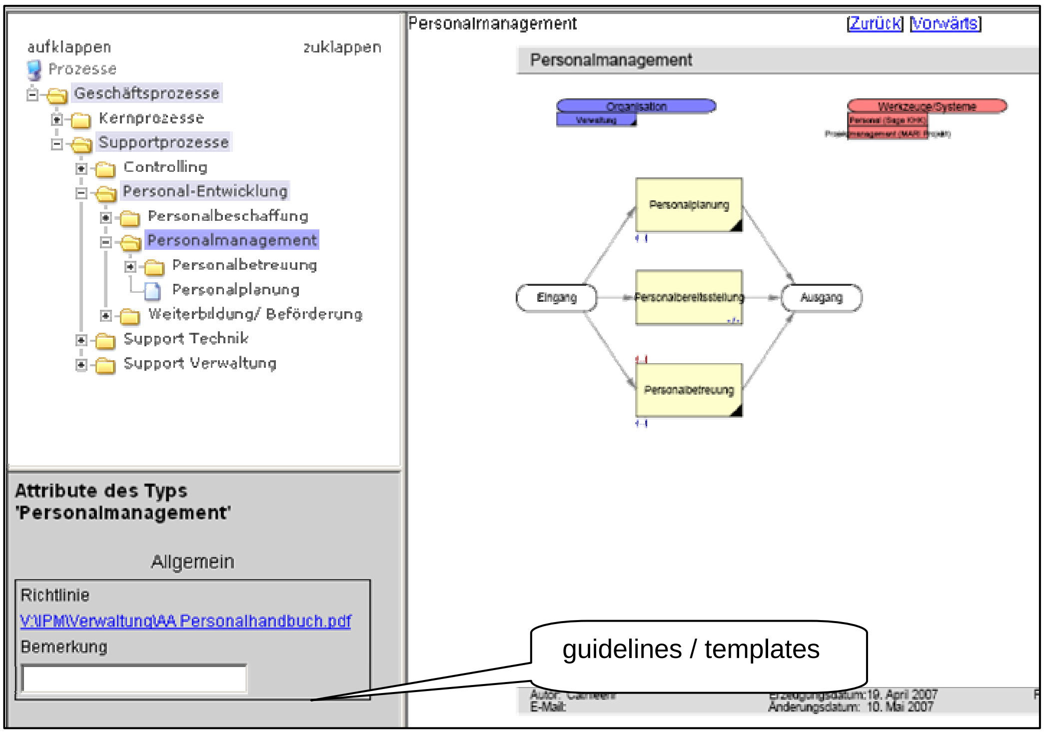

Figure 2: Example of navigable process description

Tools that support process modeling, process navigation <u>and</u> functionality required for SPICE assessments are not yet commercially available. The project “FORFLOW” of the "Bayerischer Forschungsverbund für Prozess- und Workflow-Unterstützung zur Planung und Steuerung der Abläufe in der Produktentwicklung" includes activities to develop such a process navigator [6]. A prototype was recently tested at sepp.med and the currently released version is now used for process modeling.

To guarantee homogeneous process modeling by different authors, and also to facilitate the reading of process models, sepp.med has defined some internal modeling guidelines [7]. These include mandatory fields to set and a restriction of hirearchical levels to ensure the readability.

3 Preparing the assessment

The preparation of ISO 9001 audit and SPICE assessment are an integral part of the quality assurance process. The SPICE reference model [2] is mapped to the process model – and directly within this model to keep the relationship transparent. The mapping can be done either by the company itself, if the know-how is present, or by an external consultant. However, experience shows that the know-how is automatically acquired by the company over the years. Thus, most of the work can be done internally which reduces costs.

Due to the graphical representation, the process under consideration is easy to explain and easy to understand for the assessor. A coherent terminology is used throughout the company, a fact that not only facilitates the assessment preparation, but also the internal communication between quality assurance and e.g. developers. As a result, less time is spend reading documents and during interviews.

Currently, the process modeling and mapping are both realized internally by sepp.med. Due to the lack of integrated tool support two different tools (i>PM and SPICE 1-2-1) are used. In the next version i>PM will integrate both aspects [8].

An example of the mapping of base practices directly in the process model using i>PM is shown in fig. 3. The direct mapping has the advantage that the assessor can easily check the implementation in the company's process.

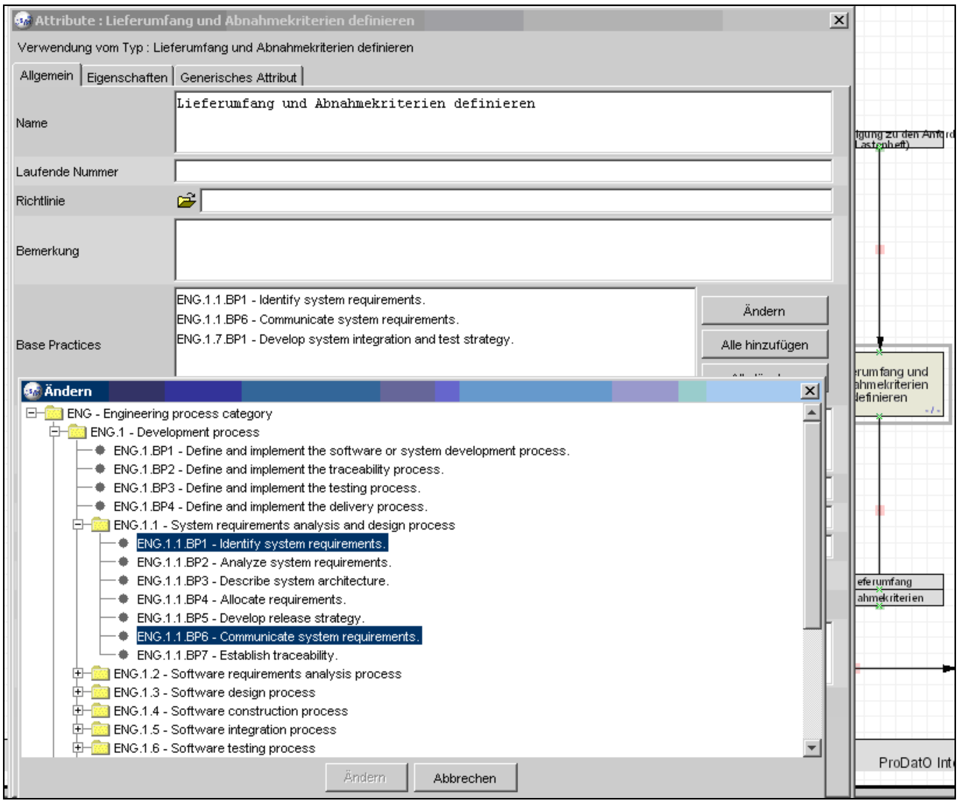

Figure 3: Mapping base practices directly within the process model

4 Assessment and audit

The evaluation, i.e. the mapping to the capability maturity dimension [2], is performed by TAW Cert within SPICE 1-2-1. The use of process models is an essential aspect for the assessment result. The process description is automatically well structured, which brings you already halfway through to level 2. Also, navigable processes are less prone to deviations.

ISO 9001 audit and SPICE assessment are conducted simultaneously. The assessor first determines the maturity level of the process. The assessment results are then used as input for the audit in three ways:

- The fact that a capability maturity model is used is already a proof that the company is striving for improvement.
- If last year's assessment results lead to process improvements they can be presented during this year's ISO 9001 audit.
- An increased maturity level indicates that improvements have been realized successfully.

To give an example: In one of the projects that have been assessed at sepp.med it has been identified during an internal audit, regular milestone planning performed and documented, but only the latest version of the planning had been kept. The assessment thus resulted in the recommendation to introduce version management for the milestone planning. sepp.med integrated this additional activity into the process description (i.e. the process model) and evidently improved the process.

The fact that assessment and audit are conducted the same day leads to improved efficiency concerning the company's resources. For sepp.med this is of particular importance because most employees work on-site at the customer's location.

It is difficult to give even qualitative ratings of the efforts saved. In 2007, the assessment itself took seven hours, involving all in all six persons. The assessment preparation at sepp.med was mostly done as part of the internal quality assurance process and, therefore, did not lead to any additional effort.

5 Conclusions

Altogether, three assessments have been performed together with sepp.med. Two of them were internal assessments with participation of TAW Cert GmbH. One assessment of a particular customer project let to a certified capability maturity rating between level 2 and level 3, depending on the subprocess. All three assessment reports have been used as input for the ISO 9001 audit.

To obtain maximum synergy between the assessment and the audit, it is important that the potential improvements identified during an assessment are realized within one year. To do so, the integrate approach is of major advantage. Weaknesses are identified directly in your company's process. Since the process dimension of the maturity model is mapped within the process model, there is no need to translate the results back from the SPICE reference model to your daily work. In the same way, improvements based on assessment results are integrated directly into the process model and, thus, will be effective immediately.

The model based process description is well adopted by the team members. New employees can be rapidly trained, an aspect, which is particularly important for rapidly growing companies (such as sepp.med). Also, changes in the process can be communicated rather easily.

We definitively recommend this approach to our customers.

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7 Author CVs

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A main aspect of the consultant activity of sepp.med gmbh lies in introduction and support of processes, methods and tool-based automatisms.

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Achieving system quality in software intensive maritime systems

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Abstract. Large industrial sites such as ships are assembled extremely fast. Standard ICT products are engineered into a system in one phase, then integrated, parameterized, and tuned on site under though time constraints. In a joint industry research project we have investigated incidents and interviewed representatives from automation system vendors and ship yards. This work has identified needs for increased attention to certain focus areas in large scale software engineering. This article suggests a framework for overall quality assessment, based on literature studies and suggestions from senior industry professionals in eight organizations from four European countries.

Keywords: industry, maritime, incidents, software, quality, assessment

1 Introduction

Software is increasingly used to control essential systems onboard vessels or offshore installations because it promises more functionality, better crew guidance, lower building costs, lower cost of operation, as well as higher flexibility for future changes and upgrades.

Unfortunately, as the use of software onboard vessels is increasing, so are the risks associated with its use. At present there are relatively few *publicly* reported incidents of failures caused by software malfunction. However, the *actual* incidents caused by software faults are nevertheless there:

- In 2002, in bad weather, a 100 meter vessel started moving without manoeuvring possibilities from the bridge. Manoeuvring capability did not return until multiple steering and propulsion components were completely powered down, and then returned to operational state. The vessel was located only 100 meters from an oil platform, which it could have damaged severely, or even sunk, if the vessel had hit the platform.
- A few years ago, a safety related on-board system on a *very* large vessel became inoperable in harsh sea. Control was not re-established until the software system was reprogrammed. During this period the vessel was exposed to very risk for complete loss of the ship.
- The International Marine Contractors Association (IMCA) reports annually incidents related to Dynamic Positioning Vessels (DP). Report IMCA M 173 [1] reports 29 incidents with loss of position

tracking, a very serious incident in narrow waters, bad weather or close to oil and gas installations. The majority of these were due to computer and software problems.

These incidents and several other incidents related to software problems that we have collected information about are further discussed in Section 3. They confirm the trend that software has increasing influence on the operation of today's vessels and show how software faults may result in serious accidents.

To address this trend *before* severe incidents occur, a multinational joint industry project called Safe Maritime ICT (SMICT) has been launched, addressing some of the quality issues that need to be addressed. During the course of this project, a need for quality assurance going further than much 'traditional SPI' has been perceived. This project investigates some real incidents, and based on this we suggest a framework for quality assurance of complex industrial sites, such as modern ships and offshore vessels.

This paper is outlined as follows: In Section 2, the research method is described. In Section 3, some results obtained are shown. Section 4 gives a short introduction to quality assurance approaches. In Section 5, directions for a framework for quality assurance of software intensive maritime systems are suggested. A brief summary and a reference to CMMI are given in Section 6.

2 Method

The SMICT joint research project studies three particular topics of interest to the maritime industry. The topics are not pertinent to this paper, but the way the topics are addressed is of importance: Focused interviews have been held with more than 25 handpicked senior industry professionals in eight organizations, in four European countries. The interviewees have been selected to represent various areas of experience from a) equipment manufacturers; b) shipyards; and c) the maritime class regime (which is a key organizational form used by the global maritime industry to achieve safe vessels).

Each interview has been conducted in such a way that there is no risk that an individual, nor an organization, can get any downside from participating in the interview. Furthermore, the interview guide used has been reviewed multiple times by multiple persons for clarity and scope, as well as to ensure that questions are not considered leading. Thus, threats to validity caused by deficiencies of the data collection have been mitigated as much as reasonably possible.

Information gathered has then been analyzed by a small group of researchers, resulting in a number of research reports. These reports have been individually reviewed and discussed in a workshop with representatives from the project partners, and then revised based on the input from the workshop.

3 Results from interviews

In this section, some results from the SMICT project are presented. **Table 1** below shows description statistics for incidents analysed.

Table 1: Statistics from the incident collection

Description	Number of incidents
Incidents reported by the SMICT partners	39
Potentially critical incidents (out of the total 39)	20
The incidents were caused by	
- Poor programming	7
- Poor design/specification	10
- Incorrect parameterization	3
- Poor integration	6

- SW did not take into consideration HW failure	7
- Unknown failure source (Complex)	6

In order to understand these incidents and our proposed approach to system quality assurance, one needs to have a degree of understanding of a typical vessel control system. As shown in Figure 1, software can be part of all components in an Integrated Automation System (IAS), either as application software, embedded software or as integration software. Much of the software is *standard software*, i.e. software used as it is without modifications in several system deliveries and by many different IAS suppliers. Standard software can be developed within the organization of an IAS supplier, bought from a supplier based on specifications developed by the IAS supplier, or it can be COTS/SOUP[1].

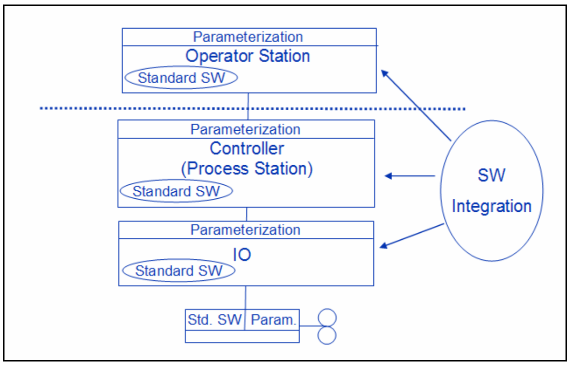

Figure 1: Architecture of a typical Integrated Automation System (IAS)

In addition to the standard software Figure 1 illustrates how *integration software* and *parameterization* is needed to make software components work properly together. Much of the integration software and parameterization are unique for each vessel delivery.

Based on the findings in the SMICT project, it is evident that there is a cost-of-risk argument in favour of increasing the quality of on-board software intensive systems, with respect to increased dependability. However, given that it is so difficult to compute a clear probability of incidents caused by software, the amount of wise investment is not easy to quantify. However, the following is clear:

- Software faults of many different types cause incidents ranging from severe (loss of major assets) to minor (loss of time). Multiple of the minor incidents identified could have been severe, if the vessel had not been at open and calm sea.
- According to interviewed engineers, faults are predominantly introduced in 'new' or unique situations such as newly written integration software, per vessel unique parameterization.
- Basis software products engineered for vessel/offshore are considered fairly stable, and less a source of quality concerns. These products are shared across multiple installations, and with a long track record.
- The interfacing between various components and systems from different suppliers is often a problem because of missing or insufficient specification of interfaces.

4 Development and QA of software intensive systems for vessels

Figure 2 illustrates Process Assessment and Product Assessment as the two different approaches to gain trust in the quality of a software product. For large and complex *systems* like an IAS it may not be efficient

[1] COTS = Commercial Off The Shelf, SOUP = Software Of Uncertain Pedigree

to use only a product approach or a process approach to qualify[2] the system. In the development of an IAS there is an extensive use of *standard software components* which should be qualified using a product approach, while the *integration and parameterization* of these components result in a large and complex system which may be best qualified using a process assessment.

Integration of software is an emerging concern in the marine industry where coordination of information systems' integration has been required to a lesser extent.

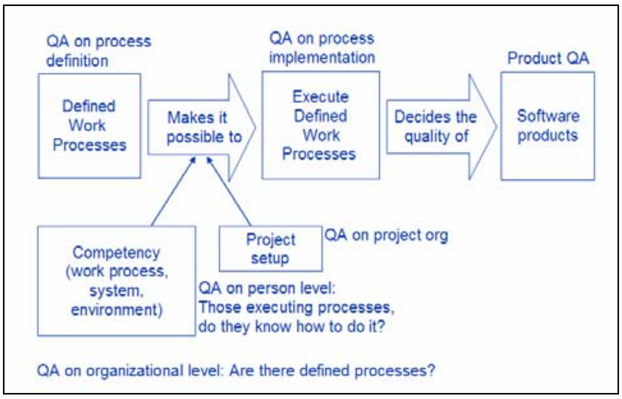

Figure 2: Ways of assuring software quality

The commissioning of the system is normally done by an individual or a few persons onboard the ship. This is to a large extent last minute adjustments and quick fixes. In such a work environment it is difficult to follow defined processes for verification of the work done, and there is also very limited time available for doing anything more than simple functional testing. In these situations the best guarantee for the quality of the work is the competency and experience of the person(s) doing the job.

5 Proposed approach

We believe that the quality assessment of an IAS should reflect the need for product focus for the standard components, process focus on the overall engineering project and competency focus for the personnel doing the commissioning of the system.

To increase the flexibility of the quality assessment process and make it as cost efficient as possible we have chosen to recommend the use of Safety Case [5] to demonstrate adequate quality and safety of the software system. The idea behind the use of Safety Case is that we will allow the supplier of the system to have a degree of freedom in how the quality is documented.

Below we give a short introduction to product assessment and process assessment in the context of marine IAS systems.

5.1 Product assessment

The IAS components best suited for product assessment are those labelled as *standard software* in Figure 1. For the IAS supplier the simplest approach will often be to buy standard software components which the component suppliers already have certified to a known quality level, however, components not intended for use in safety critical systems will normally not have such certificates. In these cases it will be

[2] Qualification in our context is a confirmation by examination and provision of evidence that new technology meets the specified requirements for the intended use.

the responsibility of the IAS supplier to supply sufficient evidence that a given component functions as intended, and that it has sufficient protection against malfunction.

To provide evidence of the quality of a software component we suggest two approaches; supplier evaluation and product evaluation.

a) **Supplier evaluation** is similar to process assessment (see below) but may include more than just assessment of the development process. Possible actions included in a supplier evaluation are:

- Process assessment, e.g. is the supplier ISO 9001 certified, CMMI certified or at least familiar with and applies relevant elements of these or similar process evaluation standards.
- Assessment of previous projects, i.e. check on the history of the supplier to see if he has a tradition of delivering software according to specification.
- Evaluation of the financial/competitive situation to estimate the risk of bankruptcy, take-overs or similar which can reduce the lifetime of the product.
- Check if the supplier uses/supports standards so that their equipment/component may be replaced if needed.

b) Product evaluation can be done in several different ways, but the objective is to reduce the risk of using COTS/SOUP. For a given component the quality may be known or unknown. With known quality we mean that the component has been qualified to a defined quality level (e.g. safety integrity level for a safety system), or it is “Proven in Use”. If the supplier of the component can not supply sufficient information about the quality of the component it is necessary for the user of the component to supply evidence that the component will functions as intended, or that the system in which it is integrated is protected against component malfunction.

5.2 Process assessment

Two different automation systems delivered to two different ships will not be identical. Because of these differences, it is difficult and expensive to use a product approach to evaluate the quality of the total system. However, even though the results are different for each delivery, the work processes are the same for several deliveries. A list of such work processes includes:

- Integration of standard software components (SW Integration in Figure 1 on page 9)
- Implementation of special functionality requested by the ship owner
- Parameterization of components
- Installation/commissioning of the system

For these processes, and other work processes which produce results which are unique for each system, process assessment is necessary to gain confidence in system quality. Process assessment will not eliminate the need for testing, but it will reduce the extent of this.

Several standards can be used to assess the quality of work processes such as ISO 9001 [2] CMM/CMMI [3], ISO 17894 [4]. Bofinger et. al. proposed in +SAFE [7] an addition to CMMI for development of safety critical software.

5.3 Applicability outside maritime sector

Several of the partners in this joint research project operate also in other industry sectors, e.g. the energy sector, and during our work we have seen that many of the challenges we have identified are valid for everyone in the process industry, not only within maritime sector. This has led to an initiative to start a new project which will take the results from this project further and investigate how to improve the operational reliability of large automation systems used in the energy sector.

6 Summing up

Product approach for standard products
Standard products are used across multiple installations. Therefore, there are multiple units onto which to share the cost of software product assessment. This also reduces risk across many vessels; therefore, there is benefit from this approach to multiple yards and multiple owners, from the effort of each supplier.

Process approach for unique products
A product quality assurance approach for one-off products would be prohibitively expensive, since the cost cannot be shared across multiple installations. Yet, significant risk is introduced in these products, which are embedded in parameterization, installations, and commissioning phases. However, competency in performing these items can be shared across installations.

Competency is embedded in deployed work processes, and in personal competency/experience. Assuring competency in its embodiments provides the ability to share costs, as well as provide a large effect.

Process assessment alone is not sufficient
We have previously stated that the complexity of the IAS is so high that reliance on product assessment as the only means to assure quality and safety is insufficient. In our interviews and discussion with industry professionals they have all stressed the necessity of good work processes, but they have also pointed out the shortcomings of process assessment. In their opinion the process assessment is a good tool to see if an organization has the necessary tools in place to facilitate good product quality, but good processes in itself is not a guarantee for good quality. Product assessment is needed in addition, but the extent of this may be somewhat reduced if the results from it show correlation between work processes and product quality.

This scepticism to reliance on process assessment alone is supported by results from SEI (see Table 2) which shows that for CMMI improvements very large variance in the quality improvements achieved may be expected.

Table 2: CMMI Performance Results from [8]. The table shows median improvements and the lowest and highest improvements for each of six performance categories. For quality improvements the median is 48 % while the lowest is 2 % and the highest is 132 %.

Performance Category	Median Improvement	Low	High
Cost	34%	3%	87%
Schedule	50%	2%	95%
Productivity	61%	11%	329%
Quality	48%	2%	132%
Customer satisfaction	14%	-4%	55%
Return on Investment	4.0 : 1	1.7 : 1	27.7 : 1

An important shortcoming of the process approach is lack of data stating the correlation between quality of work processes and specific quality attributes such as reliability and safety. This correlation has to be established for each case through product assessments. A pure work process approach to quality assessment will therefore not be sufficient to give the required trust in software system quality.

Acknowledgments
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Software process improvement for the product lifecycle

Dipl.-Math. Dirk Malzahn

Abstract

If it is SPICE, CMMI, ITIL or ISO 90003, the current process frameworks cover the software product lifecycle only partially. Whilst CMMI and SPICE have their strengths in the software development part, ITIL or ISO 20000 cover the service delivery of software. As any organization should aim for high quality in all stages of the software lifecycle, well defined processes have to cover software from the first idea up to the retirement of the software. As the standards mentioned before mainly address process improvement, a complete life cycle for software must additionally integrate the evaluation of both, the software processes as well as the software product.

Keywords

Software product lifecycle, CMMI-DEV, CMMI-ACQ, CMMI-SVC, SPICE, ISO 15504, ISO 20000, ISO 90003, ISO 9126, ISO 14598, ISO 25000, SQuaRE.

1 New requirements for the software lifecycle

What determines the quality of software? Some will say it is customer satisfaction, others will emphasize the maturity of processes and even some other will mention that the quality of a software product is assessable in the very beginning of a software project.

The truth is in the middle. The quality approach for software has to start with the very first idea – e.g. to ensure that the software is feasible. On the other hand quality should not end before the software is retired. In between processes as well as products have to be evaluated in a well defined manner. Therefore a lifecycle model for software has to address at least the following questions:

- Are we able to do it, is it feasible?
- Do we develop the product right?
- Have we developed the right product?
- Delivers the product the intended services?
- When and how will the software be retired?

Most process models and standards only cover parts of these questions. While CMMI and SPICE have their strengths in the development, ISO 20000 and ITIL address the service part and SQuaRE (ISO 250xx, ISO 9126, ISO 14598) has its focus on the evaluation of the software product, the feasibility and retirement is hardly covered by standards.

In the following chapters we will first detail the requirements for each phase of the software product livecycle. In a second step we will discuss how this life cycle is covered by the ISO world and the CMMI world. The third step will cover the “forgotten children” feasibility and retirement. This leads to a proposal for a reasonable combination of standards and approaches. The last chapter will then introduce a tool which enables a company to perform assessments based on these combinations of standards.

1.1 Project feasibility evaluation

If a software project may be successful, this can be determined in the very beginning. There are lots of indicators that show if both the customer as well as the supplier are ready to start a project for developing the software. Possible indicators may be

- Qualification and skills of the supplier
- Qualification and skills of the customer
- Supplier experience
- Customer process volatility
- Process maturity of both sides
- …

In the end an assessment of the readiness for and the risks of a project has to be performed.

1.2 Software development processes

The quality of a software product is highly influenced by the processes that are used for the development of the software. These processes are not only restricted to the software development but have also to cover organizational topics as well as management topics. A mature organization must be able to show its capabilities in the

- development / engineering of software
- management of projects
- management of processes
- support for the three categories mentioned before

If and only if all four categories are well established and aligned, software development can deliver a high quality software product.

1.3 Software evaluation

Software evaluation is often restricted to testing – but it is much more. Different stakeholders have different views on the software product. Therefore software evaluation mustn't only be seen in the view of the developing organization but by the customer, the market, maybe the legislation or even every other party who is interested and competent to use or evaluate the software.

1.4 Service processes

Developing high quality software is only half the way of the journey. The quality of software highly depends on the benefits for the user. Therefore each software system has to be operated and supported based on customer and user needs. While the duration of the software development is mostly planable, the service delivery period and the support requirements can highly differ from the original intent.

1.5 Software retirement evaluation

Sometimes service delivery is like "riding a dead horse". An organization that does not prepare for the retirement of their software faces the problem that new or replacing software is not available in time, scope or quality. The start of service delivery should be the latest point when provider and user discuss the procedures for the retirement of the software.

2 The different worlds for the product life cycle

Regarding the software community, two approaches – driven by software development - govern the world of the software product lifecycle: CMMI and SPICE. While SPICE is published as an international standard via the ISO 15504 group of standards, the CMMI is published by the Software Engineering Institute with high support by the US Department of defence.

Both approaches have their pros and cons but this should not be the topic of this paper. In fact it should be analyzed, how these process frameworks support the need for a software product lifecycle.

2.1 The world of CMMI

The Capability Maturity Model Integration (CMMI ®) and its predecessor – the CMM ® - are well known process frameworks for software development since the early nineties of the last century. The original versions of CMM and CMMI had their main focus on the development of software. This has changed since 2006. The current CMMI approach does not only cover software development but will also be – or already is - extended to acquisition and service delivery.

In near future the CMMI will be available in three representations:

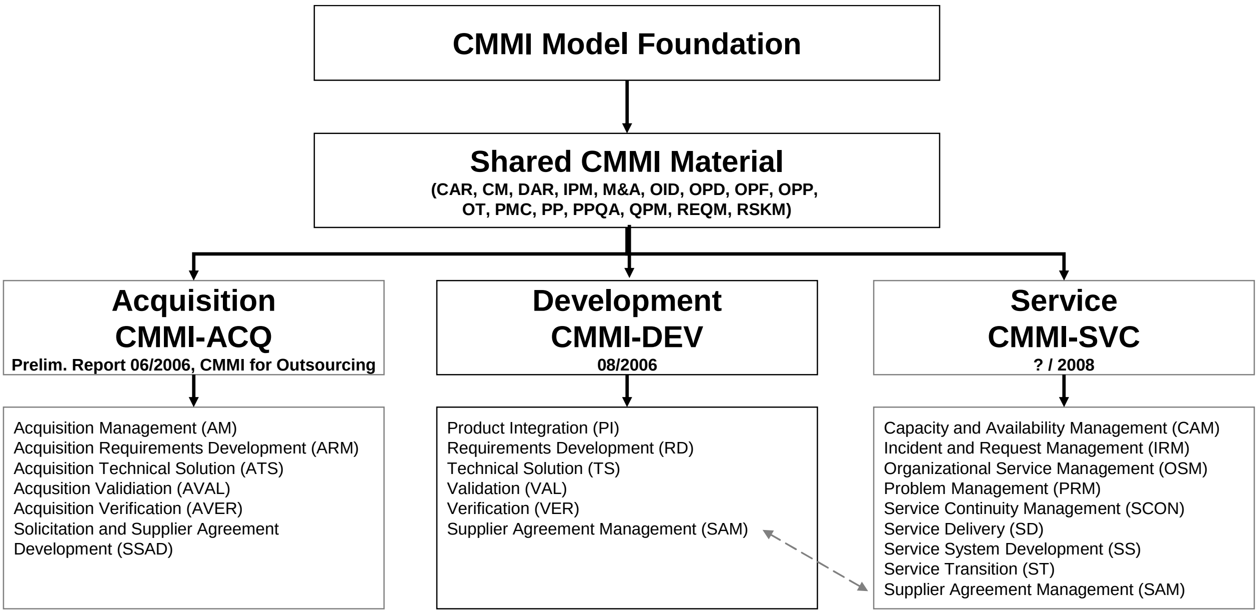
- CMMI-DEV – CMMI for development, which covers the software development part as it was done by prior CMMI versions or CMM,
- CMMI-ACQ – CMMI for acquisition, which has a special focus on acquisition processes; for this representation a preliminary report exists since June 2006 (most elements have been published in the book CMMI for Outsourcing),
- CMMI-SVC – CMMI for services, which will cover the service delivery and is available as baseline for review.

All representations consist of some shared material and additional processes which are specific for each representation. All representations will follow the model foundation concerning component structure and maturity and capability levels.

The shared material covers all processes concerning project management and organizational development. The specific material for the development representation has 6 additional processes for software development. The acquisition representation has the same processes, but here the processes are defined from a customer perspective in an acquisition position.

While these representations cover the software development, the CMMI for services defines 9 processes that cover service delivery and therefore defines the successor of the development representation.

An overview of the different representations and processes is given below.



(CMMI Model representations)

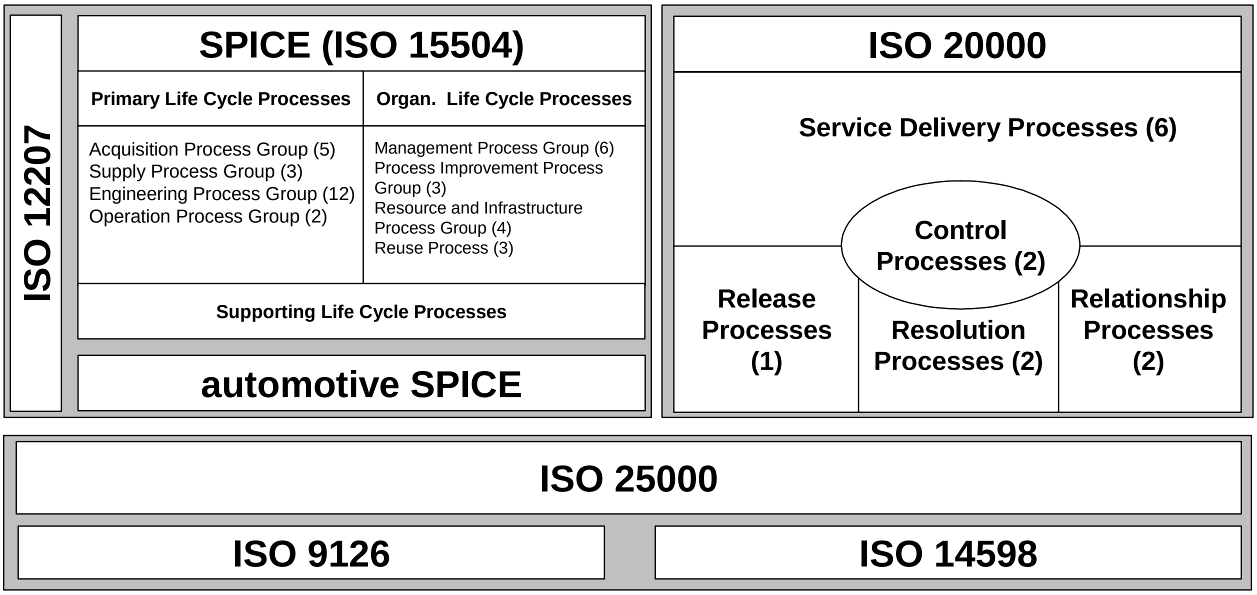
3 The world of ISO

The world of ISO gives different approaches for quality and life cycle management. Regarding the software part, at least 2 approaches are given, one by the ISO 90003 and the other by the ISO 15504

(SPICE). As the main focus of the ISO 90003 is the translation of the ISO 9001:2000 into the world of software, this approach is not considered as the best practice for a software product. It can help to optimize software quality in an ISO 9001:2000 focussed organization, but the ISO 15504 is much more focussed on software processes.

Therefore the development part of the ISO world should be covered by ISO 15504 (SPICE = Software Process Improvement and Capability dEtermination). Looking for the other parts of the software lifecycle ISO 20000 can be identified for the service delivery and ISO 25000 covers the product evaluation.

In total, the ISO world for the software lifecycle can be combined as follows:



(Standards in the ISO world)

3.1 SPICE (ISO 15504)

The ISO 15504 (SPICE) is structured in 5 parts. Part 1 defines the basic concept and the vocabulary. In part 2 rules for performing an assessment are defined and in part 3 guidance for the assessment is given. Part 4 gives additional guidance on the use for process improvement and capability determination.

The interesting part under the integration perspective is part 5. This part defines an exemplar process assessment model.

SPICE defines 3 categories. These categories are structured in groups and each group has several processes [ISO 15504-5]. The categories with their groups are:

- Primary Life Cycle Processes
  - Acquisition Process Group (ACQ)
  - Supply Process Group (SPL)
  - Engineering Process Group (ENG)
  - Operation Process Group (OPE)
- Organizational Life Cycle Processes
  - Management Process Group (MAN)
  - Process Improvement Process Group (PIM)

    - Resource and Infrastructure Process Group (RIN)
    - Reuse Process Group (REU)
- Supporting Life Cycle Processes
    - Supporting Process Group (SUP)

The Primary Life Cycle Processes consist of processes that serve primary parties during the life cycle of software. A primary party is one that initiates or performs the development, operation, or maintenance of software products. These primary parties are the acquirer, the supplier, the developer, the operator, and the maintainer of software products.

The Organizational Life Cycle Processes consist of processes employed by an organization to establish and implement an underlying structure made up of associated life cycle processes and personnel and continuously improve the structure and processes. They are typically employed outside the realm of specific projects and contracts; however, lessons from such projects and contracts contribute to the improvement of the organization.

The Supporting Life Cycle Processes consist of processes that support another process as an integral part with a distinct purpose and contributes to the success and quality of the software project. A supporting process is employed and executed, as needed, by another process.

Comparing the SPICE categories with the CMMI constellations, strong connections can be identified between the process groups of the primary life cycle processes and the CMMI constellations. The Acquisition Process Group and Supply Process Group have the same focus as the CMMI-ACQ as well as the Engineering Process Group and the CMMI-DEV. Only the CMMI-SVC doesn't have a counterpart in SPICE. The Operation Processes Group and some processes of the Supporting Process Group address service related topics, but a common approach is not delivered.

3.2 ISO 20000

ISO 20000 covers the common parts of service delivery such as control processes, release processes, resolution processes, relationship processes and the processes for service delivery itself. For these process groups 13 processes are defined. Regarding each process group,

- the objective of the Service Delivery Process Group is to define, agree, record and manage levels of service, and consists of the processes
    - Capacity Management
    - Service Continuity and Availability Management
    - Service Level Management
    - Service Reporting
    - Information Security Management
    - Budgeting and Accounting for IT Services
- the objective of the Relationship Process Group is to describe the related aspects of Supplier Management and Business Relationship Management, and consists of the processes
    - Business Relationship Management
    - Supplier Management
- the objectives of the Resolution Process Group are to restore agreed service and minimize disruption to the business, and consists of the processes
    - Incident Management
    - Problem Management

- the objective of The Control Process Group is to define and control the components of service and infrastructure, and consists of the processes
  - Configuration Management
  - Change Management
- the objective of the Release Process Group is to deliver, distribute and track changes, and consists of the process
  - Release Management

Those who know ITIL may have found lots of similarities in the process names and structure of ISO 20000. The ISO 20000 is well aligned with ITIL. Whilst ITIL is a collection of best practices, ISO 20000 defines specifications to support a service provider in delivering high quality services. Seeing it from the other perspective, ITIL best practices help to achieve the quality of service management as defined by ISO 20000.

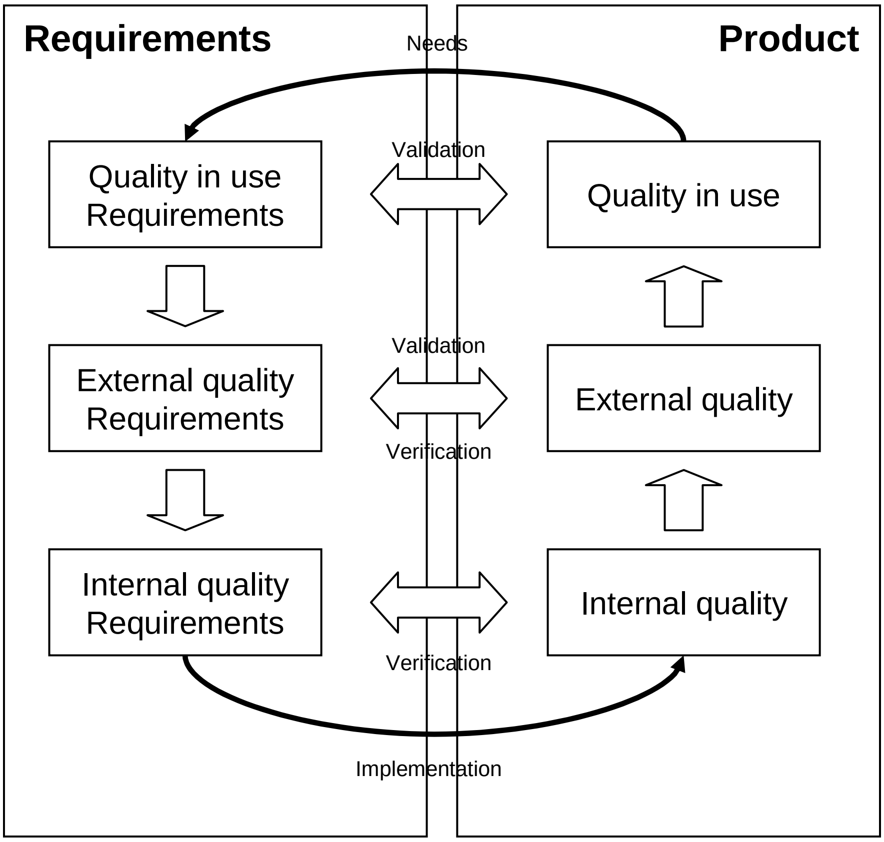
3.3 ISO 25000 and others

In future, the quality of a software product can be evaluated by the definitions of the ISO 25000 series of standards (SQuaRE = Software product Quality Requirements and Evaluation).

The SQuaRE series is organised by 5 divisions:

- ISO/IEC 2500n standards (Quality Management Division) define all common models, terms and definitions referred further by all other standards of the SQuaRE series.
- ISO/IEC 2501n standards (Quality Model Division) provide a quality model – including practical guidance – for internal and external software quality and software quality in use.
- ISO/IEC 2502n standards (Quality Measurement Division) provide a reference model for software product quality measurement, including mathematical definitions of quality measures and guidance for their application, applicable to the three groups mentioned under ISO/IEC 2501n.
- ISO/IEC 2503n standards (Quality Requirements Division) have the focus on specifying quality requirements that can be used as input for an evaluation process or the elicitation of quality requirements for a software product.
- ISO/IEC 2504n standards (Quality Evaluation Division) provide evaluators, acquirers or developers with requirements, recommendations and guidelines for software product evaluation.

The idea behind this series of standards is a Software Product Quality Life Cycle Model based on three different views: the internal view on software quality which covers the stages of software development (including non-executable software products, such as documentation, manuals, etc), the external view, targeting for technical verification and validation of the software, and the quality in use view which is focused on the end-users point of view. For all three views requirements have to be defined which are verified and / validated against the software product as follows:



(SQuaRE Software Product Quality Life Cycle Model)

As long as this series of standards is not fully published, the predecessors – ISO 9126 and ISO 14598 – have to be taken into account.

The ISO 9126 defines quality characteristics for software products grouped in the following categories (number of characteristics per category given in brackets)

- Functionality (5)
- Reliability (3)
- Usability (3)
- Efficiency (2)
- Maintainability (4)
- Portability (3)

By selecting and using these characteristics one can evaluate software product quality on a well defined basis. To perform the evaluation, a process has to be defined as given by the ISO 14598. This standard defines rules and activities for planning, management and performing product evaluations from a developer, evaluator and supplier perspective.

The combination of ISO 14598 and ISO 9126 gives a powerful tool for software product evaluation which will be optimized by ISO 25000 in future.

4 Forgotten children – feasibility and retirement

Both of the worlds discussed above hardly cover feasibility and retirement of software. Feasibility is mentioned as part of the requirements management processes. Retirement is covered in SPICE by practices in the maintenance and asset management processes.

While for retirement no common approach could be identified, the feasibility part is covered by new approaches coming from the world of service oriented architectures. The readiness and risk factor assessment as defined by [Bieberstein et al.] gives a good idea how the feasibility of a software project can be evaluated. Even though the focus of this assessment is on service oriented architectures, it gives good advice on how to rate the capability and maturity of a software developing and operating organization.

Topics covered by this assessment are e. g.:

- Business Process Knowledge
- Client Side Volatility
- Customer Understanding
- Services Sourcing Reliability
- Cross-Firm Services Availability
- Service Business Alignment
- Executive Support
- Governance of Service
- Funding
- Skills Base
- Service Ownership
- Services Identification
- Componentization
- Component Placement
- Services Management
- Services Security
- Operational Model
- Platform Heterogenity
- Geographic Dispersion
- IT Process Flexibility
- IT Standards Openess

It can be seen easily that this approach does not only cover the feasibility of the developing project but especially the feasibility of the service delivery.

5 An integrated lifecycle approach for software

Tying the two worlds together and making the best of it, it has to be stated, that the software product life-cycle could not be covered by only one standard. Nevertheless a reasonable combination can provide a useful lifecycle.

The ISO world covers more lifecycle phases than the CMMI world, but both can be used as parts of a nearly complete lifecycle:

Phase	ISO world	CMMI world
Project feasibility	Not covered, readiness and risk factor assessment may be used	
Software development processes	ISO 15504	CMMI-DEV / -ACQ
Software evaluation	ISO 25000	Not covered, ISO 25000 may be used
Service delivery	ISO 20000	CMMI-SVC
Software retirement evaluation	Not covered, no common / best practice approach	

(Possible lifecycle combinations)

Both worlds have their pros and cons. While the ISO world covers the product evaluation in much more detail, the CMMI is based on a set of management and organizational processes which are common for all phases that are addressed by the CMMI. It is up to the decision and maximum use of the organization which approach fits most, but both worlds give good advice on what to do.

6 A tool for multi model assessments

When the capability and maturity of a software developing and service delivering organization are being assessed, one of the major problems is the efficiency and effectiveness of the assessment process. Even though all standards and process frameworks have their own focus, some topics – such as management, organizational development,… - are covered by more than one standard. On the other hand some organizations already fulfil the requirements of one standard and don't accept that they have to answer the same question more than one time under the focus of different standards which cover the same topic.

An organization that e. g. has an ISO 9001:2000 compliant quality management, fulfils lots of the requirements of CMMI and SPICE. Therefore these requirements shouldn't be part of the assessments as they are already fulfilled. On the other hand if an organization performs an assessment for more than one standard in parallel, one topic should only be addressed once. If the organization e. g. performs a CMMI and SPICE assessment / appraisal in parallel, both frameworks ask for a Work Breakdown Structure (WBS). Even though the focus is different, some of the requirements for a WBS are similar.

In general, in a so called multi-model assessment in an organization that already has a quality model in place

- pre-fulfilled questions must be eliminated,
- redundant questions mustn't be asked twice.

A pre-fulfilled question is given, when the objective of the question is already covered by the quality model in place. A redundant question is given, when the objective of the question is already covered by a question of another standard that is in scope of the multi-model assessment.

That these multi-model assessments are feasible, has been proved by the research project SASQIA which won the German Future Contest Ruhrgebiet in 2004. The SASQIA tool which was published in late 2006 gives the possibility to perform multi-model assessments for CMMI, SPICE, ISO 9001, ISO 90003, Six Sigma, EFQM, ISO TS 16949 and others. The complete set of standards as defined in this paper will be covered by mid 2007.

By the SASQIA approach and tool it is shown, that an integrated software product lifecycle is not only feasible but also assessable. For further details see www.sasqia.de.

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

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Keywords:

Automotive Assessment method, Software Process Improvement (SPI)

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.

1 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]

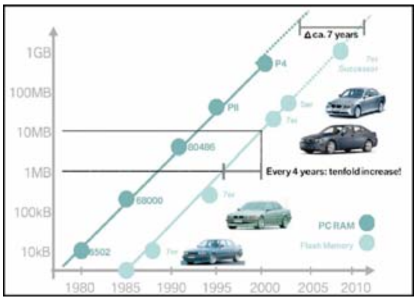

Figure 1 – Growth in the automotive Software Industry

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.

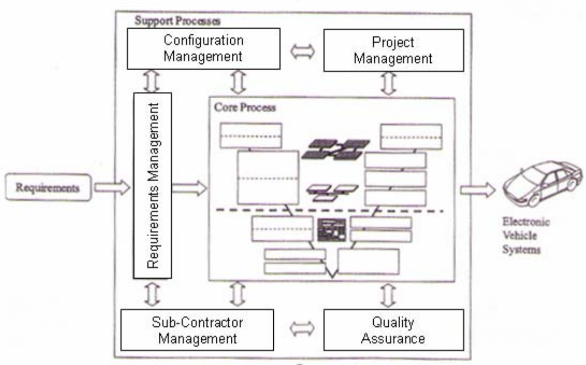

Figure 2 – Support processes for Electronic Systems and Software Development (Adapted from Schauffele and Zurawka, [9])

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 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 Group[4], and the Procurement Forum[5] 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].

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[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.

[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.

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.

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 p*ublicly 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.

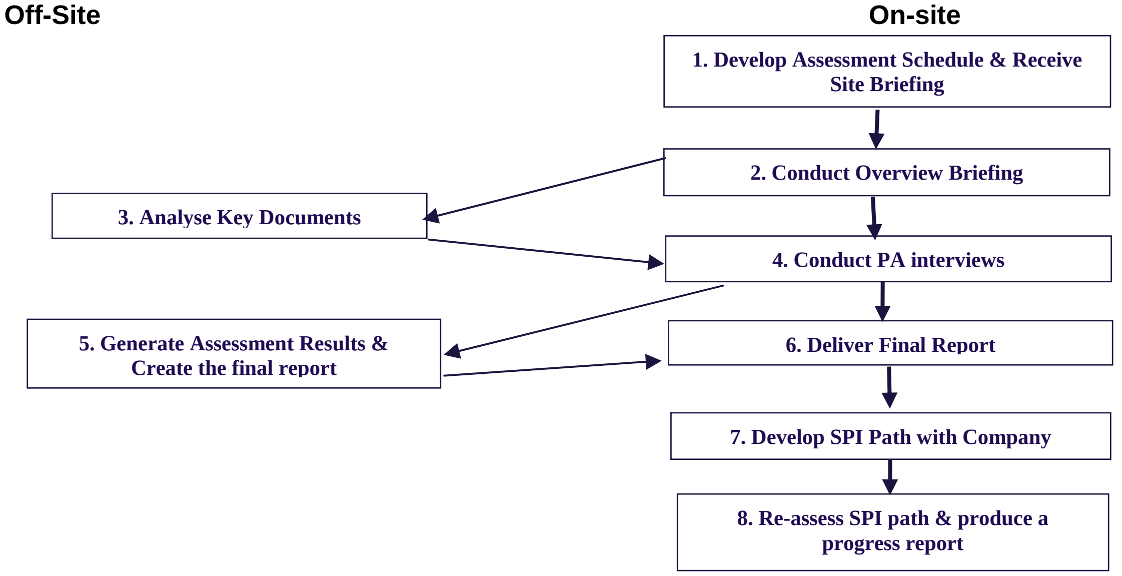

Figure 3. Automotive –Adept Stages

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**
Requirements management	7	7	18
Project Planning	21	25	2
Project Monitoring & Control	8	19	8
Configuration Management	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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Assessing IT Service Management Processes with AIDA® – Experience Feedback

Ruddy Hilbert, Dimension Data
Alain Renault, Centre de Recherche Public Henri Tudor

Abstract

Assessing processes is now a common activity in the software domain. The ISO/IEC 15504 standard, derived from the SPICE® project, is often used as a methodology to help assessors implement an objective and repeatable assessment process. The Assessment and Improvement IntegrateD Approach (AIDA®) has been developed on this basis, to provide assessors with a Process Assessment Model for IT Service Management. This paper reports on the experience of implementing AIDA® assessment in four of Dimension Data's Global Service Centres, on four continents.

Keywords

AIDA®, ISO/IEC 15504, ITIL®, Process Reference Model, Process Assessment Model, IT Service Management, Process Assessment, Process Improvement.

1 Introduction

In 2006 Dimension Data began a Service Improvement and Alignment initiative across its Global Service Centres. The objective of this initiative is to improve quality of service and to ensure a consistent client experience from Dimension Data throughout the world. Gaining a thorough understanding of current Service Support and Service Delivery process maturity in the Global Service Centres was quickly identified as a priority.

The ISO/IEC 15504 standard, derived from the SPICE® project, is often used as a methodology to help assessors implement an objective and repeatable assessment process. The Assessment and Improvement IntegrateD Approach (AIDA®) has been developed on this basis, to provide assessors with a Process Assessment Model for IT Service Management.

CRP Henri Tudor[1] was validating its AIDA® framework and methodology, and looking for reference partners. The AIDA® methodology clearly met Dimension Data's objectives and we realised that teaming up with CRP Henri Tudor would be mutually beneficial for both parties. It was agreed that an assessment of four Dimension Data Global Service Centres, on four continents, would be undertaken using the AIDA® methodology. The objective was to assess the IT Service Management processes of those centres in order to determine the capability level of the processes, identify best practices, which could potentially be shared across the Global Service Centres, and propose recommendations for improvement and alignment.

This paper reports on the experience of implementing AIDA® assessment in these Global Service Centres, the outcomes and the lessons learned.

2 Context of the experiment - Objectives

2.1 About ISO/IEC 15504 and AIDA®

The ISO/IEC 15504 standard sets out the minimum requirements for performing an assessment that ensures the consistency and repeatability of the ratings. Some parts of the standard contain guidance that will provide a more detailed understanding of the subject. A 15504 assessment is carried out against a defined assessment input utilising conformant Process Assessment Model(s) related to one or more conformant or compliant Process Reference Models. ISO/IEC 15504-5 contains an exemplar Process Assessment Model that is based upon the Process Reference Model defined in ISO/IEC 12207 Amd 1 Annex F.

The ISO/IEC 15504 standard, being derived from the SPICE® project, is mainly used as a methodology to help assessors implement an objective and repeatable assessment of software processes.

However, some companies and research centres have started to investigate the possibility of applying ISO/IEC 15504 to other processes than software. Several initiatives have given birth to Process Reference Models and Process Assessment Models in various domains such as automotive (Automotive Spice), operational risk (Basel II Agreement), knowledge management, IT Service Management (AIDA®) and IT security.

2.2 About Dimension Data

Founded in 1983 and headquartered in South Africa, Dimension Data[2] is a specialist IT services and

[1] Centre de Recherche Public Henri Tudor, Luxembourg, http://www.tudor.lu
[2] http://www.dimensiondata.com/

solution provider that helps clients Plan, Build and Support, Manage, Improve and Innovate their IT infrastructures. The company employs 9 500 people worldwide.

Dimension Data applies its expertise in networking, security, operating environments, storage and contact centre technologies and its unique skills in consulting, integration and Managed Services to create customised client solutions. Its rich history in networking has placed the company at the forefront in helping clients simplify and consolidate their IT infrastructures through Internet Protocol (IP) convergence.

Dimension Data's Global Service Centres represent Dimension Data's "Managed Service" delivery arm. The centres are located across the world (Johannesburg, Frankfurt, Bangalore, Melbourne and Boston) and provide 24 hour follow-the-sun Managed Services to regional and international clients. Each service centre is staffed by skilled professionals capable of providing online diagnostics and hence speedy resolution to a broad range of technologies, and restore service according to agreed service levels.

Dimension Data is making significant investment in becoming a strategic technology partner to its clients. In order to do this, it is necessary to expand, improve and align the *Manage* Service function by focusing on the management of the full lifecycle of the infrastructure and the efficient performance of the client's technology.

The Service elements in the Manage Service function break down into two key areas:

- Service Delivery focuses on long term planning, such as availability and capacity management
- Service Support focuses on day-to-day operations and support, such as release, change and configuration management

In this way Dimension Data plays a key role in its clients' businesses, maximising the return on their investment in a deployment, and extending of the useful lifecycle of a technology solution –in other words, we help clients to 'sweat assets'.

Dimension Data's Global Services Operations team is in charge of supporting business strategies by defining and deploying a Standard Operating Environment (SOE) for Systems, People and Processes in collaboration with their regional counterparts. This facilitates the deployment of global solutions and ensures a consistent client experience across the world.

The following chart illustrates Dimension Data's Services Continuum

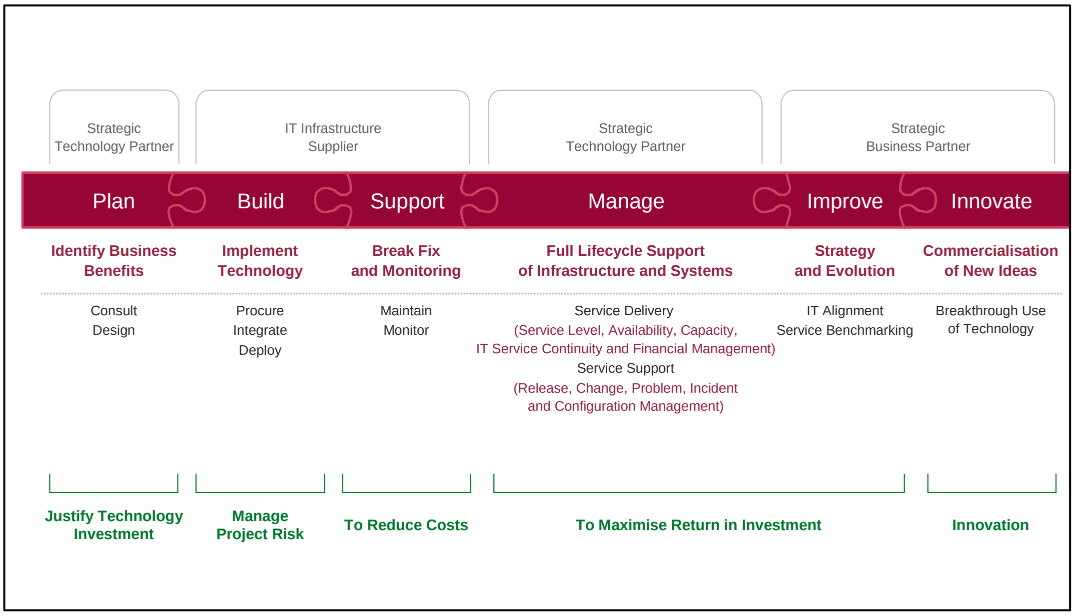

Figure 1: Dimension Data's Services Continuum

2.3 About IT Service Management and ITIL

IT Service Management focuses on delivering and supporting IT services that are appropriate to the organisation's business requirements, whatever its type or size. ITIL provides a comprehensive, consistent and coherent set of best practices for IT Service Management processes, promoting a quality approach to achieving business effectiveness and efficiency in the use of information systems. Developed in the late 1980s, the IT Infrastructure Library (ITIL) has become the worldwide *de facto* standard in Service Management.

OGC, the British Office of Government Commerce,[3] defines ten processes for IT Service Management in the two well-known ITIL® books "Best Practices for Service Support" and "Best Practices for Service Delivery".

2.4 Why this assessment project?

In March 2006 Dimension Data began a Service Improvement and Alignment initiative across the Global Service Centres, located in Boston (North America Region), Johannesburg (Africa), Melbourne (Australia), Bangalore (Asia) and Frankfurt (Europe). The objective of this ongoing initiative is to improve quality of service, align ITIL® best practices across all Global Services Centres, and ensure a consistent client experience from Dimension Data throughout the world.

Dimension Data's Service Improvement and Alignment approach is based on the six step model recommended by ITIL®.

Figure 2: Dimension Data's Service Improvement and Alignment Approach

It is important that a global company ensures that its clients benefit from the same quality of service wherever they are in the world. It became apparent to Dimension Data that each of its Global Service Centres had a slightly different scope of Services, and that their organisational and business models also varied. As Global Service Centres are fully client-focused, they have slowly changed in order to adapt to regional business contexts and business requirements. The need to assess current levels of Service Support and Service Delivery process maturity in each centre, was quickly identified as a priority.

[3] http://www.ogc.gov.uk/

The purpose of conducting an assessment was to:

- Determine the capability level of the processes in the selected Global Service Centres;
- Identify best practices, which could potentially be shared across Global Service Centres; and
- Propose recommendations for improvement and alignment.

Dimension Data reached out to a number of industry players and evaluated several different process assessment methodologies. We wanted to be sure that the assessment tool we used would not only allow us to understand the process capabilities of the different regional centres using ITIL® as the reference model, but that it would also provide some recommendations, so that we could prepare the ground for the next phases of the Service Improvement and Alignment Project.

At the time, the CRP Henri Tudor[4] was validating its AIDA® framework and methodology, and was looking for reference partners.

The AIDA® methodology clearly met Dimension Data's objectives and, after some preparatory meetings, it became evident that teaming up with the CRP Henri Tudor would be mutually-beneficial for both parties. It was agreed to first develop an assessment approach and thereafter roll out the assessment of the five Dimension Data Global Service Centres. The proposed timeframe was one Global Service Centre per quarter. Each centre would be re-evaluated every 18 months.[5]

3 AIDA® - The methodology used

AIDA® was developed to provide assessors with a Process Assessment Model for IT Service Management. The AIDA® Process Assessment Model for IT Service Management is based on the ten ITIL® processes proposed by the British Office of Government Commerce.

The ITIL® processes are presented in a very business-oriented manner and include a high level of detail. This can sometimes make reading and understanding the document a challenge, and identifying the purpose and outcomes of the processes can be difficult.

Using ITIL® best practices, the CRP Henri Tudor developed a Process Reference Model which presents those IT Service Management best practices in terms of process, with Purpose and Outcomes in accordance with the requirements of ISO/IEC 15504 2:2003. The purpose of this Process Reference Model is to define a set of processes that can be used as the process dimension for a Process Assessment Model.

The Process Assessment Model proposes additional information that can be requested when running a process assessment: base practices, inputs and outputs. The capability levels and process attributes are identical to those defined in ISO/IEC 15504-2.

The AIDA® Process Assessment Model is used as input reference for an ISO/IEC 15504 assessment. It ensures that the assessment (of the IT Service Management processes in this case) is objective and repeatable. This enables true benchmarking across assessments of different centres, and facilitates the re-assessment of the same units. It also allows for external 15504 assessors to provide input when needed, provided other members of the assessment team have adequate competence level in the application domain (IT Service Management in this case).

In addition to the Process Assessment Model, a specific questionnaire for each field of activity was developed to help assessors during the interviews. However this questionnaire is not mandatory and a competent assessor can conduct interviews using the Process Assessment Model without a questionnaire, as part of a more 'open' discussion.

AIDA® was developed by a public research centre in Luxembourg and is currently in the transfer phase of a Research and Development project. The objective is on the one hand to transfer knowledge about the methodology to the private sector (consultancy firms or private companies), and on the other hand to come

[4] Centre de Recherche Public Henri Tudor, Luxembourg, http://www.tudor.lu

[5] This paper relates the experience with four of Dimension Data's five Global Service Centres.

up with a recognised certificate for the "*competent*" assessors who have successfully completed the ISO/IEC 15504 for IT Service Management training course and can show evidence of having undertaken at least two assessments where they applied the AIDA® method.

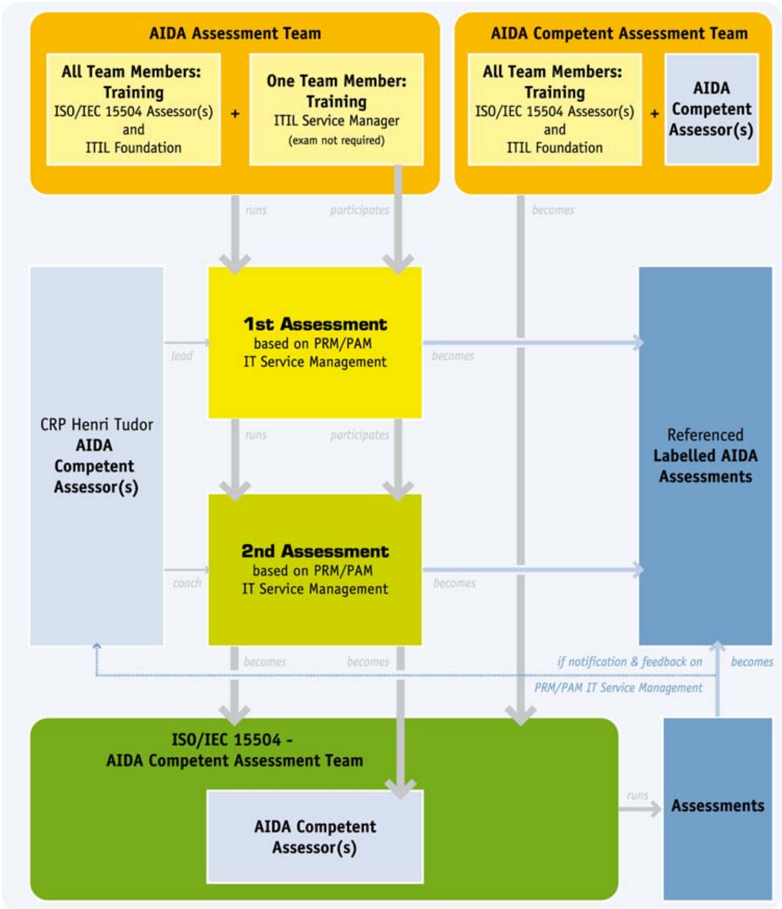

Figure 3: The AIDA® transfer scheme

4 Project overview

The AIDA® assessment was proposed to and validated by the Global Service Centre Directors at their six-monthly meeting. The required investment from the regional directors, from a time perspective, was ten days, as illustrated in the table below:

Project phases	Required Participants	Duration
Preparation meeting	Project Sponsor, Project Manager, Global Service Centre Director and Global Service Centre Process Manager (if any)	Half a day
Preparation and follow up of on-site interview planning	Project Manager	Estimated 3 to 4 days
On-site interview	Global Service Centre representatives from management and operations	Estimated 20 to 25 interviews Duration per interview is one to two hours depending on process maturity
Presentation of results	Defined with Global Service Centre Director	Half a day
Total number of days (all inclusive)		**10 days**

Table 1: Project estimated workload

The involvement of the Global Services Operations team was required for a period of between 30 and 40 days (preparation meeting, travel, on-site interviews, process rating and analysis, presentation of results and closure). Assessments were organised locally, within each of the Global Service Centres.

Global Service Centre directors were very supportive of the project and gave readily of their time, in order to ensure the project's success. The project was treated with the right level of focus and management support, which was a key element to its success. (Internal Dimension Data Service Providers such as Global IT, Regional IT and Global Services were not involved in this project.)

The scope of the assessment was agreed, in line with regional business priorities, and was focused on services to clients.

Dimension Data selected five ITIL® processes based on their direct contribution to the company's strategic goals, i.e:

- Incident Management
- Service Level Management
- Problem Management
- Change Management
- Configuration Management

Before the on-site assessment kicked off, we organised assessment preparatory sessions, in order to:

- Present the AIDA® process assessment project and methodology;
- Collect preparatory information;
- Gain a clear understanding of the organisational context of each Global Service Centre; and
- Generate momentum for the assessment within the Global Service Centre organisation.

The assessment took place in a stable and mature environment. The number of major organisational changes in progress at the time that could potentially have had an impact on the assessment results, was limited. (Performing an assessment in an operational environment facing major organisational changes doesn't make sense. The outcomes of the assessment are difficult to analyse and manage as the environment changes during and after the assessment.)

Dimension Data's Global Services team managed and led the AIDA® ISO/IEC 15504 assessment, with the assistance of external consultants and CRP Henri Tudor assessors for AIDA® knowledge transfer (assessor team members are AIDA® competent assessors, meeting AIDA® transfer scheme requirements). Consultants from the Brisbane Software Quality Institute in Australia, who form part of Terry Rout's team, also took part to the project during the assessment of the Australian Global Service Centre. (Terry Rout is the co-founder and driver of the ISO/IEC 15504 initiative.) The idea was to bring some "new eyes" into the project and to learn from each other's experiences in running similar assessments of ITIL® processes.

The assessment was conducted using the AIDA® questionnaire as a vital lead, but the interviews were generally conducted in an 'open' mode, fostering the collection of contextual information and details on the implementation of the processes.

5. Results

The results of the Process Assessment Project provided valuable insight into the respective process capability levels of Dimension Data's Global Service Centres and highlighted the importance of aligning processes across all regions.

The process assessment exercise formed part of the second step of Dimension Data's Service Improvement Initiative: "Where are we now?". The results of the assessment then enabled Dimension Data to progress to the third and fourth steps, i.e: "Where do we want to be?" (understand which level of process capability we want to achieve, according to business requirements) and "How do we get where to we want to be?" (define an improvement project plan, including quick wins and a medium to long-term roadmap).

The assessment results included recommendations on how we could drive Dimension Data's Global Service Centres to achieve greater Capability Levels. However, Dimension Data realised that its Global Service Centres' resources were stretched to the maximum – these centres are faced with the challenges of managing rapid business growth, exceeding client satisfaction and consolidating operations – on an ongoing basis. In order to ensure that the improvement plan received the right level of attention, we had to come up with a solution that would allow regional Global Service Centres to dedicate the necessary resources to the improvement plan.

Therefore, once the first Global Service Centre assessment was complete, Dimension Data created a decentralised virtual office, the Process Centre of Excellence. The role of the Process Centre of Excellence is to encourage local initiatives and to support the definition and deployment of consistent and coherent processes and procedures across all Global Service Centres. The Process Centre of Excellence comprises a virtual team, localised within regions and its members form part of the Global Service Centre headcount.

6. Lessons learnt

This Assessment and Improvement Project and the implementation of the AIDA methodology represented a new experience for Dimension Data. Nevertheless, the exercise enabled us to draw some interesting conclusions and reap the benefit of the lessons learnt. This section will examine each of these in more detail.

6.1 Sharing the project objectives

Before starting any improvement project, it is essential to set the scene and to create common understanding on the high-level business drivers for the project among the key stakeholders. We ensured that the business drivers were clearly discussed and agreed upon between all participants upfront. The business drivers were agreed as follows:

- Improve the quality of service in our Global Service Centres
- Reduce Service Delivery costs
- Deliver Services consistently to multinational clients
- Streamline the introduction of new Solutions to the Global Service Centres worldwide
- Increase service reliability

We learned that sharing business drivers amongst the participants upfront can greatly reduce resistance to the project. Furthermore, identifying contextual business drivers can generate additional enthusiasm and support for the project. The buy-in of the local sponsor is obviously also critical.

6.2 Importance of the preparatory phase

Our experiences highlighted the importance of having a clear understanding of the business model, organisation, scope of services and local terminology before beginning the on-site assessment. This allows one to improve the credibility of the assessment during the on-site interviews and facilitates open discussion, which in turn impacts the final outcome.

It is also important to secure the support of a local contact person in each region to take charge of all logistical aspects of the assessment.

6.3 Use of AIDA® and ISO/IEC 15504 methodologies

Use of ISO 15504 and AIDA® methodologies added value to this project, in the following ways:

- Standard and structured approach

A standard and structured approach provides the objectivity required to compare outcomes and to measure improvements periodically. (The proposed assessment cycle for the Global Service Centres is 18 months.) In addition, a standard approach based on ISO specifications made the project easy to sell to the regions.

- Public domain "methodology"

Use of public domain methodology ensures continuity and evolution based on user community experience. The credibility of ISO is also a key driver.

- Objectivity of results

Objectivity of assessment results is critical to ensuring that we are able to measure future improvements. Objectivity of results is achieved through the standard and structured approach as explained earlier, as well as by establishing clear project governance. For example, the participation of local resources in the interviewer or interviewee teams, even as observers, was strictly disallowed. All elements of project governance were discussed upfront during the preparatory sessions.

- Pertinence of the AIDA® model

The AIDA® model is based strictly on ITIL best practices, which has pros and cons. The objective of AIDA® is to enable objective ITIL capability assessments. Upfront, we accepted the pros …and the cons.

- High availability of ISO15504 resources across the world speaking the same ISO15504 language

This is essential when implementing an assessment in a multi-national company, such as Dimension Data.

6.4 Select a representative set of interviewees

This experience confirmed the importance of the interviewee selection process. As the objective was to obtain a 360° view of the organisation and its operational processes, the interviewee pool needed to comprise a mix of management and operational resources. Whenever possible, interviews should start with the individuals who can provide the most holistic overview of the formal process – this is key to helping the assessment team gain an understanding of the organisation's particular environment.

An adequate selection of interviewees boosts the credibility of the assessment results, as they will provide a true representation of how the organisation is working, on a daily basis.

6.5 Prove the effectiveness of the approach by example

It is always difficult to convince an internal organisation to participate willingly in a process assessment. It may be seen as an intrusion into the organisation. The project leader should first concentrate the selling effort on one entity (a department, a part of the organisation, a local centre) and prove the effectiveness of the approach by example, using the success of the first assessment to sell the next one(s).

6.6 Follow up results

While the objective of the assessment is to understand the process capability level of the current organisation, it is also (and even more importantly) to provide recommendations for improvement. The implementation of recommendations (the improvement plan) is however the responsibility of the organisation itself, due to budget implications.

Be aware that even if the assessment initially gains momentum internally, one should not expect the excitement to endure if you do not actively support and nurture it. The pressures of day-to-day business quickly return, especially when your organisation is facing two-digit growth. All individuals involved in the interviews should be kept informed about when the assessment results will be available, and informed of any subsequent actions that could impact them.

6.7 The results are the intellectual property (IP) of the local organisation

Confidentiality of assessment results is essential and results should not be distributed without the agreement of the local organisation's management. The assessment report remains the intellectual property of the assessed organisation. Promoting this statement will help generate a sense of ownership on the part of the organisation and helps prevent the adoption of a 'wait-and-see' attitude.

7. Conclusion

The implementation of the Assessment and Improvement Project and the use of the AIDA® methodology have provided Dimension Data with a clear picture of the current process capability levels in four of its five Global Service Centres. Through the project, we were able to identify a number of best practices, which can potentially be shared across Global Service Centres.

The results of the assessment, and the proposed recommendations for improvement and alignment, will prove extremely valuable in driving Dimension Data's overall Service Improvement and Alignment initiative forward. The new Process Centre of Excellence team, formed during the assessment project, is actively driving the implementation of these recommendations.

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9. Author CVs

Ruddy Hilbert

Ruddy Hilbert has worked at Dimension Data for the last eight years, moving recently from a European position to a Global position. Ruddy has assisted many IT organisations to improve their quality-cost ratio, transform their IT model into an Internal Service Provider model and move from a cost centre to a profit centre organisation, using ITIL best practices. Ruddy is an ISO 20000 Certified Consultant, ISO 15504 Assessor and AIDA@ Competent Assessor. Prior to joining Dimension Data, Ruddy's previous positions included serving as Chief Technology Officer for a software development company, where he specialised in change and configuration management process modelling.

Ruddy is Quality Manager for Dimension Data Global Services and, as such, has initiated some internal quality initiatives to improve Services to clients. The AIDA® assessment is the first quality initiative aimed at understanding process capability and creating baselines.

Alain Renault

Alain Renault is R&D engineer with Centre de Recherche Public Henri Tudor in Luxembourg. He returned to research after spending more than eight years as a software engineer and IT support. He has worked for eight years on process improvement projects, firstly focusing on software development activities and then on IT Service Support and Delivery. He is now in charge of the AIDA® R&D project.

Alain is ISO/IEC 15504 Assessor and AIDA@ Competent Assessor and he took part in the assessment of three Dimension Data Global Service Centres.

Supporting Software Process Improvement Planning by Quantitative Process Models

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Abstract. A software developing organization is a complex interdependent system. Therefore, a change at a single point, e.g. an improvement investment, triggers not just a singular, isolated result, but influences many business and process areas by networked cause-effect-relations. Without quantitative support, it is hard to assess the cumulative achievement of such a system as a whole. Therefore, this paper presents an approach of developing a quantitative model which allows estimating the effects of process improvement scenarios on business outcomes. The model relates process area capabilities to business metrics. Its results can be used as a challenge or guideline in process improvement planning.

Key words: simulation; software process improvement; capability maturity model; CMMI; balanced scorecards; validation; expert survey; process knowledge; simulation model customization

1. Introduction

1.1 Motivation

Quantitative, dynamic models and simulations are established methods to support the analysis of complex systems. Quantitative models aim at a reproduction of the real system, in which actions can be tested and potential results can be analyzed by simulations. Such a virtual environment and experiment provides many advantages, e.g. no interference with the real system, low costs, or the opportunity to test actions which are not possible in reality.

Therefore, the goal of the work presented here is the development of such a model in the context of software process improvement. Ideally, a user of such a model should be able to define investments into improvement actions and then observe the results of these actions onto the business outcomes of the organization.

To this end, a model is presented, which relates investments (model inputs) to capabilities of key process areas, e.g. assessed as CMMI levels [17], and these capabilities to business outcomes measured by core metrics (model outputs) such as defined in a company's Balanced Scorecard [2], see section 2. The model is implemented in an interactive tool that decision makers can use to test and assess different improvement strategies (investments) and to observe their respective effects on the business outcomes, see section 3.

While the actual development and parameterization of the model has been conducted for Siemens and is presented in the sense of a case study, the underlying ideas and methodology can applied in other contexts as well.

Of course, the results of such a simulation must be handled and interpreted with due care, since any model is an abstraction and, therefore, a simplification of the reality. This is especially true for the presented model of a software developing organization which is on a very high level of abstraction (and therefore simplification). Consequently, the results of the simulation can and should not be used as dependable or authoritative forecast but as additional support and challenge within the overall expertise of improvement planning, see section 4.

1.2 Related Work

Concerning the analysis of software development processes, the use of system dynamics to model a software development project was first introduced by the work of Abdel-Hamid and Madnick [1].

Since then, various aspects of software production have been quantitatively modeled. One focus of such software process models is the evaluation or comparison of processes or process alternatives [3], [5], [6], [9], [11], [15]. Other literature focuses on tools for education and training [8], [10], [12], [16] or the prediction of parameters using probabilistic dependencies [13]. (Note: the use of probabilistic dependencies as expressed by Bayesian networks for example, would add another level of complexity which is not relevant in the context of this work). An overview of the field can be found in [4] and [7].

However, most of the existing approaches model software *project* performance and evaluate improvement options by comparing project performance based on different settings of the model. In this work, the goal is a model on the level of the abstraction of the organization as a whole. This approach is similar to [14] but is extended to a comprehensive scope.

2. Model

2.1 Elements

Core elements of our model are the process areas of a software producing organization. The set of these process areas depends on the intended model context. In the context of Siemens the process areas used are essentially based on CMMI combined with specific focus areas derived from the Siemens business needs. CMMI defines 22 key process areas [17].

The Siemens software process model defines 19 process areas: Project Management, Supplier Management, Configuration Management, Technology Innovation, Requirement Management, Architecture and Design Process, Testing, Peer Reviews, Incremental Process Models, System Family, Platform Development and Component Reuse, Quantitative Project Management, Causal Analysis and Resolution, Quality Management, Process Definition and Maintenance, Organizational Process Performance, Continuous Quantitative Process Improvement, Process Modeling and Visualization, Organizational Training.

The company practice and experience has resulted in focusing on this set of adapted process areas, which adequately represent the way of how software development is done in this company. Depending on the context, alternative process areas can be chosen.

Following the ideas of CMMI, the complex behavior of such a process area is abstracted to one single characteristic value: the capability level of the process area. These capability levels vary over time and form the states of the model in the sense of continuous state-space simulation model.

However, the actual capabilities of such a process area are not directly observable (in reality, an assessment would be needed). The observable outputs of the model (and the organization) are business metrics. The set of these business metrics depend on the context as well.

In the context of Siemens, seven business metrics were used which were synthesized from software development of different company units: Scope of (Requirement) Fulfilment, Schedule Compliance, Budget Compliance, Internal Defect Correction Cost, Field Quality, Reusability, Cycle Time.

Some of those are similar to metrics that are commonly used in the software industry, like “Cycle Time” or “Schedule Compliance” [18].

In the model (as well as in the organization), the actual values of these business metrics are determined by the capabilities of the process areas and can not be influenced directly. Therefore, investments in process area capabilities are used as model input that affect process areas capabilities with a certain time dynamic, which in turn result in business outcomes. The set of these model inputs is determined by the set of process areas because it should be possible to invest in each area independently.

It is beyond the scope of this paper to describe or explain the mathematical formulas implementing this model, please see [16] for a comprehensive description of the mathematical groundwork.

With this setting, an improvement scenario can be embodied as a sequence of investment strategies as inputs of the model. The outputs of the model result in the approximated business outcome of this strategy.

Of course, the usefulness of such an approach crucially depends on the trustworthiness of the underlying model. Therefore, care was taken to set up a validated process simulation model for Siemens by using the existing knowledge of process experts from different company units, see section 2.2

2.2 Parameterization

The major difference between a conceptual process model and a model which can be simulated is the quantification of behaviour: Conceptual models often show qualitative aspects only, simulation models need complete quantification. As stated above, the goal of this research is to obtain a quantitative model. This model contains 126 parameters. Determination of these parameters is a major modeling challenge. Moreover, these parameters represent high-level abstract relations, which are hardly available from existing data. In the best case, there is anecdotal evidence for singular parameters but not for a somewhat complete set.

To cope with this challenge a two stage data collection approach was chosen:

First, the parameters of an initial model were identified by an expert survey. This is an established method to estimate quantitative values, which can not just be deduced from project or production data. Therefore, a structured questionnaire (together with an accompanying motivation and instruction manual) was developed, which was sent to process experts from different organizational company units.

Specific care was taken to phrase the survey questions in the language of the process experts, not using mathematical terminology or formulas in the questionnaire, e.g. “Please state the relative amount of monetary investment necessary to improve the process area Requirements Management by one CMMI level. Please relate it to an imaginary average investment amount”.

Overall, the questionnaire contained questions on 126 model quantifications and took about 40-90 minutes to complete. The median of the answers from nineteen completed interviews were mapped to the respective parameters.

Second, a simple to use configuration mechanism has been developed which allows process experts to interactively experiment with different parameter settings without delving into modelling or tool usage details. Therefore, a spreadsheet user interface (in this case a Microsoft Excel form) for customization of all model parameters is used which allows process experts to adapt and customize the model by staying in their familiar tool context. This customization is seen as a major part of the use cases of the model, see section 4.3.

3. Tool Implementation

The model is implemented in an interactive Java-based simulation application. The realization of the core simulation equations is rather straightforward and simple from an algorithmic and programming point of view. However, effort was spent on two issues, which can hardly be realized with a general purpose off-the-shelf simulation application:

- The tool allows arbitrary customization of all parameters as well as of the sets of process areas, business metrics, and dependencies allowing the use of the tool in different business scenarios.
- All configuration parameters mentioned above can be configured by a spreadsheet user interface without requiring a specialized tool or extensive modelling knowledge. This is seen as a major pre-

requisite to enable process experts to adapt the model in order to experiment and explore various business scenarios, see sections 2.2 and 4.3.

Figure 1 shows a screenshot of the simulation application. It is not the intent of this paper to explain details of the tool or its user interface. However, it is worth noting that the application is designed for two simulation modes: an interactive-mode and batch-mode.

In the interactive mode, the user analyses the current outputs and defines the inputs (investments) at each time step. After finishing the adjustments of the inputs, the simulation proceeds to the next time step. The user can thereby interactively analyse the current status of the organization and adjust the inputs before each time increment. Of course, there is functionality to go back or proceed a couple of time steps (instead of singular step).

In a batch-mode, a simulation scenario is run completely and analysed afterwards. To this end, all simulation data can be stored in a file (CSV- or XML-format), which can easily be imported in other applications, e.g. a spreadsheet for further analysis.

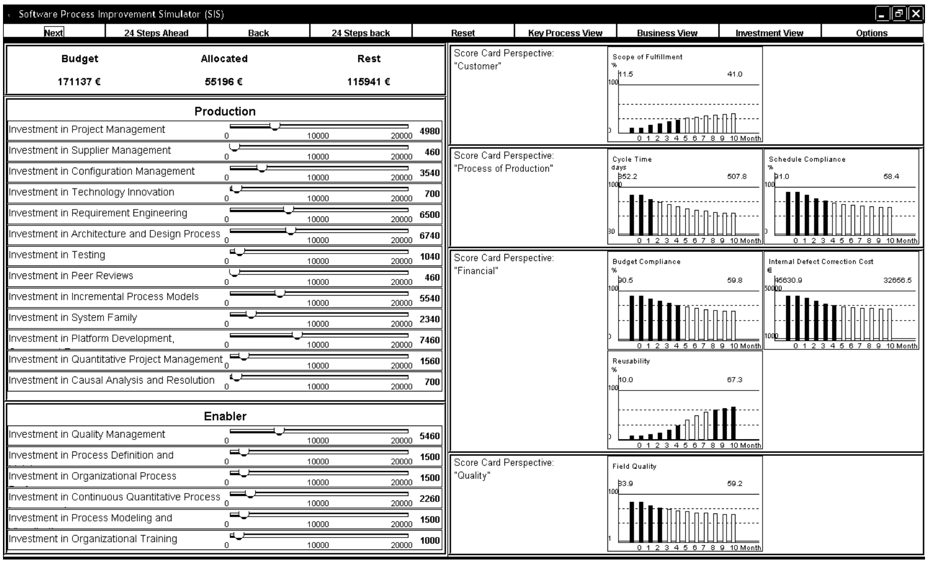

Fig. 1. Screenshot of the simulation application. The input area is on the left side, the metrics display on the right side..

4. Use Cases

The simulation approach and tool should be primarily used for two different scenarios: First, at the very beginning of a process improvement project, where the quantifiable benefit of such a project is relevant for the decision of the project start. Second, the tool can be used during project run time or even at project end in order to approve the initial benefit calculation and to justify the current targets respectively.

The quantitative model provides three distinct advantages in such a context of process improvement planning:

- Visualization
- Documentation of implicit assumptions and expectations,
- Challenging existing assumptions and expectations.

4.1 Visualization and Animation

The model presented is based on an existing conceptual structural process model, which was previously developed within Siemens. This conceptual model contains cause-effect-relations between Key Process Areas and Business Metrics. These relations are represented as a static diagram that provides a qualitative view of benefits regarding process improvement. Compared to this static presentation, the interactive simulation allows a much more comprehensive visualization of the proposed relations and their effects. Different input values can be tested and their effects observed, and complete time dynamic scenarios can be traversed.

This visualization of changes over time opens a new way to a more complete comprehension of conceptual process models.

4.2 Documentation of implicit assumptions and expectations

One major advantage of any process modeling is the creation of explicit representations from implicit knowledge or assumptions. Designing a quantitative model provides an additional challenge and value: The model representation must be precise and complete to be computable.

Although many of the single pieces of such a model are well known, the complete model reveals a considerable number of additional important connections and issues. The collection and development of the “missing pieces”, e.g. by the expert survey mentioned in section 2.2 triggers and fuels a discussion of explicit or implicit process assumptions, knowledge and dependencies between process experts, which might not arise without the need of formulating and documenting this knowledge as explicit parameters. Therefore, the development of the model enforces the explicit formulation of implicit knowledge.

4.3 Challenging existing assumptions and expectations

Developing and configuring the simulation model, its assumptions, and its results trigger and provoke questions and objections. These concern process details as well as the fundamental understanding of work processes in the company.

Such a discussion might extend from initially searching for agreed values of individual parameters to investigating which and why parameters are needed. This means that identifying process and metrics relations and their strengths needs consensus and clear understanding of the scope and rationale of process concepts such as "production" vs. "enabler" process, of key process areas, and of handling differences in process definitions and use. In consequence, while adapting the structure of the model (i.e. change, add, or delete relations, process areas or business measures), the underlying assumptions of process management (e.g. why do we assume/omit a relation between element A and B?) will be reflected and need to be clarified or harmonized as well. While the results of a model as presented here can never be used as a simple dependable forecast (in this case, the management problem would have been solved), the results can still serve as a productive challenge to the existing assumptions.

Even in case a simulation result will ultimately be considered “wrong”, the reflection on model design and rationales will probably provide valuable insight since the results were based on existing assumptions on relations and influences, see Section 2.

5. Summary

An approach has been presented to develop a quantitative process improvement model for a software developing organization. Although the presented model is based on an existing conceptual model within a Siemens context and parameterized by Siemens experts, the underlying ideas, however, might be applicable in other contexts as well. The resulting simulation model relates investments in process areas to business metrics using process area capabilities as internal states and driving forces.

The simulator can reveal process change effects and help understanding potential process improvement scenarios that fit the software development work environment investigated, not to propose a dependable forecast or solution. Despite the fact that the simulation model is a strong simplification of the real world we believe that such an approach can give valuable insight into complex process dependencies within the context of process improvement planning and, therefore, can serve as a tool to support such discussions and decisions in the future.

It seems a fundamental asset of the modeling and simulation work to consider all processes in the organization as a whole. While process experts can be expected to have a good overview over the complete set of company software development processes and their relations, the managers making decisions that affect these processes often lack such an integral view. This work can help filling this gap.

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An empirical study of introducing the Failure Mode and Effect Analysis technique

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Abstract. This article describes an experiment with three Norwegian IT companies, who develop business critical software. The goal of the experiment was to see if the companies would find it beneficial to use safety analysis techniques when developing business critical software. The participants in the experiment should identify failure modes from a class diagram. Half the participants used the Failure Mode and Effect Analysis (FMEA) method while the rest used ad hoc brainstorming. The experiment showed that the participants that used ad hoc brainstorming wanted a structured and documented method to help them reveal more problems. The participants who used the FMEA method found the method useful because it was easy to understand and helped them to identify failure modes in a structured way.

1. Introduction

Companies of every industry, large or small, must have some kind of data protection as part of their business continuity plan [1]. It is therefore important that software developers consider how they can reduce product risk in the software, so that their customers can avoid loss of assets, such as vital information, reputation and money.

The extensive use of computers and software has drastically improved the functionality and efficiency of many companies, but has also made software systems a significant risk factor [2]. Risk is here defined as the product of an event's consequence and its probability of occurrence or as its hazard level (severity and likelihood of an occurrence) combined with 1) the likelihood of the hazard leading to an accident and 2) hazard exposure or duration [3].

Our starting point is safety analysis techniques that are used to assess the risk associated with using the system, and to prevent accidents from happening in the system. The techniques analyze why accidents occur; i.e. the mechanisms that drive the processes leading to unacceptable losses, and they determine the approaches we can take to prevent such accidents [4].

Just as for general safety, business safety is not a characteristic of the system alone – it is a characteristic of the system's interactions with its environment. Safety is freedom from unacceptable risk of physical injury or damage to the health of people, damage to property or to the environment [5]. Software is business safe when it does not fail in such a way that it causes a mishap [6], which results in loss of financial assets, such as reputation or business interruption. The biggest threat to business is business interruption while the second biggest threat is loss of reputation [7].

We have earlier done a survey in Norway to see what techniques IT companies used when analyzing and developing business critical systems. The unison answer was that no special techniques were used. We thus decided to compare FMEA to brainstorming which is an ad hoc approach. Our goal was to study which effect the FMEA have on the process of developing business critical software. In the experiment the participants should identify failure modes in part of a system based on a class diagram. The identified failure modes can be used further in the development phases as additional safety requirements and as a basis for testing, and to mitigate or eliminate the failures by building in compensating efforts like redundancy, alarms or barriers that helps to avoid the failures to arise.

Software may be highly reliable and correct [4] but still be unsafe if the software:

- correctly implements the requirements but the specified behavior is unsafe from a system perspective;
- requirements do not specify some particular behavior required for system safety, i.e. they are incomplete;
- has unintended and thus unsafe behavior beyond what is specified in the requirements.

Unfortunately, meeting safety requirements can not be achieved by meeting a set of written specifications [8]. The design effort needed to make a system safe consists of a series of coordinated activities needed to assure that the final product will be safe. Developers who develop business critical software must, in addition to satisfying the functional requirements, add business safety requirements to their solution, [9, 10], or else, the software will undermine the prospects for creating value and delivering profits to businesses [7].

The rest of this paper is organized as follows: First we give a short description of the FMEA technique followed by a short description of how we analyzed the data. Thereafter we describe the experiment and its results. Finally we conclude the paper and discuss some further work.

2. What is FMEA?

FMEA is a method that is used for reliability analysis of systems, subsystems, and individual system components [11]. FMEA was introduced in 1954, and formalized in 1968. The method has been used with success for many years when developing safety-critical systems for avionics, trains, and nuclear plants and for the process industry. FMEA allows a systematic analysis of possible hazards and failures, and also allows us to assess the effects of these hazards and failures on the components of a system.

We decided to use FMEA in our experiment since it is easy to understand and easy to use. Thus, no extensive coursing is needed. Using FMEA will help them to create a system that is more business safe. FMEA serves two roles. Firstly, it helps the developers to identify possible hazards and failure modes associated with the system. Secondly, it helps the developers to verify that all failure modes leading to hazardous events or mishap are mitigated by the design modifications made to the system [7]. The most important part of the FMEA process is a systematic walk-through of components to identify possible failure modes such as “fails to operate on demand”, “calculates a wrong result”, etc.

Using FMEA will not make it cheaper to develop software, at least not in a short term perspective. Increasing the products’ business-safety must be viewed as an investment. The return of investment will come when the company can deliver software products with higher quality, which again will lead to more business from existing customers and new business from new customers. In addition, we will have less need for fire-fighting. The workload will be larger in the beginning of the project. This bigger workload will reduce the rework needed in the project, since latent hazards are identified early and the developers can use their new knowledge to limit, reduce or eliminate them

How we apply FMEA and the information we obtain, depends on the documents that are available when the method is applied. In object oriented software development this can, for instance, be classes and their methods [12]. The behavior of an object is defined by the object’s methods and its attributes. As long as the methods of an object are executing in accordance with their specification, the object has not failed. Conversely, when a method does not execute in accordance with its specification, the object has failed. The effect of the failure will depend on the conditions under which the method failed – the values of the attributes. The class diagram shown in figure 1 can be used an example. The result of using the FMEA on this class diagram will give the results shown in the FMEA table shown in table 1.

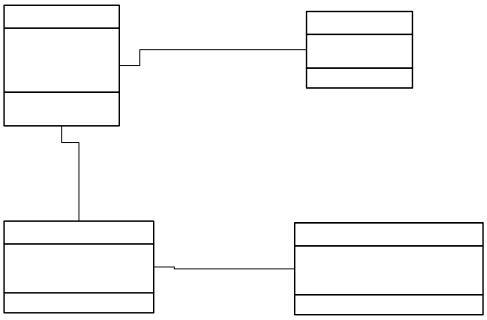

Figure 1. Example of a high level class diagram [13]

Method	Failure mode	Effects of failure	Action / barriers	Severity
Customer. creditRating()	creditRating is too high	Customer places orders for more than he can pay for	Manual check when setting or changing credit rating	H
	creditRating is too low	Customer is not allowed to buy as much as he wants and can pay for		M
	No creditRating	The company can lose money selling goods to customers who will not be able to pay	Function to obtain credit rating from external sources	H

Table 1. FMEA table for creditRating()

In the FMEA table we start by identifying what class and which method we are going to analyze. We then identify the failure modes. For the creditRating() method in fig 1, we found three failure modes: the credit rating is too high, the credit rating is too low and no credit rating is performed. We then assess the effects of the identified failure modes, and possible actions and barriers that can be used to prevent the failure modes from arising. Last, but not least, we prioritize the identified failure modes, so that we know where to start when we shall implement mitigation activities.

3 The experiment

3.1 Research approach

Our experiment was designed as an exploratory and qualitative study. The goal of the experiment was to answer the following research questions:

- RQ1 – will developers find it useful to use the FMEA technique instead of their current ad hoc brainstorming when developing business critical software?
- RQ2 – will the developers find it beneficial to involve the customers in the FMEA?

The experiment was executed during June 2005 in three Norwegian IT companies. Two of the companies are IT consultancies, while the third is a privately held company that has its own software development department. In each company we used four software developers that have worked in the IT industry for two to thirty years. All participants are familiar with the Rational Unified Process (RUP) [14], and most of them used this methodology in their daily work. Only one of them was familiar with agile methods, and uses test driven development in his daily work.

RQ1 will give us an indication of how useful FMEA is for the identification of problems, compared to the techniques the developers use today and how effective the participants felt the FMEA was. Domain knowledge is important in traditional FMEA. In addition, XP focuses on the concept of the on-site customer. We thus wanted to check if the developers thought that the customer could help by participating in the FMEA since they have the domain knowledge. This is checked in RQ2.

3.2 Experimental methods and procedures

In each company we started the experiment by dividing the participants into two groups - later called A and B - with two persons in each group. Each person was assigned randomly to group A or B. the companies involved were small and the four participants from each company knew each others and had worked together earlier. It was thus easy to work together on their experimental tasks. We designed the introduction, the experiment and the questionnaires in a neutral way but we may have influenced the participants by focusing on safety throughout the introduction and the experiment.

We gave group A an introduction to safety analysis of design diagrams, while group B – the FMEA group – filled in a background questionnaire. When group A was finished with the introduction and group B had filled in their questionnaire with background information, the groups switched tasks. Group B got an introduction to the FMEA technique and a short introduction to the importance of considering safety issues during the software development, while group A filled in the background questionnaire. In both cases we used the class diagram in figure 1 and guided them through an example of the analysis based on the creditRating() method in the Customer class.

To explain the concept of failure mode, group A was walked through a list of possible failure modes for the creditRating() method but without showing them table 1. In addition, we discussed possible countermeasures. Group B got the FMEA table shown in table 1, together with a detailed walkthrough of the table.

After the introduction and the completion of the background questionnaire, both groups started to identify failure modes and consequences for the case “customers purchase goods from a company” based on the class diagram in figure 1.

The experiment lasted for approximately 90 minutes. Filling in the questionnaires took approximately 30 minutes, while the experiment itself took 30 minutes. The remaining 30 minutes were spent on introducing the method and discussing the participants’ experiences from the experiment.

3.3 Data analysis

The most important results from the experiment are the information given by the participants to the questions in the questionnaires. This information is qualitative – one or more statements per participant. There are several ways we can analyze such data – e.g. coding [15] or grounded theory [16] - but we have chosen to use all statements as they are given by the participants and used the method developed by Kawakita Jiro [17] – the KJ process - to construct affinity diagrams. We have a long experience with using the KJ process, since it is an important part of the post mortem analysis. The analysis was done by the two authors together and resulted in nine set of affinity diagrams.

It is important to remember that the KJ analysis does not give one single result. The results are critically dependent on the experience of the people who perform the analysis. In our case, both participants had several years of experience with software development and one of the participants also had a long experience with analyzing safety critical systems. Thus, in our opinion, the results from the KJ process are trustworthy.

We started out without any fixed hypothesis. The purpose of the experiment is to study how developers react to the introduction of FMEA and not to accept or reject any particular hypothesis on its use. Since we only had time for a short introduction to the method, the participants will all be at the start of their learning curve and we can thus for instance not assess FMEA against other methods. We will base our discussions on the content of the affinity diagrams and the grouping of ideas and concepts that surface during the KJ process.

4. Experiment results

4.1 The current approach

We started by asking all participants to describe their current approach with focus on what they are doing in line of safety assurance: “How do you analyze and reduce failures when you develop software systems?” As should be expected, testing one way or another came out on top – split into general validation and verification activities, systems test and unit testing. In addition, some of the responders also included rigorous specification and some XP-related techniques such as “always have a running system”. 19 of 36 answers consider testing when they want to analyze and reduce failures in their software systems.

In addition, however, some of the responders used some form of informal risk analyses – e.g. “use case deviations” and “discussions with the customer”.

4.2 Results from the ad hoc group

Five out of six participants in the ad hoc group stated that they missed a good description of the system they should analyze in the experiment, e.g. use cases, sequence diagrams and more background information of what technology is going to be used. One person said that it could have helped if he had been given a checklist related to the addressed issues. In their daily work, the participants primarily used use cases to identify possible problems.

More important, however, is how they approached the problem given to them in the experiment. In this case, testing was not a viable alternative. Through the KJ analysis we identified three groups of activities – make a use case diagram and connect failures to use cases, read and understand the data model (in this case the class diagram) and what the participants called the list method, where they first brainstormed a problem list and then checked off each item as they identified an appropriate barrier.

When asked if they thought a systematic method would be useful when analyzing UML diagrams, the participants identified two areas where such a method would be useful – make it easier to start the failure identification process and help the participants to be more systematic and detailed when looking for potential problems. There was, however, a big “if” included; the method would only be useful if the UML diagrams were correct and complete.

They were positive to involving the customers in the analysis of the UML diagrams, on the condition that the customers have the necessary skills to understand the diagrams. The customers have important know-how of the problem area and have a good understanding of how failures could arise. They might also have ideas on how failures should be dealt with.

The participants also provided statements pertaining to what they missed when trying to identify critical failure events. They identified two things that they would have improved the analysis:

- More background information for the system to be analyzed. Items mentioned were a better UML model – including use cases, and a detailed technical description of the system.
- A systematic analysis method. They claimed that they would have been more efficient if they had a documented, predefined method.

4.3 Results from the FMEA group

When we analyzed the data collected from the persons who had participated in the FMEA part of the experiment, we focused on two areas: what went well (what are the strong points of FMEA) and what needed improvement. As is seen from the KJ diagram in fig 2, the most important point is not the FMEA per se but that there is a method that can be used to focus group discussion and to improve the work process. The answer to RQ1 is thus a clear yes.

All the participants agreed that the FMEA method was easy to learn and that it would help them to be more attentive to problems and failure modes.

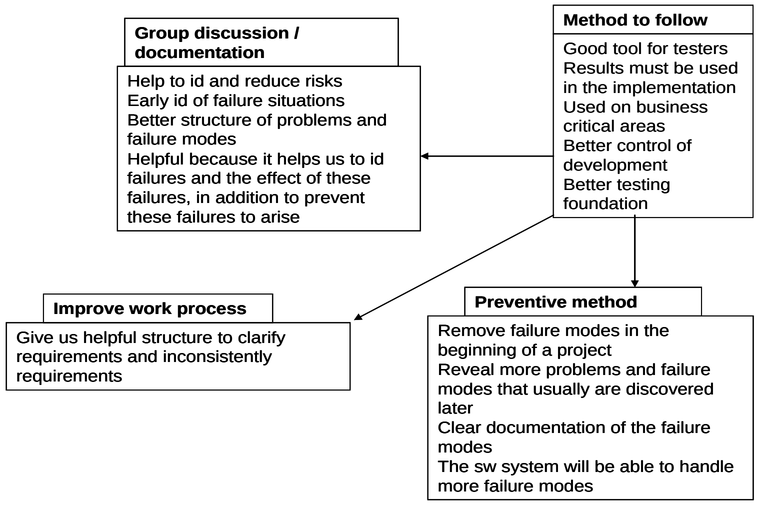

Fig 2: Affinity diagram for positive elements of FMEA

Compared to other ways to do risk and failure identification, the participants did not consider FMEA more labor intensive or expensive. The extra cost will be earned back by removing failures at an early stage, before they become problems. Quite a lot of the comments we received were concerned with the use of the FMEA results as a basis for better testing. The KJ diagram in fig 3 shows this clearly.

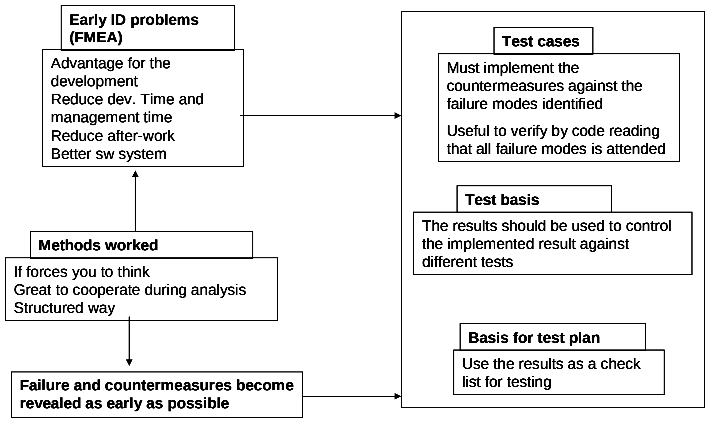

Fig 3: Affinity diagram for the participants' opinion of how to use FMEA

The collected data showed that in the participants' opinion, the customers should be involved if possible, because of their domain knowledge. The problems with customer participation are whether they can read and understand UML diagrams and learn to use FMEA. These are the same problems as the ones identified by the ad hoc group. If the customers cannot read and understand UML diagrams it will be difficult to communicate with the customers. In the same way – if they cannot learn to use FMEA, it will be difficult to use this method as a vehicle for customer involvement. Thus, the answer to our last research question RQ2 is a conditional yes.

The last set of questions for the FMEA participants were pertaining to how the FMEA method should be improved. The data collected indicated two improvement areas:

- It was easier to identify failure effects than to identify failure modes. The reason could either be that the concept of failure mode is new to them or that it really is easier to identify and describe the effect of the failure than its cause.
- The FMEA table was in some sense too strict. The participants wanted the opportunity to change the table, e.g. include other columns or change their sequence when the need arises.

4.4 Other improvements

The strong focus on use cases both from the FMEA part of the experiment and from the data pertaining to what they use in their current processes indicate that we should consider a way to combine use cases and FMEA. Our suggestion is that the FMEA, as a minimum, should have both use cases and class diagrams as input. The results should be documented in the FMEA table and cross referenced to the use cases. This will improve the traceability of the results from the FMEA and make it easier to use the results for later verification and validation activities. This will also enable us to link all new requirements for barriers and other mitigation directly to the rest of the system's requirements.

5. Threats to validity

We will use the categories defined in [18] as a starting point for our discussion on threats to validity. We will look at each threat in a short section before giving a sum-up of our validity claims.

5.1 Conclusion validity

Conclusion validity is concerned with our ability to draw the right conclusions about relationship between the treatment and the outcome. Many of the concerns related to conclusion validity are statistical problems such as sample size and the assumptions used for a statistical test. This is not an issue here – we have no hypothesis and use no statistical analysis. We have two concerns when it comes to conclusion validity – fishing for results and random heterogeneity of the participants. Since our sample is small – six groups of two developers, there is always a risk that we have got hold of a batch of especially competent or incompetent developers. This risk is, however, small.

The risks related to fishing are important. The experimenters influence the results in two ways, namely by (1) in some sense pushing a method and (2) when analyzing the data. The latter risk is especially important here since we use qualitative data only and a subjective method for analysis – the affinity diagrams.

The first risk – a variant of the fishing for results – is small. The persons involved did not know the person who administered the experiment. They will probably never see him again and should have no motivation for agreeing or disagreeing with the questions put forward in the experiment questionnaire.

5.2 Internal validity

Internal validity is concerned with the relationship between treatment and outcome – was it the treatment that caused the outcome? Each participant participated only once and there is thus no learning effect that can disturb the outcome of the experiment. Given that the participants were randomly grouped and had no previous experience with the tested method, it is our opinion that our choice of participants did not affect the outcome.

Another concern that is relevant here is instrumentation – was our measurement procedures good enough? All our data are qualitative – they describe the participants' opinion on the method they used and how it worked. For the analysis method used, this should be sufficient. We can, however, not be sure that the participants were honest when they wrote their comments. On the other hand, the participants could get no advantage out of fooling us and we thus believe that their comments describe their honest opinions of the experiment.

5.3 Construct validity

Construct validity is concerned with the relationship between theory and observations – was the experiment realistic? The experiments were executed at the premises of the participants' company. The setting was realistic – based on one or more class diagrams, the developers should identify possible problems. The participants got 30 minutes introduction to FMEA, which is a bit short. In addition they had no opportunity to practice before the experiment started. The fact that they still found the method useful is a point in favor of the FMEA.

It is difficult to brainstorm or use a new analysis technique on an unfamiliar design documents. This should, however, not favor one method over the other. Everything considered, we see no threats to construct validity in this experiment.

5.4 External validity

External validity is concerned with generalization – where and when are the conclusions applicable and can we generalize from our experiments to industrial practice? We used twelve IT professionals, and even though their experience varied from two to thirty years, we think that our sample reflects the real IT community quite well. We tried, as far as possible, to run the experiments in a real development setting. We will therefore claim that the results are transferable to the software industry.

5.5 Our claims to validity

From the short discussions in sections 5.1 to 5.4 we see that the main threat to validity is the subjective nature of the registered data and the data analysis itself. We have tried to let the data speak for themselves but it is impossible to avoid a strong injection of personal beliefs and disbeliefs when using the affinity diagram method for analysis. The statements we have used in the analysis are the actual statements that were collected during the experiments. There are other ways to organize the information items from the questionnaire but we find it hard to see that this could have lead to a set of conclusions different from the ones we have arrived at.

6. Conclusion and future work

We started out with two research questions – RQ1 and RQ2. The first two are answer with an unconditional "yes" – the developers found the FMEA useful and using the FMEA will be, at least in the long run, profitable for the company. RQ2 got a conditional "yes" – including the customers in the analysis process will be beneficial if the customers can understand the UML diagrams and are willing to learn the FMEA method.

In addition to affirming the research questions, the experiment gave some new insights into the use of FMEA in the software development process:

- Both the ad hoc groups and the FMEA groups focused on the need for a documented process that could be used to analyze business critical systems.
- The groups that used FMEA found the method useful for two reasons – it would help to create discussions within the group and the output would be important input to all phases of the system's verification and validation.
- Use cases are heavily used and any hazard or risk analysis should be coupled to the use cases - either in a textual or diagrammatic representation.

As the next step of our research we will run a similar experiment using the HazOp method. First and foremost, we want to see if the extra information provided by the HazOp guide words will improve the safety analysis – or in our case the business safety analysis – of the developed system. The data from this experiment will be analyzed in the same way as the data from the FMEA experiment, which will enable us to compare ad hoc analysis, FMEA analysis and the HazOp.

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Changing Attitudes – Improving performance

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Abstract

This presentation is based on the real life experience within Serco of a major Process Improvement Programme, which began in February 2006 and is continuing today. The presentation provides first hand experience from those directly involved. Two different perspectives are given; first the consultant's view and secondly the client's view. By sharing the experience with others we hope that we can give the audience things they may wish to consider if they are involved in a similar undertaking.

The presentation will be looking at the more human side of change and how the participants were both affected by, and reacted to, the problems and challenges they were faced with. The collaborative team approach worked extremely well in this instance and we will impart why this proved to be such a success.

Those attending the presentation will benefit by gaining an insight into the benefits and pitfalls of creating a staff driven improvement programme and the achievements that can be realised. Visual examples from the programme will be presented so that everyone can see what the actual results were.

Although the original focus was on retention of the existing ISO 9001:2000 TickIT certification there was always a longer term objective of moving towards CMMI L2/L3. Serco sought outside help from Software Measurement Services Ltd. (SMS) to carry out an initial assessment, against best practice in software development, and to identify areas for improvement. SMS were then invited to guide and support the internal change programme.

The real challenge in the Programme was to make major changes to the way staff operated on a day to day basis without impacting the live delivery dates. It was not an easy transition and there were casualties along the way, even so the changes have been dramatic at all levels in the organisation.

Finally, the presenters will make recommendations to the audience for their change Programmes, what must they do and what must they avoid, based on the Serco experience.

Keywords

Change Management, CMMI, Collaborative Team, Continuous Improvement, Culture, ISO9001:2000, Lean, Management Commitment, Metrics, Motivation, Process Improvement, Software Development Life Cycle, Staff Motivation and TickIT.

1 Introduction

Serco was facing a number of challenges in 2006; not only maintaining the good relationships with their existing client base but also significant expansion of the business to take on new high profile clients. They needed to have absolute confidence that their existing Software Development and Delivery could cope with the major changes that were planned.

In February 2006 Software Measurement Services (SMS) were commissioned to perform an assessment of the software development activities at Serco, from bid stage to post development support. The objective was to compare Serco to industry best practice and provide a benchmark for starting a continuous improvement programme.

The SMS report identified a number of areas that were considered to be at risk and could even jeopardise Serco's chances of passing their ISO 9001:2000 re-certification audit. A programme of projects to improve the software development capability was initiated in March 2006 and the staff called it PRISM.

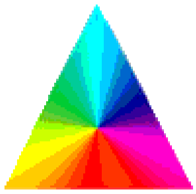

Figure 1: PRISM **Process, Review, Implement, Standardise, Maintain**

2 The Consultant's view

2.1 Change Programme Approach

From the very start the decision was taken that the work would be led by the Development Staff themselves. A series of work streams were set up and each stream used the SMS reports findings to review current practices and suggest improvements.

The Work Streams were made up of staff volunteers representing a cross section from every Software Development team. The initial streams, based on the priorities within the SMS report were:

- Requirements Management
- Document Management
- Project Management
- Release Management
- Change and Configuration Management
- Reviews
- Software Development Life Cycle
- Metrics
- Communications (across all the work streams)

Individual Stream Leaders were put in charge of each Work Stream and those taking this role were deliberately not the senior people within Development. They co-ordinated the work and ensured that views were sought from a wide selection of people, at all levels within the Organisation before a proposed solution was put forward.

The streams were continually supported in their activities by both Serco Management and SMS.

In addition, a Steering Group was set up chaired by the most Senior Manager at Serco. This group met monthly and the stream leaders attended and presented their achievements. This often resulted in further iteration of the proposed solutions based on feedback given at the meeting.

The proposed solutions were formally documented using a defined standard process model approach and piloted before roll out to the wider organisation. The Steering Group had to give formal sign off before roll out could commence.

Training in the form of both awareness events and training courses for those required to use the new processes were arranged.

2.2 Why this approach was chosen

The Work Streams promoted an inclusive approach which helped to gain staff commitment and encouraged staff ownership to the change programme.

Clear goals and targets were set for each Work Stream to ensure everyone was clear on their overall responsibilities, priorities and objectives. This created an early Shared Vision with everyone pulling in the same direction.

2.3 What worked well

Creating a separate Communication work stream to co-ordinate the information from all the work streams was very effective. Regular Newsletters, Intranet notices and emails meant that the work was visible within Software Development as well as to other external teams and clients.

The streams were asked to provide visual displays of their results, as they progressed the work e.g. Process Model diagrams and associated template documents. This acted as a catalyst for discussion and led to further improvements across the operation.

The development of the Software Development Lifecycle (SDLC) proved to be the most important element. The mapping that was initially done, individually per work stream, was gradually brought together and the impact this had when people could see how their part fitted with the others was quite remarkable.

Some of the individuals who took on the role of Stream Leaders changed significantly during the 9 months of the programme. Some started out with feelings of uncertainty about the task and how realistic it was going to be to complete it alongside their day to day activities. Over time they realised that it was possible to manage them both.

For others being given the responsibility for a stream created a momentum that once started has continued to develop.

In addition, the programme has helped the Software Development Manager to identify which staff members may be ready to take on more senior roles e.g. to move into Project Management.

2.4 Adapting the approach to ensure success

During the change programme it was important that the team remained flexible and responsive. Not all the proposed changes worked first time and we continually monitored progress and reviewed our approach. Where necessary, changes to the approach were made, including in some instances changing a stream leader who had recognised they did not have the skills needed to convince their colleagues that change of this sort was worthwhile. There is no doubt that some people are very good at this and others find it much harder.

One of the benefits was an appreciation within the teams that ‘managing’ is not always as easy as it might seem. They now have a very different perspective in tackling their current role and to the process of change.

It was recognised that without visible management commitment at the most senior level the programme was likely to fail. Once the Senior Manager agreed to chair the Steering Group, and he attended every meeting, we knew we had to make his valuable time commitment worthwhile. This was achieved by adapting the format of each Steering Group meeting so that there was always something fresh and interactive. The Stream Leaders were presenting what they had done face to face with the Senior Manager and getting his direct feedback. It almost became a competition between the streams to have made the most progress. The results were always impressive.

3 The client’s view of the Programme

3.1 Managing the change programme

One of the key concerns staff had about implementing a change programme was the lack of time available for the additional tasks and a fear that the day to day work would suffer. Management demonstrated its commitment to the programme by agreeing that development staff could have up to 25% of their time allocated to the streams of work. Resource allocated to the change programme was monitored using cost codes and although some individuals did use 25% of their time, the average was much lower than expected at only 3.8%.

In the beginning there was a tendency for the streams to get side tracked and spend too much time discussing interfaces between the streams. The Steering Group had to step in and re-focus them on their individual activities. Later on when each stream had developed their own process models and the whole thing was put together on the Board Room wall there was a sharp intake of breath when they realised that many of the connections were already there.

3.2 What skills the staff obtained from the experience

There has been a significant impact on the skill levels of those involved. Not only do they now understand how difficult it can be to change within an organisation but they also understand their colleague’s perspectives more deeply. A solution that might work well in one area can in fact have a detrimental effect elsewhere. Previously, they might have just gone ahead anyway and not have been concerned about the impact to others; now they are far more likely to put relevant people together to discuss and jointly agree the approach that best suits them all.

In the past errors were allowed to proceed further into the development activities with an expectation that testing would ‘pick things up’. Now people are adapting to regular reviews as a mechanism for finding problems earlier and fixing them. Initially this was seen as ‘big brother’ but quite quickly people realised that they were involved in less re-work and recognised the benefits of ‘get it right first time, every time’. People are now happier to embrace change within the organisation and look to the positives, rather than perceive change as a threat to the status quo.

3.3 The effects on customer relationships

The use of visual displays of work has had a significant impact on the levels of understanding across the Organisation. Having a defined Life Cycle which can be shown to customers has made communication easier. The client's now have a greater understanding of the complexity of managing what they see as a 'simple change request' and a more 'lean approach' is evolving both internally and externally.

Management have more confidence that Software Development activities are properly controlled and this has also had an impact on the Bid cycle. Those seconded to the Bid Teams are now properly equipped to handle the task by having a defined process to follow.

3.4 Unexpected results and benefits

There has been a visible change in the attitudes of both Staff and Management. They both have a better appreciation of their respective roles and responsibilities within the Organisation.

It was not always the people expected who rose to the challenges presented by the change programme.

4 The Results

In a relatively short time period of 9 months significant success has been achieved, the most tangible results being:

- Retention of ISO 9001:2000 certification
- Significant cost reduction for Software Delivery; the first 6 figure project to use the full end-to-end life cycle came in <u>on time</u> and <u>under budget by 29%</u>
- Defect levels have dropped; they are identified and fixed much earlier in the lifecycle, thus reducing development costs.

In addition, the following has been achieved:

- Improvement of Software quality
- Greatly improved governance
- Reduction in "Silo" working
- The software development lifecycle has been reviewed and documented. Gaps and duplication have been identified and work is underway to resolve these
- People now understand exactly where they fit in the lifecycle, and more importantly, conflicts have been identified and processes updated
- Review checkpoints positioned throughout the SDLC
- Prince 2 guidelines positioned through the SDLC with more clarity
- Basic metrics have been established to monitor where defects occur throughout the lifecycle
- The IMS (integrated Management System on the intranet) is being improved and simplified to contain all of the processes
- Process mapping has been expanded outside Software Development to include a number of other departments, i.e. Service desk
- Induction training now uses the defined processes to bring new starters up to speed quicker

5 What Next?

The success of the PRISM programme has given Serco the momentum to continue with a new programme of work to implement ISO 20000:2005 IT Service Management and over time to reach CMMI level 3. PRISM 2 is about to start. Management have taken the decision to apply continuous improvement to the Service area for a number of reasons:

- To align IT services with the current and future needs of the business and its customers
- To demonstrate to customers that a recognised certificate has been achieved for Service Management
- To reduce the long term cost of service provision
- To improve the quality of the IT services delivered

In Software Development management have decided to use the building blocks already established in PRISM to reach CMMI level 3 because:

- Some client’s now require it for tendering, so it is becoming essential.
- The work already done in PRISM is compliant with CMMI and it makes sense to move to a higher level of maturity in their industry sector
- It makes Serco stand out against the competition

Both of these initiatives will:

- Provide a ‘goal’ that staff and Management can aim for, this will help to maintain momentum
- Embed the culture of continuous improvement throughout the whole operation
- Provide a standard approach, across all teams, regardless of type of work carried out. This will, over time, make day to day management easier.

6 Our recommendations to you

The reason for submitting a paper of this sort was to give others the benefit of our experience. Having gone through such a significant change project at Serco there are lessons we have learned along the way which we would like to share.

- Don’t be disheartened if things do not come together first time, this is normal and should be seen as an opportunity to achieve a better, longer lasting result. You learn as much, if not more, from the things that go wrong.
- Consider an assessment against best practice rather than a specific model as a starting point
- Remember, many of the fundamental building blocks will be the same regardless of model
- Focus on ‘Quick Wins’ as this encourages people to continue when they see positive results
- Get the staff who will be using the processes to develop them
- Design a standard style and layout for your processes which is applied by everyone, as this gives them a recognition that makes it easier for people to take on board
- Make sure you have visible management commitment, our Sponsor was very much part of the process and staff were more committed as a result

7 Finally - Be encouraged if we can do it, so can you!

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ISO/IEC 20000-2:2005 Information Technology Service Management – Part 2 Code of Practice

9 Author CVs

Jill Pritchet, Software Measurement Services Ltd

Jill is a Chartered Information Systems Practitioner with over 20 years experience in the Software Industry. As a Consultant she uses her extensive experience to guide her clients to significant success in making change programmes really work.

Jill has a particular flair in the area of ‘cultural change’ her approach ensures that the necessary skills are fine tuned within the client organisation so that they build the in-house confidence to tackle any future change, (whatever framework is selected), and fully understand the issues they may face and how to overcome them.

As well as extensive knowledge of the various Software Process Improvement (SPI) methods, including ISO 9001:2000, ISO20000, ITIL and CMMI(SM) Jill has given SPI tutorials and presentations at conferences across Europe encouraging others to learn from her experience including most recently ESEPG 2006.

Tim Davis, Serco

Tim Davis from Serco is a seasoned software development professional with over 25 years experience with blue chip companies. His career has been wide ranging, from software engineering to IT strategic planning with a focus on programme planning and change management.

As well as being delivery driven, Tim is particularly interested in enabling staff to excel, by creating environments where people can exceed expectations.

Tim has presented at previous international conferences, including Turkey and the USA, as Chair of User Groups e.g. AGIT

Outsource the Software Process Improvement consulting service: an alternative solution for Small-Settings[1]

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Abstract. The focus of this paper is to outline the main structure of an alternative solution to implement a Software Process Improvement program in Small-Settings using the outsourcing infrastructure. This solution takes the advantages of the traditional outsourcing models and applies its structure to propose an alternative solution to make available a Software Process Improvement program for Small-Settings. With this outsourcing solution it is possible share the resources between several Small-Settings.

Keywords: CMMI, Outsourcing, SPI, Small-Settings.

1 Introduction

The Information Technologies (IT) outsourcing has become more popular in many companies around the word. IT outsourcing means that the physical and human resources related to an organization's information technologies activities are going to be provided by a specialized external supplier. IT outsourcing started in the late 1980s and early 1990s and its market has grown rapidly during the past 20 years [1].

Many organizations have reported the success and benefits of the outsourcing. For example a study research realized on 750 organizations from USA and Europe confirm that the majority of those polled (56%) are satisfied with their outsourcing, 38% indicate they have mixed feelings as to the value they have gained from their outsourcing, and less than 6% report dissatisfaction with their outsourcing experience [2]. Nowadays more organizations are transferring their nonessentials functions to external suppliers, reducing their structure, and limiting their activities only to business core functions [3].

[1] Small-Settings are small and medium size enterprises, small organizations within large companies, and small projects.

[2] This work is sponsored by Endesa, Everis Foundation, Sun Microsystems, through the Research Group of Software Process Improvement for Spain and Latin American Region.

The outsourcing has been used by some organizations with good results, and many successful experiences have been presented in different forums. These experiences and their advantages could be applied to design an outsourcing solution to support all Software Process Improvement activities.

1.1. Problems to implement a Software Process Improvement in Small-Settings

One of the impediments to put in practice a Software Process Improvement (SPI) program in Small-Settings is because the majority of these organizations do not have a SPI group or a SPI specialist dedicated full time to SPI activities. Moreover, Small-Settings could not distract their own resources for process improvement activities.

Some Small-Settings implementations experiences founded that the principal factor to affect the success of a SPI program in a Small-Setting is the implementation costs [4, 5]. The fact is that Small-Settings are not able to afford the costs that represent an SPI specialist. Consequently, a small business in general is undersized to have personal dedicate full time to implement a SPI program. Moreover the SPI consultant costs are often prohibitive for small organizations.

This paper takes the outsourcing advantages and applies its structure to propose an alternative solution to make available a SPI program for Small-Settings. This outsourcing solution will provide the process improvement infrastructure to implement with an affordable cost an SPI program in Small-Settings. With this outsourcing it is possible to share the SPI infrastructure costs between several Small-Settings.

2 Alternative Software Process Improvement Outsourcing solution for Small-Settings

Every process improvement project requires at the initial phase a group of specialists that facilitate the definition, maintenance, and improvement of the software process. This group could be defined in the SPI infrastructure, and will help the organization to implement and institutionalize a continuous process improvement. The name of this group is Software Process Improvement Group (SEPG).

The SEPG is the most important component of the improvement infrastructure, and is the engine and the catalyst of the SPI program itself [6]. The SEPG infrastructure, elements and responsibilities most be clearly defined at beginning of the project, in the Initiating phase of the IDEAL approach, and be staffed with competent persons possessing both management and technical skills. It is crucial that these persons have good interpersonal skills because the success depends on ability to communicate, teach, negotiate, and consult all SPI problems and activities [7]. Also the SEPG must have the specific domain knowledge of the industrial domain to be supported.

The IDEAL model recommends that 1-3% of the organizational personnel be applied to support SEPG. In an organization with less that 30 people is recommended that at least one person be applied full time to facilitate and execute SPI.

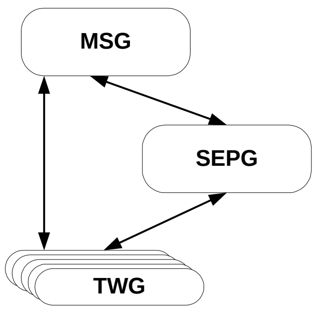

Figure-1 IDEAL's SPI infraestructure

To get a reasonably price to implement an SPI program in Small-Settings, this paper proposes an alternative SPI Outsourcing solution. This solution is based on the SPI infrastructure described by the IDEAL model (Figure-1) [6]. This outsourcing solution takes the advantages of IDEAL and includes the modifications that to adapt the SPI infrastructure for an outsourcing situation (Figure-2).

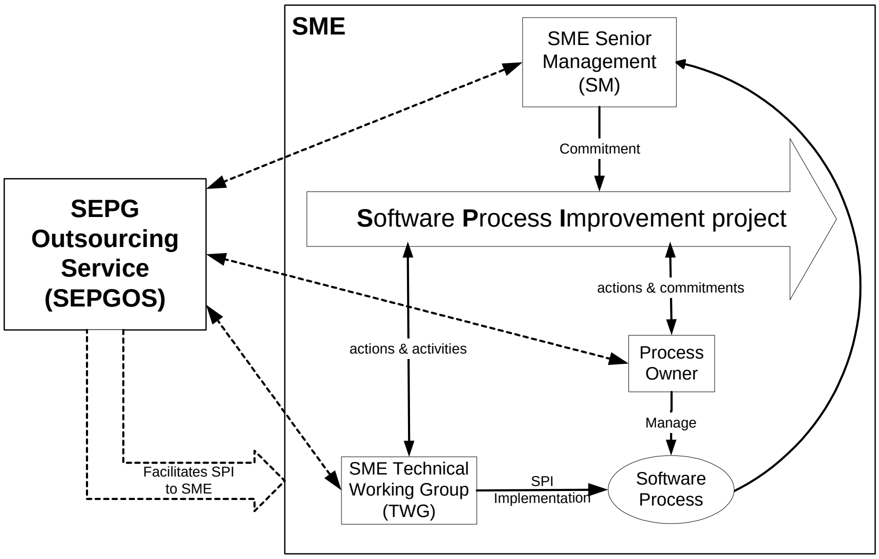

Figure-2 SEPG outsourcing service infrastructure

The focal point of the SPI Outsourcing solution is SEPG externalization, therefore this paper proposes an SEPG outsourcing infrastructure with the following functions descriptions:

Small-Setting senior management (SM). The SM takes also the name of: CEO, chairman, senior manager, high-level manager, etc. and his principal function are providing commitments and sponsorships for the entire SPI initiative.

Small-Setting technical working group (TWG). The TWG is the operative element of the SPI program, and address a specific process area in order to improve it. The TWG members are the software process developers and report directly to the process owner.

Small-Setting process owner. Is responsible for managing a specific Small-Setting process, support the improvement plans, and participate in improvement activities. Also he provides information and measurements of the process. In a typical Small-Setting the leader of TWG is the process owner. The process owner reports directly to senior manager.

SEPG outsourcing service (SEPGOS). The services provided by the SEPG are outside of Small-Setting. In consequence an external organization provides all SPI outsourcing service. The SEPGOS does not implement or develop the improvements, but its mission is planning and coordinating the individual improvement actions, leading the improvement effort and facilitate to Small-Setting all SPI activities. In addition, the SEPGOS has a significant role in building a positive, improvement-oriented culture by promoting awareness and collaborative communication about the improvement action. The SEPGOS should be shared by various Small-Settings to split up the cost that implies a qualified SEPG.

2.1. Organizational structure of the SEPG outsourcing service

The SEPGOS is organised in several Software Engineering Process Groups, each SEPG is specialized in a specific industrial domain such as Government, Financial, Services Industry, Commercial, Manufacturing, Travel Industry etc. Each SEPG is composed for at least one leader by domain. The SEPG could give SPI services for several Small-Settings depending of the size of each SPI project. Consequently the SEPGOS organizational size is directly proportional to the number of SPI projects of each Small-Setting. With the use of this model the cost that implies a qualified SEPG is divided between several Small-Settings (Figure-3).

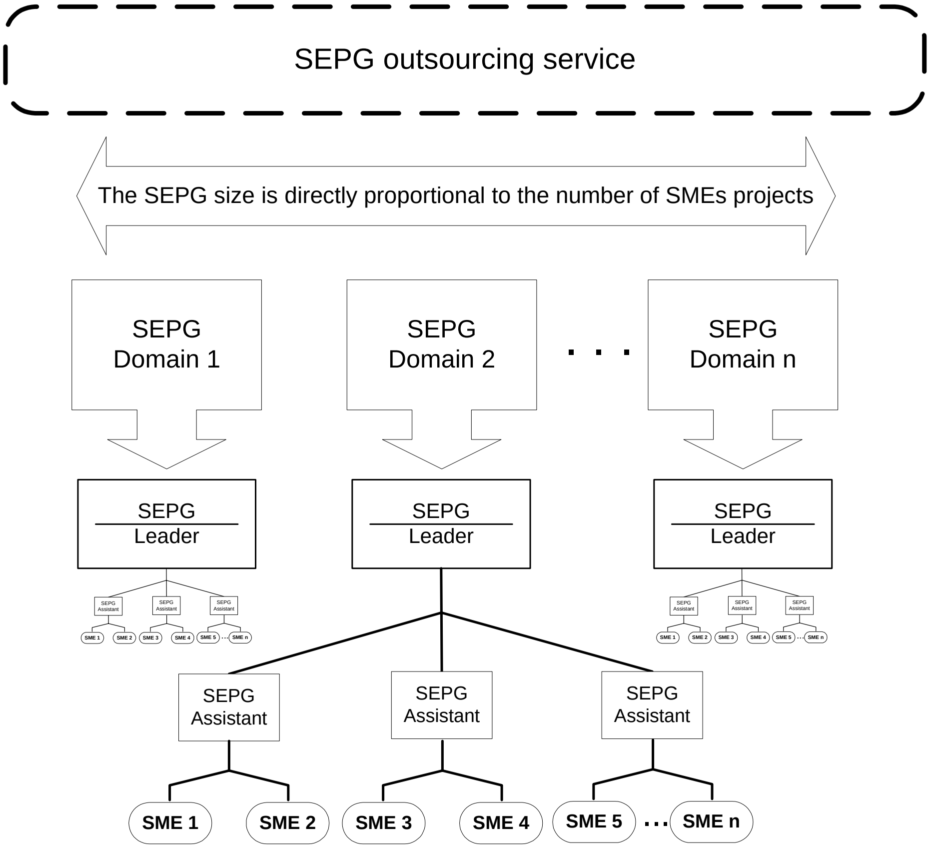

Figure-3 Organizational structure of the SEPG outsourcing service

2.2. SEPG outsourcing service lifecycle

The phases of the SEPG outsourcing lifecycle are similar for small and large organizations, but the amount of complexity and work involved require different approaches. The lifecycle of the SEPG outsourcing service (SEPGOS) include three phases:

Beginning → Ongoing → Conclusion

Beginning. Negotiate SPI service costs; establish a formal agreement with Small-Settings that clearly articulates the responsibilities and commitments; obtain and use SPI feedback in order to ensure that the services are meeting the Small-Setting's requirements and the agreed-upon commitments.

Ongoing. Deliver SPI service according to the agreed-upon commitments; planning and tracking the SPI activities; provide adequate SPI training to enable effectively use the SPI practices; identify problems that impact the SPI service delivery and take both preventive and corrective actions.

Conclusion. Transfer the responsibility and the knowledge back to the Small-Setting or to another SPI service provider according to the agreed-upon commitments; manage the effective transfer of resources to the new SPI service provider.

3 Implementation of the SEPG outsourcing service

The Polytechnic University of Madrid in collaboration with ENDESA, Everis Foundation, and Sun Microsystems supports the Research Group of Software Process Improvement for Spain and Latin American Region. The main objective of this Research Group is the investigation, adaptation and diffusion of software process improvement techniques, and transference this knowledge to industries.

A research line of this group focuses on developing mechanisms for Software Process Improvement in Small-Settings. In agreement with this research line the Spanish government through Ministry of Industry, Tourism and Trade will support those projects for implementing Software Processes Improvement in Small and Medium Enterprises (SME). The objective of the program is to obtain a measurable quality improvement of the software produced by SMEs in Spain. The SPI proposal must be includes: the commitment of each one of SMEs to reach the certification, the previous appraisal of the current state of software process, the definition of the certification level that each SMEs needs, and the implementation of the SPI project in each one of SMEs.

The Research Group of Software Process Improvement for Spain and Latin American Region in collaboration with an association of small companies and freelance software developers has presented the previous proposal to grant funding by the Spanish government. The proposal consists of the CMMI implementation in 26 small companies to get certification CMMI capacity level 2.

The aims is innovating the software processes and improve the quality of the software of those 26 SMEs. In order to help the implementation of the SEPG outsourcing service applied in a group of 26 small companies could be the best solution to commit an affordable cost the SME implementation and certification.

4 Conclusions

This paper proposes an alternative SPI outsourcing solution that will be useful to resolve some Small-Settings software process problems. With the outsourcing of the SPI services some Small-Settings could improve their software process at affordable cost. The focal point of this model is the outsourcing SEPG functions in order to share its costs between several small and medium-sized organizations.

One example about the benefits of the externalization of the SEPG was presented by Vodafone Spain [8]. This company subcontracts the services of an external SEPG to help them and implement the process areas of the CMMI level 2. The external SEPG supplier gives all SPI services and leads the improvement effort of the R&D group of approximately 50 members. This outsourcing service has helped Vodafone to reach CMMI maturity level 2.

The Research Group of Software Process Improvement for Spain and Latin American Region will implement this outsourcing solution to support the Software Process Improvement activities for 26 SMEs in a project founding by the Spanish government.

However, it is important to considerer the following advantages and disadvantages of an alternative SPI outsourcing model for its implementation:

Advantages

- The implementation costs of SPI, with sharing expenses among several SMEs, are diminished.
- The software process improvements could be measured by the use of standards as to compare it with diverse SMEs projects (benchmarking).
- A preventive approach to identify the SPI implementation problems is reached.

- The lesson learned could be used by other projects, because the Process Assets Library (PAL) includes information of the projects of each SMEs.
- The SPI project will collect the experiences that assurance the improvement for each SME.

Disadvantages

- The projects that are not in the same industrial domain of SMEs have implementation difficulties.
- The expert staff to commit the improvement is required.
- The group of companies must be homogenous and non-dispersed to be guaranteed that the implementation of the SEPGOS.
- The outsourcing staff is invasive and external to the company consequently it is difficult to establish effective mechanisms of communication.
- A minimum number of companies that share the SEPG infrastructure cost is required.
- The change resistance and the confidentiality of information could be a negative factor to commit the improvement.
- Special communication systems and manage mechanism to control the improvement activities for each SME is required.

The potential benefits of the SEPG outsourcing service that this paper proposed will show its effectiveness with the implementation of the SEPG outsourcing service in the CMMI certification project for 26 Spanish SMEs.

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Focused Competence Planning for Large Scale Software Development

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Abstract

In the modern software development, especially in the telecommunication industry, high requirements on the quality, reliability and security, along with short time to market and high system complexity, force the software development organizations to be more and more efficient, flexible, adaptable and competent. Both, their management and development processes have to continuously evolve in order to meet rapidly changing environment conditions. This paper addresses the problem of the management of resource competence planning during system desk check which turns out to be the most efficient verification activity in the rapid development of large scale software. After identifying the competence categories for the system desk check, it proposes a refinement of the usual competence planning processes with special attention devoted to the focused real time planning and competence upgrading in time. An example of such competence planning from a real telecommunication industry is given.

Keywords

Competence development, telecommunication software, desk check.

1 Introduction

The modern software development in telecommunication industry provides an excellent example for the problems encountered nowadays by software development industry in general. Strong requirements on quality, reliability and security due to real-time services on one hand are in contrast to every day shorter time to market and higher software complexity on the other. In order to sustain on the global market, both, the software development company and its products, have to be competitive. This is achieved through higher efficiency of the company, its management and development processes, and not only through better product quality.

The management of software development is defined as the ability to manage technical aspects of the development process as a whole, i.e. starting with agreed requirement definition and covering the creation of software designs, the creation of actual software components and finally the installation and testing of the software. An important aspect for improvement efficiency of the management process is better and more accurate project planning. The well planned software development makes possible efficient use of resources, early risk identification and better quality of product delivered to customer.

The main focus in the modern project planning is to increase its reliability and confidence [2]. The estimate of technical hours needed for each activity execution from the project time plan is usually based on very detailed analysis of impacts across the software product. Throughout the project phases the estimate is getting more precise and reliable, and is based on more detailed analysis.

However, usually the analysis of required resource skills and competence is not precise enough. The goal of this paper is to explain how to improve the efficiency and the quality of the product by classifying technical hours into several competence categories based on the process activity following the knowledge areas of [1] and competence categories proposed in Sect. 3 of this paper.

After classifying the competence categories, we propose the refinement of the management of resource competence planning process. This is the main core of the paper. The main benefit of our approach is precise focused planning of competence through time and for the project and/or organizational resource pool as a whole enabling overall competence upgrade planning before the problems show up.

In this paper our approach to focused competence planning based on the forthcoming development impact analysis is presented for the system desk check which is identified as one of the most efficient testing techniques in software development (see Sect. 3 and [4]). It is applied in the real telecommunication industry software development project.

The paper is organized as follows. After this Introduction, we give in Sect. 2 an insight into telecommunication software specifics. Section 3 explains in more detail the importance of system desk check and classifies the competence categories. Section 4 is devoted to the proposed approach of the focused competence planning.

2 Telecommunication Software Specifics

The competence planning in software development industry is based on the knowledge areas described by the PMBOK [7] and the SWEBOK [1]. The PMBOK is a general collection of knowledge and practices for the Project Management profession. On the other hand, SWEBOK comprises general knowledge areas for the Software Engineering profession. The specific knowledge areas required for the development of large scale software, especially for telecommunication equipment, are described and presented in Sect. 3.

The telecommunication software is a large scale software for telecommunication networks which is organized into network nodes communicating to each other using well defined network interfaces. Each node has its specified function within the telecommunication network. The node software is a large scale software package with strong quality, reliability and security requirements, as well as high complexity and rapid development, as explained in the Introduction. The node software is divided into number of software units.

One of the main requirements the telecommunications equipment has to implement is the concurrent handling of incoming calls. Therefore, the calls are served within the equipment node as a sequence of smaller executions, usually referred to as jobs, enabling the concurrency. However, due to existence of jobs of different nature, such as recovery functions, traffic handling, idle load, the jobs are prioritized into several levels. The lower priority jobs may always be interrupted by the higher priority ones. Telecommunication network performance and quality parameters define time limits for execution of jobs for each priority level.

Another important issue for telecommunication network is the signal multiplication. The signal multiplication refers to the fact that every incoming signal produces several signals towards job buffers. Hence, in order to meet the performance requirements, it is important to assure that the mass signaling towards the job buffers is done in a controlled way. Otherwise, high load conditions could overload the processors.

Due to short time to market in telecommunication industry, the software product development model is a variant of iterative development model with waterfall increments. For each waterfall increment the knowledge areas described in the SWEBOK are required. The development is divided into a sequence of iterations. Each iteration is carefully planned within the project time plan regarding the schedule, effort, resources and cost. This paper addresses the resource competence planning for such development model.

3 System Desk Check Competence Categories

Due to shorter time to market and higher product quality requirements, the importance and efficiency of desk check is continuously growing as pointed out by several authors [6], [5] and [3]. During software process improvement program described in [4], the system (also called multiblock) desk check is identified to be more efficient than before, as the speed of development iterations is growing and even overlapping iterations on the same software base occur.

The classical desk check activity has been focused on a single software unit at a time checking just coding rules and logic. The idea behind the system desk check is to detect faults which could not be detected in classical desk check and thus produce significant savings in later verification phases. During system desk check one should think in advance and always be aware of all the call scenarios, node performance requirements at network level and required node behavior in that context. The focus is on signal sequences and related data transfers within the node and between software units in order to satisfy expected system behavior in the network.

The system desk check activity, as introduced in [4], turns out to be very successful in terms of business case. We have developed the list of check points for the system desk check. The list is developed by conducting an analysis of trouble reports from the history database aiming to find the fault patterns in the most faulty software units. The check points are grouped according to the system reliability categories of [8]. These categories we used as competence categories in the competence development approach presented in this paper. The competence categories are the following:

- *A.* Structured design
- *B.* Program structure
- *C.* Data structure
- *D.* Language semantics
- *E.* Signals (use cases)
- *F.* Real time requirements
- *G.* Recovery functions

- *H.* Time supervision and alarms
- *I.* Common resource usage
- *J.* User terminal commands
- *K.* Traffic handling
- *L.* Operation and maintenance
- *M.* Files handling, linked lists and pointers

The categories *A, B, C, D* are issues more related to the classical desk check technique. However, the implementation of function over different blocks is the issue for the system desk check. In the system desk check understanding the required system behavior within the specified network enables verifying if the system structure, program and data structure, including state machine handling, is satisfying the intended network needs.

As explained in Sect. 2, the signals are the result of a division of system program execution into a sequence of jobs. System desk check category *E* is focused on check of various signal interactions, unique signal identification and correct definition, matching of signal types and purposes, correct signal data manipulation within and between software units, and implementation of signal in backward compatible way. Another important issue is to deal with signal priority levels, time execution limits per signal defined and maximal allowed number of signals sent from the same sequence.

The signal category *E* overlaps with the real time requirements of category *F*. It considers the maximal execution time for each priority level since all overruns turn out with job termination and a recovery action. System desk check addresses the possible termination of jobs and signal multiplication especially when signals are sent from within a loop.

The recovery functions of category *G* are defined to help automatically recovering of the system when unexpected events and abnormal conditions occur. They are extremely important due to their strong influence on system reliability and customer satisfaction. The system desk check of a recovery function is focused on proper system recovery such as entire state machine check, recovery after restart, recovery status reporting for test and maintenance purpose, proper use of recovery procedures, data recovery, all relevant job termination, etc.

Category *H* system desk check is concerned with implementation of counters for capacity sensitive processes or time measurements between events using time supervision functions and proper alarm notifications.

The system desk check could be especially efficient for category *I*, i.e. checking of possible interferences on shared resources. Such situations are hard to verify in basic test, function test or even system test level without hardware equipment, but could be detected using proper desk check approach. The capacity issues are related to resource usage, such as early predictions of system processor signaling buffer or instruction processor load, and memory leaking conditions.

Importance of category *J* and *L* system desk check comes from the fact that the command execution initiated from user terminal has always lower priority than traffic handling. In case of multiple user terminal operation, it should be verified that command execution from different user terminals are properly handled. For command execution it is important to verify all possible not properly defined changeable parameters set by the command. Also, if several software units are involved into command execution it is important to secure coordinated execution. For any command there are strictly defined conditions for the command acceptance.

The file size definition is either dependent on hardware resource availability or is modified dynamically. Usually within large scale software the file records are linked together for call execution. During category *M* system desk check one could check proper coordination of the size modification of linked records belonging to different files (even in different blocks), alarm and audit function for too high utilization of file, standard language routines for size alteration, initiation of variables within new file records, linking of new file records with others, scanning the linked lists, removing file from the list, interaction of several processes on the linked list, handling the state changes with linked lists, etc.

4 Focused Competence Planning

As explained in Sect. 2, success of modern software development, especially in telecommunication industry, strongly depends on carefully planned and organized project work. With shorter development cycle, desk check efficiency significantly grows as explained in Sect. 3. The goal is to identify earlier as much faults as possible. For deployment of improvements of [4] related to the system desk check, competence development programs have to be performed. The competence development program depends on the organization. Here we present a generic competence analysis approach for development of competence development plan (CDP). It could be performed for any selected period of time which depends on the development iteration cycle. Also, it could be performed for any resource pool (belonging to project or organizational module) that is assigned to feature execution pool (committed by project or organization). The steps of the analysis are the following:

- *Step 1.* Identification of development scope (for project, for development iterations within rolling period, etc)
- *Step 2.* Identification of deliverables over selected period (project time, monthly, quarterly, annually, etc)
- *Step 3.* Identification of competence needs in competence categories (described in Sect. 3) per deliverable
- *Step 4.* Combining of competence needs for deliverables over selected period to obtain competence need at any given point in time inside selected period

		Time/Months								Competence Areas												
	L=1, M=2, H=3	1	2	3	4	5	6	7	8	Structured design	Program structure	Data structure	Languague semantics	Signals (use cases)	Real Time requirements	Restarts	Recovery functions	Time supervision and alarm	Common resource usage	User terminal commands	Traffic Handling	Linked lists, pointers
Features	Feature 1		■							L	L		M	L	L	H	L	M		H	L	M
	Feature 2			■						L	L	H	M	L	L	M	H	M	L		M	M
	Feature 3			■	■					L	L	L	H	M	H	L	L	M	H		H	H
	Feature 4				■					L	L	L	H	M	M		L		H	H	H	H
	Feature 5					■						L	L		L	M	H	M			M	H
	Feature 6				■			■		M	M	M	L	H	H	L			M		L	
	Feature 7						■			M	M	H		M	L	M	H	L		H	L	H
	Feature 8					■				L	L		H	M	L	L	L		L		H	H
	Feature 9						■			L	L	L	M	L	L	L	L		H	M	L	M
	Feature 10							■			L			M	M	H	M	H			L	L

		1	2	3	4	5	6	7	8	Required competence level	Actual competence level
Competence Areas	Structured design		1	2	4	1	3	2		4	5
	Program structure		1	2	4	1	3	3		4	5
	Data structure			4	4	1	4	2		4	7
	Languague semantics		2	5	7	4	2	1		7	6
	Signals (use cases)		1	3	7	2	3	5		7	8
	Real Time requirements		1	4	8	2	2	5		8	6
	Restarts		3	3	2	3	3	4		4	5
	Recovery functions		1	4	2	4	4	2		4	8
	Time sup. and alarms		2	4	2	2	1	3		4	4
	Common resource usage			4	8	1	3	2		8	3
	User terminal commands		3		3		5			5	7
	Traffic Handling		1	5	7	5	2	2		7	5
	Linked lists, pointers		2	5	6	6	5	1		6	8

Figure 1: Competence matrix

- *Step 5.* Identification of maximal competence need per competence category during the selected period
- *Step 6.* Comparing to organizational or project capability (using resource competence records)
- *Step 7.* Development of competence development plan (identify training type, met\-hod, resources for training, duration, time plan).

In the sequel we give more details on the issues of the above approach which are additional compared to the standard process as explained in the PMBOK [7]. They are related to more focused and better planning activities including the detailed analysis of the forthcoming development efforts based on stability analysis of baseline products, opportunity for improvement (OFI) analysis from the history projects and forthcoming deliverables impact analysis. The analysis is summarized in the time plan, impact and competence matrices of Fig. 1 which we explain below.

The first two steps of the analysis refer to the matrix presented in the upper left corner in Fig. 1. All features from the feature execution pool (already committed) are listed, so that every row represents one feature. This activity is *step 1* above. The columns of the matrix represent time increments for the analyzed time period. In our case time increments correspond to calendar months. In *step 2* we consider the delivery increment per every feature and fill in the upper left matrix in Fig. 1. by shading the crossings of the row of the feature and the columns of months of its delivery increments. In other words if i^{th} feature is delivered in j^{th} month, then the crossing of i^{th} row and j^{th} column is shaded. More precisely, let n be the number of features considered and m the number of months in the selected period. Then, we define the $n \times m$ matrix, denoted by A, by putting 1 at shaded places and 0 elsewhere. In other words, for $1 \le i \le n$ and $1 \le j \le m$, the element a_{ij} of the matrix A is given by

$$a_{ij} = \begin{cases} 1, \text{if i}^{\text{th}} \text{ feature is delivered in j}^{\text{th}} \text{ month, i.e. place (i, j) is shaded,} \\ 0, \text{otherwise, i.e. place (i, j) is not shaded.} \end{cases}$$

For every development iteration over time the impacts per competence category are identified in step 3. The results are given in the upper right corner matrix in Fig. 1. It gives the impact level of forthcoming feature per analyzed competence category explained in Sect. 3. Just note that competence categories are actually related to system functions. The impact level is identified by detailed analysis of feature impacts on specified system function, fault report history of the impacted system components and its relation to the specified system function. Impacts are ranked per iteration as no impact, low *(L)*, medium *(M)* or high *(H)* impact as presented in Table 1. Observe that the numerical values for every level of impact are the ones used in our example.

Table 1. Levels of impact and competence

Level	Impact	Competence	Num. value
L	Low	Basic	1
M	Medium	Intermediate	2
H	High	Expert	3

As above, if l is the number of competence categories, we introduce the $n \times l$ matrix B corresponding to the impact analysis given in upper right corner of Fig. 1. For $1 \le i \le n$ and $1 \le i \le l$, the matrix element b_{ij} is given by

$$b_{ij} = \begin{cases} 0, \text{if i}^{\text{th}} \text{ feature has no impact in j}^{\text{th}} \text{ competence category,} \\ 1, \text{if i}^{\text{th}} \text{ feature has low impact (L) in j}^{\text{th}} \text{ competence category,} \\ 2, \text{if i}^{\text{th}} \text{ feature has medium impact (M) in j}^{\text{th}} \text{ competence category,} \\ 3, \text{if i}^{\text{th}} \text{ feature has high impact (H) in j}^{\text{th}} \text{ competence category.} \end{cases}$$

In *step 4*, based on upper two matrices A and B, we obtain the matrix in lower left corner of Fig. 1. giving the amount of competence needs per competence category over time. The amount of competence is calculated using the numerical convention given in Table 1, which for the impact and competence levels takes L=1, M=2 and H=3. If we denote the lower left corner $l \times m$ matrix by C, it is obtained simply as a matrix product

$$C = B^T A,$$

where X^T denotes transposed matrix. In other words, for $1 \le i \le l$ and $1 \le j \le m$, the matrix element c_{ij} is given by

$$c_{ij} = \sum_{k=1}^{n} b_{ki} a_{kj} .$$

Having the matrix C at hand, we can easily read the competence needs per month for every competence category. Competence capability of the organization should always be equal or greater than the amount of identified impacts per competence (system) category in any given point in time. To assure that, in *step 5*, we find the maximal competence need per competence category during the selected period of time. It is given in the column matrix D next to the matrix C in Fig. 1. For $1 \le i \le l$, the element d_i in the $1 \times l$ matrix D is given by

$$d_i = \max_{1 \le j \le m} c_{ij} .$$

The required competence level for the selected period of time is compared to the organizational competence in *step 6*. Organizational competence for our example is given by the $1 \times l$ column matrix E in the lower right corner of the Fig. 1. It is calculated using the same numerical convention as in Table 1 based on the competence level of the organizational resources involved in the project. The comparison of the two matrices D and E is best presented by the spider chart as in Fig. 2, where the solid line represents the maximal competence required at a certain point in time and the dot line represents the existing organizational competence.

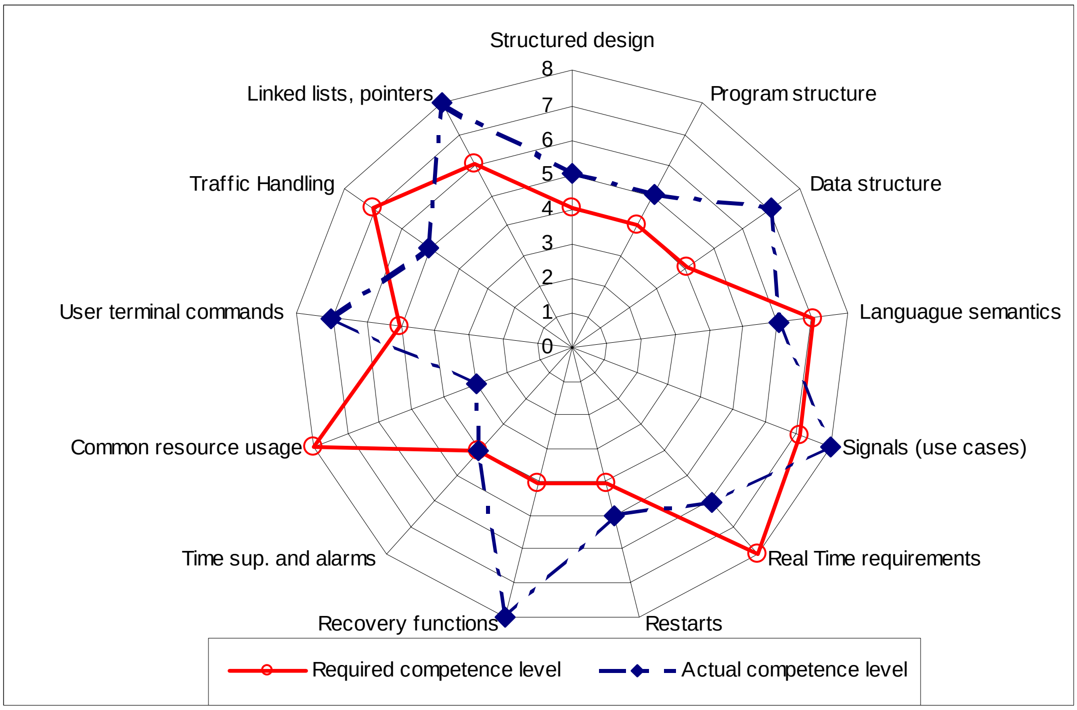

Figure 2: Competence chart

The goal of the competence development plan in *step 7* is to reduce the competence gap, i.e. to build up competencies until the grey line is inside the black line in Fig. 2. The training actions in competence development plan strongly depend on the time issues, identified gaps, current level of competencies and personnel availability for competence building activities. The actions taken could be given internal support and on job training, external support and external on job training, attending organized focused courses, early self preparation in focused category using specified material with examples and problems from reality.

The competence planning approach presented here is an example performed in the real telecommunications industry showing benefits of the proposed approach. The proposal was a part of the wider software process improvement explained in [4], where the benefits are reported.

5 Conclusion

In this paper we have identified the competence categories required for the system desk check verification activity in the development of large scale software. As explained in Sect. 3 from the telecommunication industry experience, system desk check turns out to be more and more efficient in a sense that the faults which slipped through from the desk check phase to the later verification phases produce tremendous expenses. This is especially true in modern rapid software development since every fault found late should be mapped to several projects running in parallel. Of course, this does not mean that other verification activities should be neglected, but it points out the system desk check as a verification activity which produces considerable saving to a software development company if performed correctly. Compared to the classical desk check which is done per software unit, the system desk check activities include verification of interconnections between software units. Therefore, it enables finding more faults which would have been found only later in the project otherwise.

Having identified competence categories, we have proposed an approach to the focused competence planning management process. It is a refinement of the existing project management techniques. The most important benefit of our approach is careful in-time planning of competence needs in advance. This enables the project management to upgrade resource competence before it is too late and therefore ensure the project success.

The suggested focused competence evaluation and development strategy is becoming more interesting especially in dynamic environment of rapid telecommunication development, software development and technology development. Another very important but not ultimate aspect of dynamic environment is every day increasing competition, requiring fast and frequent adaptations to market needs. Since software development companies are based on personal knowledge and skills, a precondition for success is the competence development model that will effectively and efficiently satisfy dynamical environment needs.

6 Literature

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Successful Six-Sigma Improvements in - Agile Methodology of Software Release Management

P Radhika Ravi

Abstract:

The dependencies amongst the modules and module elements at the build and run time level is evolving to be more complex day by day. There is the challenge of managing discrete modules that must work together when released. Releases consist of multiple iterative cycles of multiple modules, in which some of those are parallel releases, and some might be sequential – one after the other. Concurrent builds with multiple development teams developing different modules makes Release Management an even bigger challenge. The merging process – Most of which was selective merging was laborious and time consuming. Ultimately build and Release Management process which was not mature became a critical roadblock to product quality and deliveries Ontime.

The software development framework adopted was agile processes. Agile method of software development focuses on satisfying customer-defined requirements with a minimum overhead to the project. Agile software methodologies, based on the principles of the Agile Manifesto, are typically adaptive processes.

The challenges in release management area had its root early in the development life cycle.

The Challenges were typically related to the following

- ✓ Formal Process for release Management
- ✓ Commitment to follow Process
- ✓ Issues related to Machines
- ✓ Contents of releases unknown and Uncontrolled.

There was a need in the project to do a causal analysis, correct and prevent the issues and problems and have a mature process of release in place. Six Sigma uses defects and deficiencies as striking point for reducing the Cycle time of delivery, and costs of rework during development. Six Sigma and Agile development are both dedicated to reducing failure rates and improving customer satisfaction. Six-sigma tools are very effective in investigation, tracking and Controls and to bring out tangible results. There fore it was decided to implement six-sigma methodology to achieve tangible results.

This paper elaborates on the six sigma DMAIC (Define, Measure, Analyze, Improve, and Control) methodology and tools that were implemented in a truly agile software development process to reap tangible results.

The achievements were:
The following were remarkable achievements in a time span of 4 weeks. Few of six sigma tools were implemented and the SPI journey was very successful.

The following were remarkable achievements in a time span of 4 weeks. Few of six sigma tools were implemented and the SPI journey was very successful.

- ✓ Process sigma rose from -1.45 to 2.49
- ✓ Release Management Process made formal. A Release Management Process Manual was released and implemented.
- ✓ Commitment from all the stakeholders on every delivery made.
- ✓ No code updation from N-3 day of release. Therefore the Content of each release was known and controlled.
- ✓ Tangible improvement in short span of time. On time Deliveries and the number of days for each release was between 3 to 7 days which was expected.
- ✓ Lesser defects in Merging. The numbers of defects were reduced by 44.7%.
- ✓ The Results were achieved in a span of 4 weeks.

Keywords
Agile Methodologies, Six-Sigma Methodology, Sigma level calculations, Release Management, Fish Bone Diagram, and Action Plan Matrix.

1 Prologue

1.1 About the Entire Project

This project was carried out for a leading provider of eCommerce services and software, specializing in electronic bill payment and investment services that provide financial services in the field of Separately Managed Accounts.

This project is for developing a Portfolio Management System for an Enhanced Portfolio Lifecycle (EPL) for the provider. The scope of the project included the preparation of technical specifications, EPL application architecture, application design, development, construction, and testing and release implementation of specific release applications of the EPL system.

The build and Release Management happens in the Construction phase. The construction phase is where emphasis is placed on the following

- ✓ Managing resources

- ✓ Optimize costs,
- ✓ Schedules
- ✓ Quality

The Build and Release Management Process was highly complex because, the Releases were of multiple iterative cycles with multiple modules and Interdependencies. The Use cases prioritized based on risks and priority of requirements were developed into modules. These individual modules have to be merged into the main branch for creation of builds. The creation of final builds, Preparation of User manual and the technical manuals, Smoke testing were the archetypal activities of Release Management team.

This software process improvement initiation was carried out for the “Release Management” phase of the EPL project.

1.2 The Scenario and the Challenges

The Core activities in the Build and Release Management phase are:

- ✓ Acquire Code from the Main Branch.
- ✓ Integrated software on the prescribed platforms.
- ✓ Prepare builds and test
- ✓ Prepare user manuals and Technical manual.

The major challenges were related to delay in deliveries with a bet on the quality of the deliverables.

The key problem that attributed to the delay and lesser quality were analyzed and listed.

The Problem:

- Undue delay in weekly deliveries.
- Defects due to improper merging process.

The deliveries which should happen between 3 to 7 days were happening with undue delay. The commitments on schedule and quality of the deliverables were pulling down the trust of the stakeholders.

The following table shows the days between deliveries.

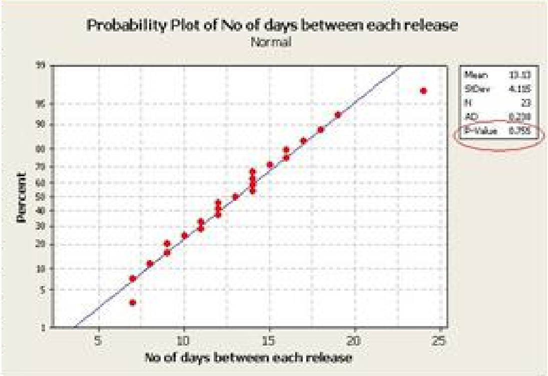
No of days between releases - Before Process Improvement	
9	Data Normalization - Normality Test
19	
15	
12	
16	
14	
18	
10	
14	
14	
24	
14	
9	
12	
8	
13	Mean: 13.13
17	Standard Deviation: 4.12
11	**Mean:** The mean, also called theaverage value, is the quantity obtained by summing two or more numbers and then dividing by the number of numbers .
11	
12	
16	**Standard Deviation:** Standard deviation is a statistical measure of spread or variability
7	
7	**Normality Test:** A normality test is a statistical process used to determine if a sample or any group of data fits a standard normal distribution.
12.58	

Figure 1: Release dates. Before Improvement initiatives.

The Challenges essentially were into the four main factors:

- ✓ People
- ✓ Process
- ✓ Machine
- ✓ Environment.

The End result of this SPI journey: Reducing the cycle time of Releases.

The technology and tools deployed in the project were:

Description	Tools
Development Methodology	Best Practices of Agile Methodology
Programming languages	C#(C-Sharp) on .NET Framework
Design and Modelling	Enterprise Architect
Data Modelling	ErWin
Configuration Management	Visual Source Safe
Project Management	MS Project
Testing	WinRunner and LoadRunner are Mercury Interactive products

Table 1: Technology adopted for developing the software.

1.3 Achievements:

The following were remarkable achievements in a time span of 4 weeks. Few of six sigma tools were implemented and the SPI journey was very successful.

- ✓ Process sigma rose from -1.45 to 2.49
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- ✓ Lesser defects in Merging. The numbers of defects were reduced by 44.7%.
- ✓ The Results were achieved in a span of 4 weeks.

2 Why Six-Sigma with Agile?

1. The customer's expectation was faster improvements and Better deliverables in short span of time.
2. The Area of improvement – The Release Management Processes was identified. Six-Sigma methodology and tools were better options to achieve quick, focused, tangible results.
3. The reduction in release cycle was a burning problem with need for implicit attention and corrections.
4. Defects in the Merging process of the code of individual modules in the main stream had to be reduced.
5. Six sigma tools help in identifying the main causes. There are choices of tools of which we shall select some for process improvement.
6. An agile methodology does not prescribe any particular problem solving methodology or frame work.

3 The Process

The solution was based on the six sigma methodology iSTRIVE methodology which id derived from DMAIC (Define, Measure, Analyze, Improve, and Control) methodology. The following figure 2 is the pictorial depiction of the methodology.

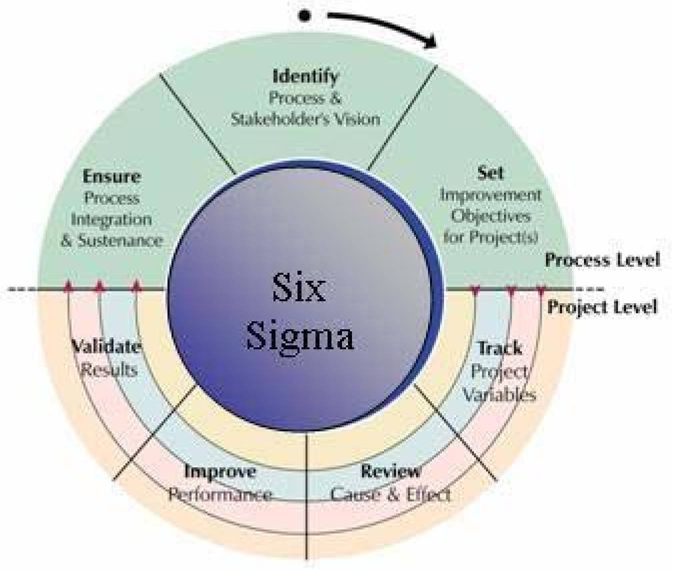

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Figure 2: iSTRIVE - Six-Sigma DMAIC Methodology

In the Identify phase of the improvement project 2 to 3 brainstorming sessions were conducted with permutation and combination of different stake holders. Brainstorming is a six-sigma tool in which a team of stakeholders participate to tap experience and expertise of each and every member. The outcome of these brainstorming sessions was the problems that were part of the release process.

The objective of this improvement was already set: Reduced cycle-time for releases.

Therefore the six-sigma initiative was anchored around this expectation. Timelines were decided for the completion of this initiative.

The track phase consisted of the following activities

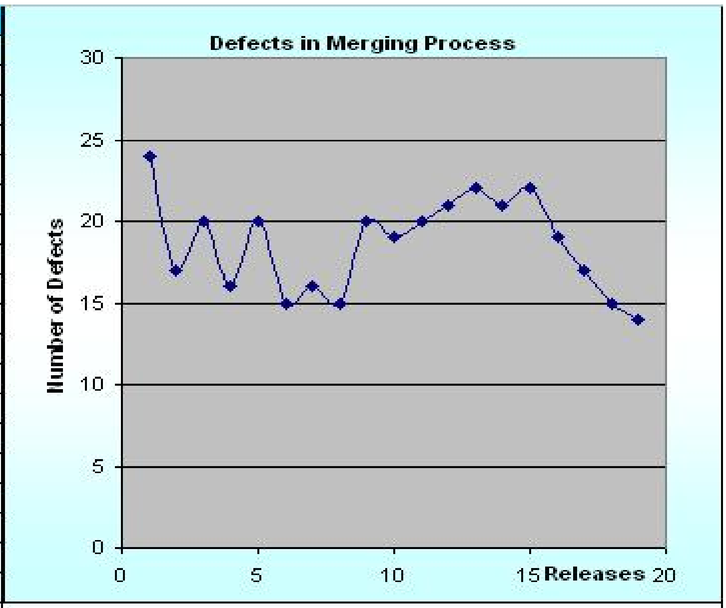
- ✓ Data Collection
- ✓ Sigma Level Calculation
- ✓ Identify the Problems

The Data collection was from the Project Management team and the data collected were "Release dates – Planned and Actual". Refer Figure 1. Which lists the number of days between releases.

The Defects which have surfaced out of merging of code into the main branch were also identified.

The following figure 3 depicts the defect numbers.

Defects due to Merging	
Release No	**Defects**
Release 1	24
Release 2	17
Release 3	20
Release 4	16
Release 5	20
Release 6	15
Release 7	16
Release 8	15
Release 9	20
Release 10	19
Release 11	20
Release 12	21
Release 13	22
Release 14	21
Release 15	22
Release 16	19
Release 17	17
Release 18	15
Release 19	14
Average	**18.58**



Merging: Merging if a process carried out to append the code written by individual developer into the main source

Figure 3: Defects due to improper merging of source code into the main branch.

Merging was carried out manually which was laborious and prone to human error. The process was time consuming there by leading to delay.

The large number of defects was mainly due to the merging of the code without detailed analysis of the impact of merging.

Analysis and preliminary sigma levels were calculated and appropriate sigma goal line was set.

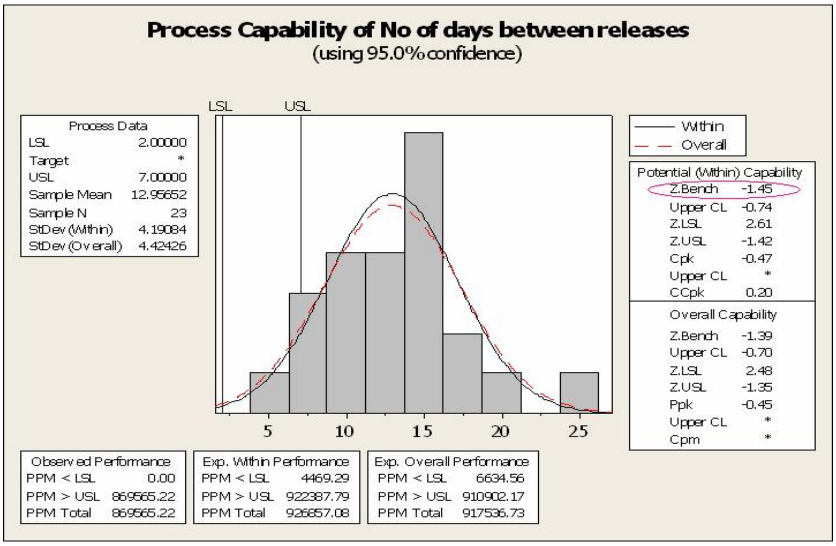


Figure 4: Process Capability of number of days between Releases

The identified Problems were listed a Cause-Effect analysis was done. The problems identified were put across into a fish bone diagram. This tool helps to identify, explore, and graphically display all of the possible causes related to a problem or condition to discover its root cause.

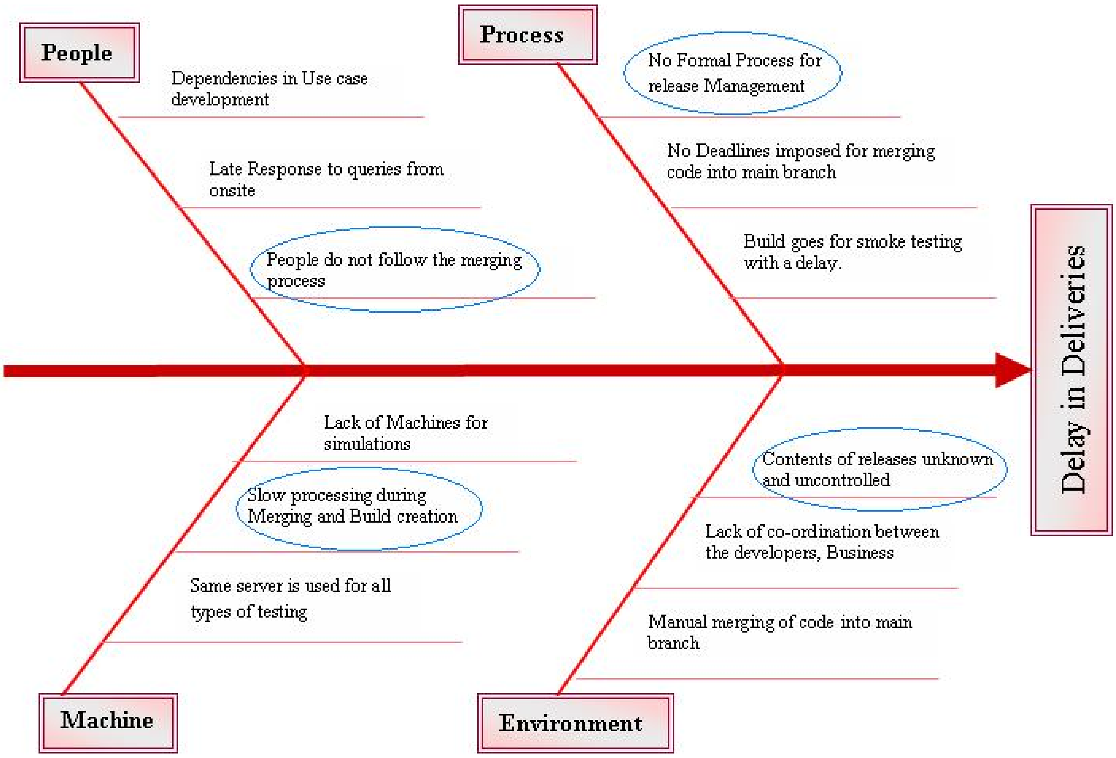


Figure 5: Cause-Effect Analysis of all Root Causes.

The figure 5 above depicts all the root causes and major causes.

The Potential Root Causes attributing to the delay in deliveries were

- ✓ No Formal Process for release Management
- ✓ People do not follow the Merging Process
- ✓ Slow Processing during merging and Build creation
- ✓ Contents of releases unknown and Uncontrolled.

The issues have been identified, and analyzed. For more pointed analysis a Relationship matrix was chosen. The Relationship Matrix is a convenient method of visualizing relationships quickly and definitively. This relationship matrix clearly convened the “First Priority “factors that will lead to implicit improvements.

Relationship Matrix					
Validated X's / Expected Outcome	Good communication strategy	Formal Release Management Process	Better Processing Machines	Plan Contents of releases	Automation of merging
Formal Process	□	◆	◇	□	◇
Lesser Issues and defects	□	◆	◇	□	◆
Deliveries on schedule	◇	◆	□	◆	◆
Total	7	27	5	13	19
	Legend	**Weightage**			
Strong Relationship	◆	9	A Formal release Management Process and Automation of Merging receives high weightage.		
Medium Relationship	□	3			
Weak Relationship	◇	1			

Figure 6: Relationship Matrix

Organizing the prioritized root causes, an action matrix was prepared. An Action Plan matrix is a probable implementation schedule with responsibilities using only the top priority root causes.

Action Plan Matrix			
Root Cause(s)	**Counter Measure (What to do?)**	**Action Plan (How to do?)**	**Responsibility**
No Formal Process for release Management	Create a Release Management Process	Collect existing practices, and with the industry standards, create a formal Process	Process Engineer along with all the stakeholders
People do not follow the Merging Process	Conduct Training and create awareness	Contineous traings to educate people and to create awareness	Process Engineer / Project Manager
Slow Processing during merging and Build creation	Upgrade Machines and aquire new machines	Update machines with appropriate RAM or procure new machines	Project Manager
Contents of releases unknown and Uncontrolled.	Plan releases with emphasis on schedule adherence	The releases are to planned with all the stakeholders involved. Commitment to the plan to be obtained before implementation of the plan.	Project Manager

Figure 7: Action Plan Matrix for major challenges

4 The Solution

The Solution was for two typical Factors

✓ Formal Process and guidelines for release

✓ Upgrade machines and automation of the release phases.

✓ Acquire tools and techniques that will increase productivity and decrease overheads.

Existing practices were collated and a formal process for release management was devised. The Release management process addressed the Scope of Release, Roles and Responsibilities, Release Content, Release Versions, User Manuals, Technical Manuals.

We can't have new features being added to the released code base as that will impede a stable release. There fore the criteria for limiting the content of release was emphasized. The Project Manager was made responsible for deciding schedules to lock the main branch so that no new code would be checked-in after the dead-line.

As the development methodology is an Agile Methodology, An emphasis was made for frequent releases with iterations of important use-cases. This would minimize inherent risks and surface defects early before penetrating and aging.

Merging of code into the main branch from the development branch was the main focus as this was the main pain area that led to delay and recurring defects. Guidelines for merging were developed with clear emphasis on when to stop merging. The process of merging should be stopped before the release team starts to prepare a build.

The new process was communicated to all the stake-holders of the process to acquire a buy-in. The process was baselined and communicated to all stakeholders.

Frequent assessments were planned to ensure that the processes were adhered to. This alleviated time for testing of the build. The sigma level was calculated continuously for all releases after implementation of the release management process and the guidelines.

Introduction of Visual Studio Team System (VSTS) in the place of Visual Source safe (VSS) considerable reduced the time fore releases. The Team System supports two conceptual frameworks for software development, Agile and Capability Maturity Model Integration (CMMI). VSTS uses Team Foundation Server (TFS) as the data storage and collaboration backend. TFS provides a source control repository, work item tracking and reporting services. TFS works on "work items", which are a single unit of work which needs to be completed. Items themselves can be of several different types, such as a Bug, a Task, a Quality of Service Requirement, a Scenario, and so forth. Therefore for this agile process of development the VSTS was a good choice.

A major benefit of VSTS was the ability to apply/promote labels for delivery. The release team just shared the label applied on the code base with the onsite team and deployment was done by taking the latest of the code base from the given label.

A Central build server was installed. This helped in identifying broken branches and lot of time was saved on compilation errors. With the introduction of CCNet as a continuous integration/build server, it was possible to have a build error free branch. CruiseControl.NET is an Automated Continuous Integration server, implemented using the Microsoft .NET Framework. CCNet server builds the code base after every check in and displays the result in form of a dashboard.

Once the build was ready to be released, A “Pre-Release Review” was initiated. During the Pre-release Review, some of the factors considered were:

- ✓ If all the Indented Use cases for release have been deployed successfully.
- ✓ Does the build carry the latest version, checked out from the server?
- ✓ Has enough testing been done to ensure that the merging has been accomplished successfully?
- ✓ Are major defects closed?
- ✓ Are Release notes prepared?
- ✓ Are the User manual and technical manual ready?

- ✓ Whether all plans have been signed off.
- ✓ Communication to all relevant stake holders.
- ✓ The readiness of the production environment for the release.

5 The Results

The following graph represents improved sigma level. This improvement was achieved in a span of 4 weeks.

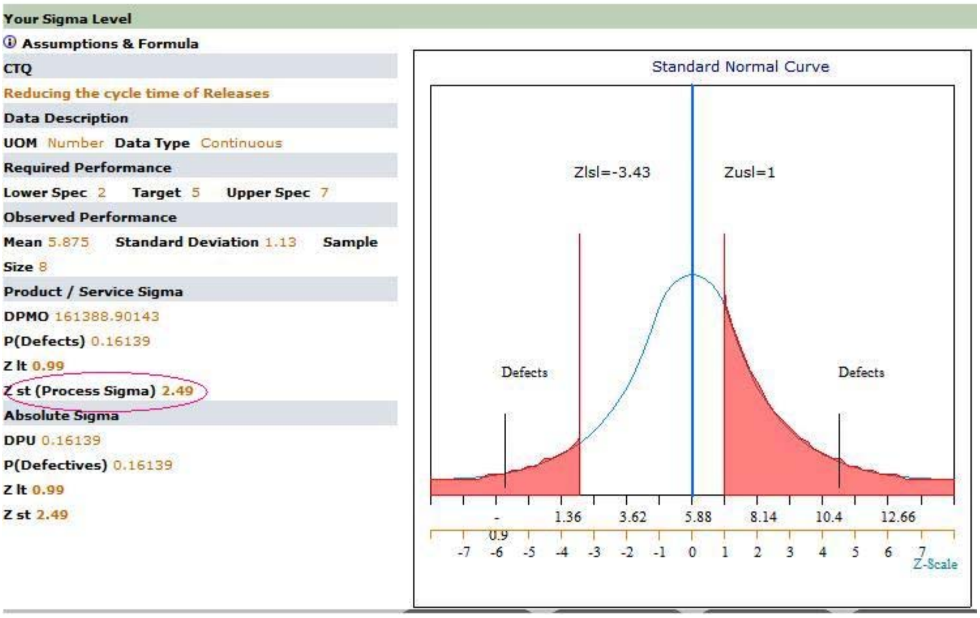
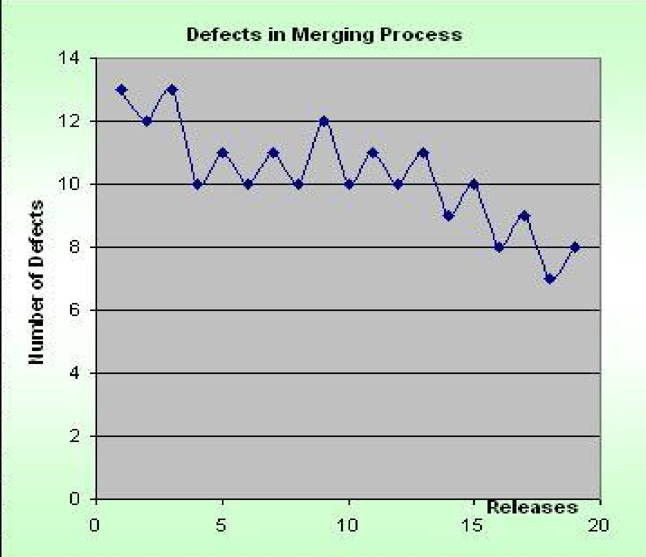


Figure 8: Improved Process Sigma

The z-score will describe how much a point deviates from a mean or specification point. A higher process sigma means a less defective process. The term Six Sigma originates from the z-score. 6σ means that six standard deviations lie between the mean of a sample and the nearest specification limit.

Here the Z-score has rose from -1.45 to 2.49 in the span of 4 weeks.

Defects due to Merging	
Release No	**Defects**
Release 1	13
Release 2	12
Release 3	13
Release 4	10
Release 5	11
Release 6	10
Release 7	11
Release 8	10
Release 9	12
Release 10	10
Release 11	11
Release 12	10
Release 13	11
Release 14	9
Release 15	10
Release 16	8
Release 17	9
Release 18	7
Release 19	8
Average	**10.26**



Merging: Merging if a process carried out to append the code written by individual developer into the main source

Figure 9: Decreased defects in Merging Process

The above figure 9 shows run-chart which depicts defects from release of drop 2 which is post six-sigma implementation.

The defect number was reduced by 44.7%.

Six Sigma implementation focuses on the process, whether it is Conservative development processes or any new non conservative, light weight processes. The improvement achieved in this case was quite dramatic. The scenario of improvement was quite critical and the results were to be tangible in the shortest span of time.

The improvements were evident in the sense that

- ✓ Release team was able to delivery quality deliverables once in a week.
- ✓ Code Merging was no more a problem except for few unique cases for which selective merging was mandatory. People were aware of the roles and responsibilities.
- ✓ The schedule for development, merging creation of build and testing were all planned and adhered to.

6 Key Take away

Most of the problems had its root into process deficiencies and commitment to process. Agile promotes “Light weight Process” and not “Process at all”. A disciplined structure was lacking in the Release management area of the project’s life cycle.

The other problems were related to upgradation and automation of the technical aspects, which was possible quite easily.

6.1 Achievements

The following were remarkable achievements in a time span of 4 weeks. Few of six sigma tools were implemented and the SPI journey was very successful.

- ✓ Process sigma rose from -1.45 to 2.49
- ✓ Release Management Process made formal. A Release Management Process Manual was released and implemented.
- ✓ Commitment from all the stakeholders on every delivery made.
- ✓ No code updation from N-3 day of release. Therefore the Content of each release was known and controlled.
- ✓ Tangible improvement in short span of time. On time Deliveries and the number of days for each release was between 3 to 7 days which was expected.
- ✓ Lesser defects in Merging. The numbers of defects were reduced by 44.7%.
- ✓ The Results were achieved in a span of 4 weeks.

6.2 Key Deliverables

The Key Deliverables of this process improvement journey was:

1. Formal process manual for Release Management
2. Formal Merging Process with Guidelines for Merging
3. Pre-Release review Checklist
4. Guidelines for deciding a release.

6.3 Factors that Influenced the success:

1. Commitment from all the stakeholders to adhere to processes.
2. Contents of release planned and strictly adhered to.
3. Automation of manual processes like merging of code.
4. Replacing existing tools and techniques with new tools and techniques
5. More time for testing

7 Literature

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8 Author CVs

Parameswaran Radhika Ravi

Radhika – A senior member of Satyam's Process Improvement consulting group has Overall 11 Years of experience years in IT industry. She holds a Bachelors degree in Electronics and Communication Engineering.

She is practicing ITIL®, RUP® and SEI CMMI®. She is a CSQA® and a PMP®. She has also completed her Foundation course in ITIL and Certified in IBM RUP V7®.

Radhika has been involved in various facets of quality consulting right from the inception phase – The process analysis, Recommendations, Process Implementation and Internal assessments.

Radhika has been on consulting assignments in APAC, Europe and US.

She possesses 6 Years of experience in Project Management - most of them on SPI projects.

Radhika has published papers in various domains of her experience.

Sreesha Sanne

Sreesha Sanne - A senior member of Software Process Consulting Team at Satyam Computer Services, USA. With over 18 years of experience in manufacturing / S/w development and Software Quality Management has worked in several key assignments in various countries. Some of his ISO 9000/ CMM / CMMI and other Quality consulting assignments were for US, UK and European clients and known for completing on schedule and budget. Sanne has played a key role in completing end to end projects under mentioned frameworks and led the teams towards few certifications. Process Definition, Process Integration / automation and Metrics Implementation are prime areas of interest. Sanne has a Masters in Technology & Engineering and Certified Project Management Professional (PMP). Sanne has developed expertise in Function points, RUP / Rational suite of products, ISO, CMMI, Six Sigma and TQM. Some of his papers have been in international magazines and conferences.

Implementing a Value Assessment for Products: A Case Study

Pasi Ojala

Abstract

During the last decades software process and product improvement (SPI) has been recognized as a usable possibility to increase the quality of software development. Recently more attention has been focused on the costs of SPI as well as on the cost-effectiveness and productivity of software development, although the roots of economic-driven software engineering originate from the very early days of software engineering research.

This study outlines the concepts and principles of a value-based approach, which has seen to be as one outcome of the economic-driven discussion related to software engineering. As well it defines the process to be used when assessing value. Defined concepts, principles and processes are based on Value Engineering and are justified in earlier discussion. Therefore this study assumes that this discussion has given a theoretically justified evolutionary plateau for using Value Assessment in practise to see its usefullness for companies as well.

The main purpose of this study is to collect experiences whether the Value Assessment for products support value-based approach and whether the Value Assessment works in practise in industrial context, what are the strengths and weaknesses of using it and is it useful to companies. This is done by implementing Value Assessment in a case company step by step to see which phases possibly work and which phases possibly do not work.

The practical industrial case and research results show that proposed Value Assessment for products is useful and supports the meaningfullnes of value-based approach. As well it demonstrates in practice, which are the strenghts and weaknesses of using it and what should be taken into consideration when implementing it.

Keywords

Software engineering, software process and product improvement, value, worth, cost, value - based approach, Value Engineering, Value Assessment.

1 Value-based approach

According to Boehm (2003, 33), “the value-based approach to software development integrates value considerations into current and emerging software engineering principles and practices, while developing an overall framework in which these techniques compatibly reinforce each other.” As Boehm’s definition is very general, it is not enough for the purposes of this study. Mostly this is due to the fact that it does not offer support as to where to find the needed concepts, principles and practical methods of economic-driven software engineering to adopt the value-based approach in practice.

Using the framework presented by Koskela & Huovila (1997), the value-based approach is understood in this study as a process. The main principle of this process is to eliminate value losses in software development, products, processes and SPI. It uses economic-driven tools, which are based on economic studies including, for example, the areas of cost estimation, cost calculation (for example ABC and life cycle costing) and investment calculation. The value-based approach prefers calculating costs instead of estimating them, and also considers software development and SPI as investments, on which it is possible to spend too much money (Erdogmus *et al.* (2004) & Solingen (2004). In practice, it takes care that the customer requirements are met in the best possible manner, ensuring quality, timeliness and value in products as well as in processes, over their entire life cycle. In particular, the aim of ensuring quality connects it to the other methods aiming for quality improvement.

The value-based approach also indicates a clear dependency between the process and products. It sees that we need to develop and optimize process activities so that processes produce the products needed. Furthermore, it sees that we must analyze products in order to reveal problems in processes and develop processes from the product point of view as well. This is vitally important, especially for companies respecting customer opinions and aiming to optimize costs in their processes, because the customers are the ones paying for the products and product-related services, and companies have to allocate all costs to products to be able to price them. The happier the customer is, the more worth he sees in buying the products from us. It is also clear that when we know our process and product costs, worth and value, our ability to estimate, budget and control future risks will improve significantly.

Due to the economic-driven nature of the value-based approach, several improvement decisions are made at the management level. Management support is also vital in software process and product improvement initiatives. Therefore it is surprising that several studies in the area neglect the importance of product value by assuming that it is only achieved by improving processes. To be effective, the value-based approach to successful software engineering should evaluate processes and products as well as the economical benefits of starting and implementing their improvement. The purpose of this study is to collect experiences of using Value Assessment for products in an industrial case. In more detail the purpose is to answer to following questions:

- How the proposed Value Assessment for products works in practice
- The strengths and weaknesses of Value Assessment for products
- Whether the Value Assessment for products support the value-based approach
- Whether the company assessed sees the Value Assessment for products useful

2 Value Engineering process

Even though there are several definitions in the literature for the VE process, they all have similarities. Generally, they state that VE collects and analyzes value-related information, to create new ideas using the analyzed results and to evaluate and further develop them into a meaningful package, with the reduction of costs or the increase of worth and improvement of value as ultimate goals. In practice, this study categorizes VE process into three main phases: pre-study (orientation), value study (information, functiona analysis, creativity, evaluation, development, presentation), and post-study (monitoring, implementation). These phases are considered appropriate since they constitute independent areas of VE and have been justified in earlier discussion (Ojala, 2006)

According to Value Engineering, value is a measure – usually in currency, effort or exchange, or on a comparative scale – which reflects the desire to obtain or retain an item, service or ideal. Cost is the price paid or to be paid. It can be divided into elements and, to some extent, functions. Park (1999, 50) defines cost as "an expenditure of money, time, labor, etc., to obtain a requirement." Worth is usually defined as the lowest cost to perform the required function, or the cost of the lowest-cost functional equivalent. The most typical definition for value, is perhaps (1):

$$Value = \frac{Worth}{Cost} \qquad (1)$$

where:

Value = The value of some object, product, service or process.

Worth = The least cost to perform the required function (product, service or process), or the cost of the least cost functional equivalent. If possible can also be the worth in money, what customer sees in product, service or process.

Cost = The life cycle cost of the object, product, service or process (price paid or to be paid).

3 Implementing a Value Assessment for products

Company A is a large corporation with several subsidiaries.Value Assessment for products was implemented in it at 2004. It was based on requirement lists and architectural component description lists. Together with the requirement and component lists, several other documents were analyzed during the assessment, including for example, different strategy and project plans as well as different financial statements, principles and reports.

3.1 Information

The product to be assessed was a typical electronic product containing software and hardware. It was developed in collaboration, by the vendor and the customer. The vendor was responsible for developing the product and the customer for defining user requirements for it. The vendor and the customer used project organization for specifying, implementing and testing the product.The implemented product-focused assessment was supported and sponsored by the vendor's and customer's high-level management. In the assessment opening meeting, the purpose of the assessment was discussed with the vendor and the customer. The definition *value=worth/cost* was discussed, and it was seen as extremely important to find out which requirements and components of the product gave the best value to the vendor without neglecting customer value needs and value.

It was considered natural that too much detail in the architectural description would probably cause problems when calculating customer worth, because the customer does not necessarily have enough technical expertise to understand the technical product structure. Therefore, in the assessment, an architectural list was provided which included functional descriptions defining the activities for each existing component. The vendor also emphasized the importance of the component list because all resources were roadmapped using this list, and cost overruns could be more effectively analyzed using the component list rather than the requirement list. After the discussion, it was decided that value would be calculated for the requirements described in the product sales agreement and for the architectural components listed in the architectural description.

The vendor emphasized that it would like to undertake the phases from creativity to presentation without the customer being present, since these phases included brainstorming to gain a new understanding of all the processes used to develop products. The customer saw that the most interesting phase for them was functional analysis, where both sides would prioritize requirements and components, and give estimates of worth and cost using relative numbers like percentages (not stating real costs). The customer understood all wishes of vendor and saw that they did not have a strong interest in development methods and improvement proposals, which were considered to be more critical for the vendor's business.

3.2 Function analysis

In the first assessment meeting four customer representatives (referred to as "customers") and three vendor representatives (referred to as "vendors") prioritized the requirements and architectural components. Afterwards, the customers allocated worth to each requirement and component using a percentage scale from 0% to 100%. The idea was to identify in percentages what kind of worth the customer sees in the requirements and components. The vendors allocated costs using the same percentage scale from 0% to 100%. As a result of this, the customers had given worth percentages for all requirements and components, and the vendors had given cost percentages for the same items. The calculated worth and cost were later compared, using percentages, to the real worth and cost, to find out the difference between "belief" and "reality".

During the function analysis phase the technical representative of the customer pointed out that, when prioritizing, one cannot necessarily treat all components equally, because some components are tied together. In practice certain components have to be implemented before other ones. Some components are independent, and others are not. Certain components rely on certain other components for their existence. However, he emphasized that even though this is the case, it does not affect all components, and prioritization clearly gives one a better picture of components and requirements, and of their importance in relation to each other.

All the interviewees agreed that the prioritization of requirements and components clearly helped in the next phase, in which the same requirements and components were analyzed in terms of worth and cost. When asked to mark how much of the total price they would assign to each requirement, the customer representatives preferred to use percentages rather than actual monetary values. The vendors shared this viewpoint, and stated that it was easier for them to give cost information in percentages rather than in actual figures. As the final customer price and real production costs for requirements and components were all known, it was decided that these allocations would also be done, but for vendor use only.

The customers found it easy to assign worth to their requirements, based on the customer price. The vendors also considered it easy to assign costs to requirements. Both sides emphasized that requirements are easy to understand because they are based on a clear, existing agreement. Only the architect found it slightly challenging to assign costs to requirements, because resources are usually assigned to components and not to requirements. Therefore, certain designers and their work cannot necessarily be easily converted from the component level to the requirement level. However, he noted that it is important to do this because this is how cost and worth can be analyzed at the same level.

The results of requirement prioritizations were understandable and expected among the customer and vendor representatives. Slight differences existed, and these were discussed thoroughly. The customer found differences between how their technical and user oriented personnel saw requirements. The vendor also found differences between the project management's and the technical personnel's comments. It seemed that the amount of technical knowledge gave more logical reasoning for understanding the implementation of requirements as components. By comparing the customer's and vendor's averages it was also possible to identify some significant differences between their respective priorities. For example, requirements such as services were clearly seen as more important by the vendor than by the customer. The discussion of how the two parties could be part of the same project and yet understand each others' interests so surprisingly wrongly was extremely profitable.

One conclusion of discussions was that worth and cost allocations for all requirements and components were seen as relevant for both sides, even if only stated as percentages. According to customer they also had their own idea about the actual costs of production, and since they knew the worth they were satisfied for the situation. Figure 1 presents the average worth and cost for requirements. In this figure we can observe how, for example, the customer has evaluated the worth of picture call function as being noticeably higher than the vendor's estimation of its production cost. In practice, this means value for the vendor. Figure 2 presents the average worth and cost for components.

On the whole, the experiences of using prioritization in ranking requirements and components were positive. Even more interest was seen in the analysis of worth and cost for each requirement and component, and especially in the differences identified between customer and vendor, as well as between technical- and user-oriented personnel.

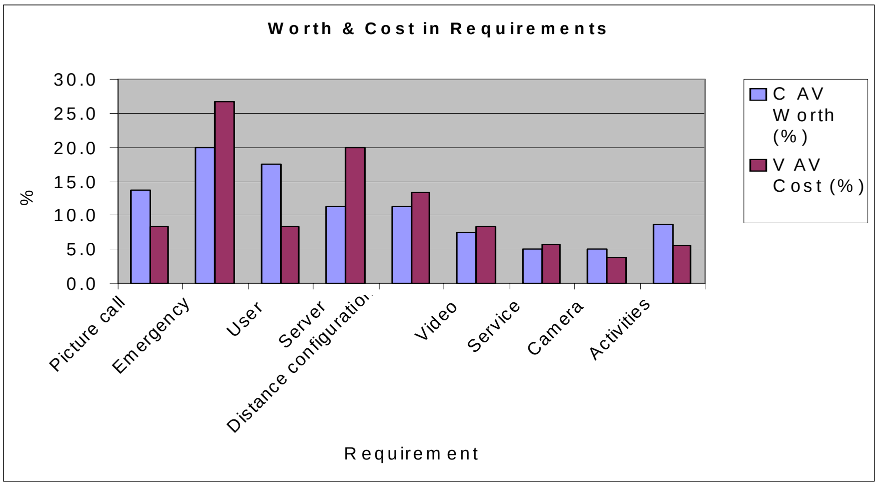

Figure 1: Average worth and cost for requirements including all interviewees (AV=average, C=customer, V=vendor)

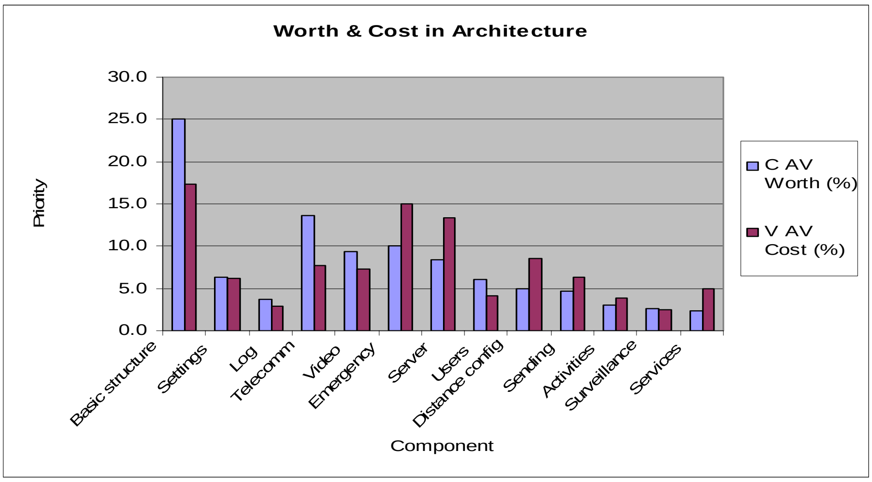

Figure 2: Average worth and cost for components including all interviewees (AV=average, V=vendor)

3.3 Creativity

In accordance with the agreement between the customer and the vendor, only the vendor participated in the phases from creativity to presentation. The first step in the creativity phase was to allocate costs to all requirements, and then to all components. According to the vendor it was easy to allocate costs to the requirements and components. General costs were perhaps the most difficult costs to allocate. This was because costs such as the project manager's salary usually cannot be allocated directly to any particular requirement or component.

After cost allocations had been completed, the project team started brainstorming. The vendors evaluated priority lists, figures, and worth and cost calculations for all requirements and components. All personnel were encouraged to explain how they would improve value at both requirement and component levels. According to their comments, clear figures helped a lot in understanding where the most significant differences in value existed. Based on the figures it was noted that certain requirements and components did not create good value. After discussion of this, the project members shared the opinion that this was because of the unfinished architectural plan. This had an influence on the planning and design of these items and thus they had been delayed, and created significantly higher costs.

Project members could also see from the charts presented how time-consuming it was to start using new technical environments, without good planning. The new technical environment delayed the implementation of certain requirements and components significantly.New technical challenges, such as developing software for multiprocessor environments, were also named as one reason for delays. This was because project personnel did not have sufficient training in working in the multiprocessor environment. As a result of all the problems mentioned, working hours were about 20 % higher than expected, and three components were not implemented at all.

3.4 Evaluation

At the beginning of the evaluation phase the project team discussed criteria for the evaluation of improvement ideas. The criteria decided on were system stability, safety, optimized functioning, ease of use, maintainability, and profitability. First, all the project team members were asked to give a relative percentage (max 100 %) for how important each criterion was for their project. Secondly, project personnel calculated averages for all the criteria. The calculated averages were as follows: system stability 25 %, safety 20 %, optimized functioning 7.5 %, ease of use 20 %, maintainability 15 %, and profitability 12.5 %. After thus defining the weightings of the criteria, the project personnel gave points to each improvement proposal on a scale of one to six, where six indicated maximum points and one, minimum. The points allocated were multiplied by the calculated weighting percentages. The results can be seen in Table 1 as follows.

Table 1: Evaluated improvement proposals

	System stability	Safety	Optimized functioning	Easy to use	Maintainability	Profitability	Total
Estimation	25.0	40.0	15.0	80.0	15.0	75.0	250.0
Multiprocessing	125.0	20.0	22.5	20.0	30.0	12.5	230.0
Technical environment	75.0	80.0	37.5	100.0	60.0	25.0	377.5
Architectural plan	150.0	100.0	30.0	40.0	75.0	50.0	445.0
Design plan	100.0	120.0	45.0	120.0	90.0	37.5	512.5
Project mgnt process	50.0	60.0	7.5	60.0	45.0	62.5	285.0
	525.0	420.0	157.5	420.0	315.0	262.5	2100.0

The project team discussed these results. The most surprising result was that the importance of the technical environment was as high as third place. Problems in design and architectural planning were expected, as were problems related to project management. Estimation and multiprocessing got the least points, so their importance to the project was not considered to be as high. However, it was noted that if the project would have been more business critical this would not have been the case. The more business critical the project would have been the more weighting the profitability criterion would have got.

3.5 Development

In the development phase, the biggest improvement ideas were separately developed further, in order to examine their practical implications. Each idea developed included issues such as description, positive consequences, negative consequences and potential cost savings.

The project personnel stated: “It has been difficult to get the necessary working resources for small projects.” The architecture and design phases have perhaps suffered from this the most. There had not been enough time to review these phases, which can be seen in the presence of incomplete plans. Both plans had been updated several times during the writing of code, which had sometimes stopped coding for several days.The project team calculated that if there had been support resources for making more comprehensive plans and reviewing them, the project would have been 440 working hours shorter. The potential cost savings would have been about 26 000 €.

At the moment, the ability to use the existing characteristics of technical tools is weak. The use of pre-existing components is also rather poor. The result is that code has to be written from start to finish each time. The project group evaluated that if basic components for development work had existed, 100 fewer working hours would have been required. If there had been sufficient technical training concerning the new environments (dotNET and ATL 7) for key personnel, 150 fewer working hours would have been required. In total, the potential cost savings would have been approximately 9 000 €.

From a project management point of view, it is problematic that all the employees are always assigned one hundred percent to a given project. As a consequence, there is not enough support available if needed, and “the wheel is invented several times in different projects.” The project team evaluated that with satisfactory support in evaluating the architectural plan, the design plans, and the extra need for time in starting to use new technologies, 100 fewer working hours would have been required. In financial terms, this would have meant a saving of about 6 000 €.

3.6 Presentation

The results of the product-focused Value Assessment were presented phase by phase to the high-level management. The project team supported the presentation by giving brief comments. In the presentation, a clear emphasis was placed on presenting customer needs and wants, and the corresponding costs to the company. The value indexes were used to outline the existing value-increasing opportunities. The potential cost saving proposed was approximately 26% of product price.

After the presentation had ended, the management wanted to discuss the value improvement opportunities presented with the project personnel. Some improvement ideas were implemented and some were developed further; others were postponed due to lack of resources. As a whole, the assessment strongly emphasized collaboration between the customer and the vendor, and all the improvement proposals were in line with the customer’s interests as well. All customer and vendor representatives considered product-focused assessment an interesting method for the development of product quality and value, and process capability.

4 Conclusions

This product-focused assessment worked very well in Company A. All participants agreed that the assessment process was clear and practical. The product assessment was considered to be significantly more effective than the process assessment. All the representatives of Company A were thus pleased to hear that it is possible to involve the customer in the assessment too since it increases the business point of view to assessment.

The product-focused assessment had several strengths. It was seen to give more customer-oriented improvement proposals than process assessments and product-related improvement was the language that the customer understood and was in a way “buying”. Product-focused assessment also involved the customer in the decision process. For the customer it was important to participate in decisions about which features would be implemented and which would not. The customer also wanted to prioritize product components and considered it important that the vendor asked questions what should and should not be done. Company A considered it important that when the assessment is undertaken together with the customer, it can keep the customer more satisfied, which is a good basis for business. It was also emphasized that if Value Assessment is done in the planning phase of a product, it is cheaper for any company than making changes after several months of development work.

Value Assessment for products supports value-based approach to software engineering in several ways. The comments from Company A show that there exists a practical need for enhancement of the scope of software engineering, in a more value-driven direction. This seems to be reasonable, especially if the company in question wants to calculate costs in order to plan product-related actions before implementing them. In practice, both Company A and their customer showed a special interest in this kind of planning, from which both parties get value.

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6 Author CVs

Dr. Pasi Ojala has worked several years as a Financial Manager in different companies forming an understanding of the possibilities, which accounting can offer to help decision making. He also has several years of practical experience of implementing different kinds of audits and assessments in industry as well as being responsible of leading SPI related development projects. His latest responsibility has been the role of acting as a Senior Manager in risk and quality managent of Nokia ltd. Academically he has published several studies and papers in the field of software engineering.

Using ISO 15504 Process Assessment for Internal Financial Controls

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Abstract
The ISO 15504 process improvement and process capability determination aspects are presented in the context of evaluating the internal financial control process related risk.

Keywords
Process Assessment, ISO 15504, Internal Control, COSO, Financial Reporting, Control Risk, Capability Advisor

1. Introduction to the COSO based Process Assessment

New generation of governance models referring to either IT or Internal Control – like COBIT [1] and COSO [2] - are extended with business perspective willing to gain top management's ear. But the practice shows, this opening solely does not enough to reach a breakthrough, because models became more complicated than it could be applied without some difficulties. Very frequently exposed that the best catalyst of improvement programs - even related to IT governance - are the more and more mandatory rules coming into force, nowadays mainly from financial reporting area [3]. Sarbanes-Oxley Act for US SEC registrants and its affiliates, the Basel II framework and the 8th Directive on company Law in the EU require strict internal control and effectiveness conclusion performed by the executive management.

This part provides a summary to the principles of the Process Assessment Model for evaluating Internal Financial Controls in accordance with the requirements of ISO/IEC 15504 standard [4].

An integral part of conducting an assessment is to use a Process Assessment Model (PAM) constructed for that purpose, related to a Process Reference Model (PRM) and conformant with the requirements defined in ISO/IEC 15504-2. ISO/IEC 15504-2 provides a framework for process assessment and sets out the minimum requirements for performing an assessment in order to ensure consistency and repeatability of the ratings.

The Process Reference Model, derived from COSO Small Business Guidance (Internal Control over Financial Reporting - Guidance for Smaller Public Companies), has been used as the basis for the proposed Internal Financial Control Process Assessment Model. This COSO based Process Reference Model associated with the process attributes defined in ISO/IEC 15504-2, provides a common basis for performing assessments of internal financial control process capability and reporting of results by using a common rating scale.

The Process Assessment Model defines a two-dimensional model of process capability. In one dimension, the process dimension, the processes are defined and classified into process categories.

In the other dimension, the capability dimension, a set of process attributes grouped into capability levels is defined. The process attributes provide the measurable characteristics of process capability.

Figure 1 shows the relationship between the general structure of the ISO/IEC 15504-2 conformant Process Assessment Model and the COSO control processes (grouped into the 5 components).

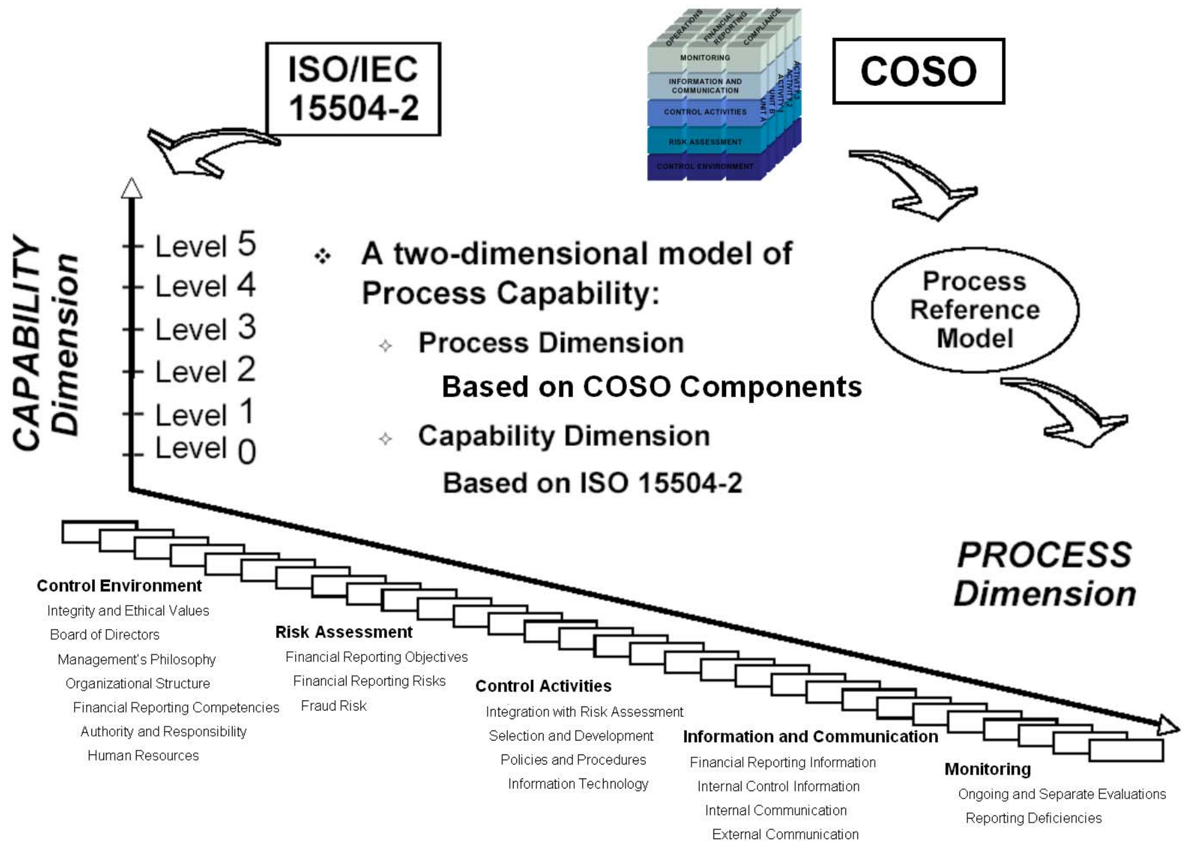

Figure 1: COSO components as Process Dimension of the Process Assessment Model

The proposed Process Assessment Model includes processes, which are grouped in five process categories, identical to the control components defined in COSO models, which are:

- Control Environment;
- Risk Assessment;
- Control Activities;
- Information and Communication;
- Monitoring.

For the *process dimension*, all the 20 internal control processes referred as Principles in the COSO guidance, are included within the process dimension of the proposed Internal Financial Control Process Assessment Model. Each process in the Process Assessment Model is described in terms of a purpose statement. These statements contain the unique functional objectives of the process when performed in a particular environment. A list of specific outcomes is associated with each of the process purpose statements, as a list of expected positive results of the process performance.

Within a Process Assessment Model, the measure of capability is based upon the nine process attributes (PA) defined in ISO/IEC 15504-2. Process attributes are used to determine whether a process has reached a given capability. Each attribute measures a particular aspect of the process capability. At each level there is no ordering between the process attributes; each attribute addresses a specific aspect of the capability level.

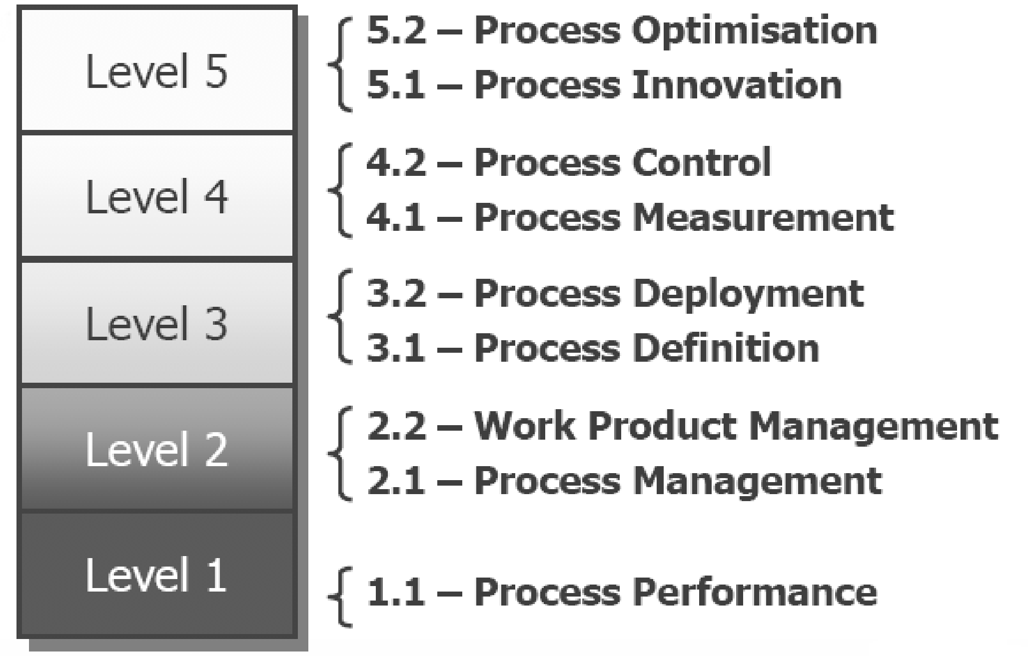

Figure 2: Process Attributes by Capability Levels

The Process Assessment Model is based on the principle that the capability of a process can be assessed by demonstrating the achievement of process attributes on the basis of evidences related to *assessment indicators*. There are two types of assessment indicators: process capability (generic) indicators, which apply to capability levels 2 to 5 and process performance (specific) indicators, which apply exclusively to capability level 1.

The process attributes in the capability dimension have a set of process capability indicators that provide an indication of the extent of achievement of the attribute in the instantiated process. These indicators concern significant activities, resources or results associated with the achievement of the attribute purpose by a process.

Assessment indicators are used to confirm that certain practices were performed, as shown by observable evidence collected during an assessment. All such evidences come either from the examination of work products of the processes assessed, or from statements made by the performers and managers of the processes.

The first and second capability levels are focusing on the instance or activity view of the processes, while from Level 3 the attributes are focusing on the corporate entity view. This observation helps us to understand how the COSO Internal Control and ERM frameworks fit into this assessment model. The Internal Control framework’s third dimension is the Unit/Activity, while in ERM the third dimension is the corporate structure. Figure 3 identifies the applicability of the capability levels to the COSO main objective categories:

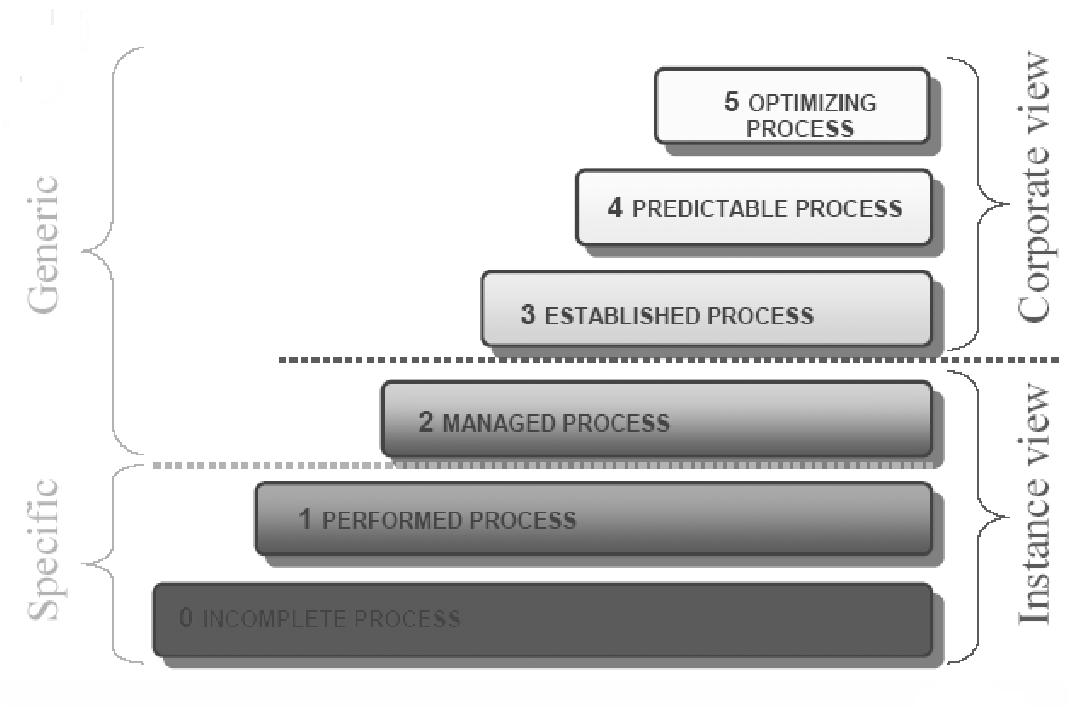

Figure 3: Assessment indicators per capability levels

2. Capability Levels and their context to COSO objectives

Mapping and applying the COSO and COSO ERM main objective categories into the capability dimension of the measurement framework provide guidance to set target capability profiles by the assessment sponsor, give effective tool to the management to identify, understand and manage control risk areas.

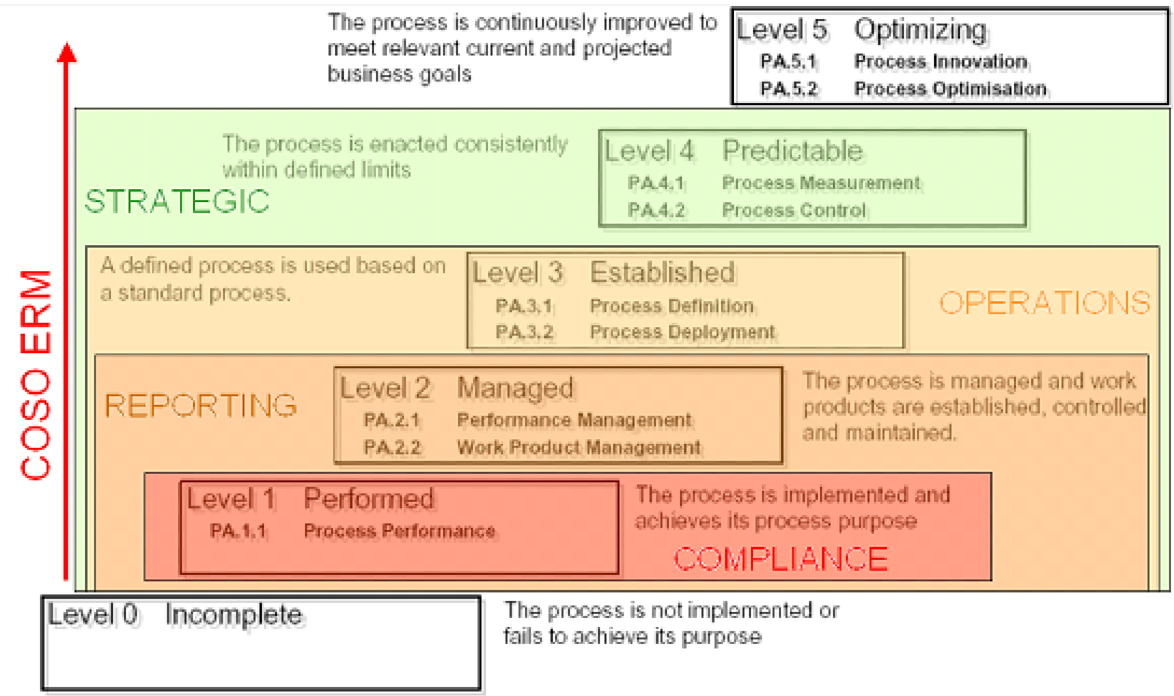

Figure 4: ISO 15504 capability levels and COSO objective categories

2.1 Achieving Compliance Objectives at Performed Process Level (1)

The process dimension of the assessment model adopts the same process definitions (Principles) as COSO Small Business Guidance. The achievement of the process performance attribute represents that the management has good understanding of the basics of the internal control requirements and the financial reporting activities are managed by keeping in mind the components of internal control framework in an ad hoc base. There are evidences of achieving control process purpose, however not in a systematic way.

As mainly focusing on fulfilment of the sectoral and accounting regulatory requirements in financial reporting related business activities, the Level 1 assessment results are mainly usable in further process improvement context.

Achieving Compliance objectives in all (relevant) internal financial control processes from the COSO based Process Reference Model provides good image and reputation of the management in both internal and external environments. However external bodies having wider scope than just verifying periodic financial statements cannot utilize these results. For example: a chain of control/audit structures cannot reuse the Level 1 assessment results at different management levels, like in the case of complex European funding structures or banking supervisory functions.

In private sector, even in the case of strict regulatory requirements like SOX, Level 1 assessment results on the full set of internal financial control processes can be sufficiently utilized by the stakeholders. As these processes are building up a comprehensive framework, the complementarities of the outcomes and purposes of these processes can provide reasonable assurance even for reliability of financial reporting, as the COSO Small Business Guidance aims it. However, the complexity of business activities and corporate structures, the applicability of risk management principles makes management and shareholders considering advantages of lower control risk levels.

2.2 Achieving Reliable Reporting Objectives at Managed Process Level (2)

This level represents that the Performed control process (already achieving compliance objectives at Level 1) is implemented in a *managed* fashion (planned, monitored and adjusted) and its work products are appropriately established, controlled and maintained.

Besides Level 1 achievements, the internal control process is managed and fulfils the reliable reporting objectives. At Level 2 assessment the financial reporting activities shall be investigated, whether the performance and work product management *indicators related to the internal control processes* are assessable and how they are evidenced.

At this level, not only the financial reporting (related) activities are performed in a systematic way (as already resulted by Level 1 achievements of the full set of internal control processes). Moreover, the performance and work products of the internal control process are appropriately managed; also providing reusable evidences for wider scoped external or supervisory investigations. The lower control risk level resulted by Level 2 achievements provides higher credibility of the results of all financial reporting related activities.

Complex institutional structures and business or programme/project activities in all sectors require Managed process capability level, which in case of internal financial controls contribute to reliability of reporting processes in such circumstances.

2.3 Achieving Effective and Efficient Operation Objectives at Established Process Level (3)

At his level the Managed process (already achieving compliance and reliable reporting objectives at Level 2) is implemented by using a defined process capable of achieving its process outcomes.

Besides Level 1 and 2 achievements, the internal control process is built into the operational processes and fulfils the objective of “Effectiveness and efficiency of operations”. At Level 3 assessment the financial reporting related activities should be investigated together with the organizational/entity level policies and procedures, whether the process definition and deployment *indicators related to the business process*es relevant for financial reporting are assessable and evidenced.

The „Related Business Activities” (work product) defined by the “Financial Reporting Objectives” control process shall define these activities. Either the scope of the “Policies and Procedures” control process can cover wider integration with other business processes, or the related business activities can be grouped into an optional process category to be assessed against the attributes of the Managed process level in advance. Without adding specific business processes to the process dimension, Level 3 type assessment of the full set of internal control processes has only limited additional value in comparison to Level 2 achievements.

Achieving Level 2 capability profile for the entire set of processes from the COSO based Process Reference Model already represents Level 3 achievement for those control processes which are not embedded into other business activities due to business area, type, size, etc. This is typical case for smaller companies, where for example the Control Environment processes performed by top management are closely or directly influence employees’ actions. Vice versa: a major capability Level 3 (process deployment attribute) gap at a control process - which outcome is embedded into a relevant business activity - causes significant gap at a lower capability level of “Policies and Procedures” control process.

However, setting different target levels for a subset of the processes from the COSO based Process Reference Model can be also reasonable. Fulfilling Level 3 process attribute targets at those processes which are not (necessarily) embedded into other business activities, together with Level 2 results at some other control processes can also provide more reasonable assurance regarding the achievement of compliance and reliable reporting. For example Level 3 Monitoring processes enhancing internal audit functions can have real additional value for any type of organizations targeting lower capability levels for other control processes.

The cornerstone of applying practices for Level 3 process attributes is how the scope of the internal financial control system is defined. If the scope is narrowed just to financial reporting activities, then a full set of processes from the COSO based Process Reference Model fulfilling Level 2 capability profiles can provide reasonable assurance to achieve compliance and reporting objectives. If the scope is widely open to other business activities identified among the “Related Business Activities” defined by the “Financial Reporting Objectives” control process, the “Policies and Procedures” control process can be supported and implemented by advanced business-driven management approach aiming higher capability profile.

Level 3 achievements have some significant consequences. Once, this is the level where the process capability determination aspects of the ISO 15504 conformant assessment can be widely utilised by external parties for assurance purposes. Normally the “Standard Policies and Procedures” at entity level are not divided or separated into different application areas; so different assurance activities (e.g. internal control, quality management, information system management, etc.) can apply for the same set of standards within an organization.

Secondly, this is the level where entity/organization level performance of the “Related Business Activities” can be assessed. It is a very important issue to define adequately the scope and coverage of standard processes, and how they facilitate embedding the outcomes of internal control processes into operational processes. Too complex scope and excrescent coverage can result too much cost of controls, high bureaucracy, inefficient usage of resources. If the scope and coverage is too narrow (e.g. limited to financial administration activities), the Level 3 advantages do not fully prevail.

Thirdly, Level 3 achievements represent the base for applying ERM principles. In this context, the range of the key control processes also influence the minimum scope and coverage of Level 3 standardization. If the internal financial control assessment has a limitation in scope to the material weaknesses in financial statements not be prevented or detected on a timely basis by internal controls, then the range of the key controls will be a subset of the financial control activities. In wider (ERM) context, the key controls are all those processes, which are necessary and sufficient for keeping business performance within a tolerable variance from business objectives. Hereafter we use the narrower term of key controls.

2.4 Achieving Strategic Objectives at Predictable Process Level (4)

At this level the Established process (already achieving compliance; reliable reporting; and effective and efficient operation objectives at level 3) operates within defined limits to achieve its process outcomes.

Besides Level 1, 2 and 3 achievements, the internal control process is incorporated into the enterprise risk management system and fulfils the Strategic objectives relating to high-level goals, aligned with and supporting the entity’s mission. At level 4 assessment the key controls shall be investigated, how they are applied in strategy setting and across the enterprise together with the entity level risk management, whether the process measurement and process control *indicators related to the achievement of entity objectives* are assessable and evidenced.

Setting of Level 4 target capability presumes, that the concerning internal financial control process and the related business processes where control outcomes are built in comprise *key controls*.

> *“Key controls are those significant controls within our business processes, which if operating correctly will both ensure and give assurance that the organization is achieving its key business objectives”* [5]

By customising the generic financial reporting objectives linked directly to specific business objectives the management will be able to adequately react to external and internal events representing inherent risks to financial reporting.

A key control exception can happen at any time (e.g. automated process is not working, inadequate segregation of duties is identified or loss contingency is realized, etc.). Achieving Level 4 process attributes means that exceptions are handled within the accepted deviation (risk tolerance) of the settled risk levels (risk appetite) to the desired business objective. Financial impact shall be reasonably estimated and the resolution to the control exception shall be identified, scheduled and followed.

3. Evaluating internal control process related risk

The Control Risk Assessment performed on ISO 15504 conformant process assessment results, provides feedback to the management whether the existing gaps between the target and assessed capability profiles represent acceptable control risk level for the sponsor ("the individual or entity, internal or external to the organizational unit being assessed, who requires the assessment to be performed, and provides financial or other resources to carry it out" - *ISO/IEC 15504-1, 3.13*).

This approach provides more flexible and customisable method to evaluate the system of internal financial controls, necessary to define the coverage of the substantive examinations of the economy, efficiency and/or effectiveness of the organisations, activities, programmes or functions concerned.

ISO/IEC 15504 standard provides guidance on how to utilise a conformant process assessment within a process improvement programme or for process capability determination.

3.1 Setting target capability

The sponsor should determine which processes from the selected Process Reference Model are (most) important for the pre-defined requirements (Process Capability Determination) or business goals (Process Improvement).

Also the sponsor should specify a target process profile, showing which process attributes are required for each selected process. Also the necessary rating for each process attribute should be given. Only ratings of "Fully achieved" or "Largely achieved" should be set. "Partially achieved" rating has no meaning to set, as this would indicate that the achievement would be unpredictable in some aspects. "Not required" should be noted for a process attribute taken to be unnecessary.

The set of target process profiles expresses the target capability, which the sponsor judges to be adequate (to the organization's business risk appetite and tolerance).

3.2 Gap assessment

Process-related risk can be inferred from the existence of gaps between the target and the assessed process profiles.

The potential consequence of a gap depends on the capability level and the process attributes where the gap identified. Some Internal Financial Control related considerations and examples (by using the above example process profiles) are presented as follows:

Typical consequence of the gap at Level 1 PA 1.1 Process performance attribute is that not all of the relevant process outcomes (Attributes of COSO Principles) are achievable, and no recoverable documentation exists to track the necessary control. E.g. Management communication to personnel in roles affecting financial reporting is not adequately documented, so updates on internal or external finance matters are not taken into consideration.

At Level 2 PA 2.1 Performance management gap, the typical consequences are the missing deadlines, lack or inefficient use of resources, unclear responsibilities, uncontrolled decisions, etc. E.g. Management communication with oversight board or personnel is not planned or scheduled; the related management does not do deficiency disclosure in time; unauthorized decisions are done at period closing; policies and procedures are not under revision on a timely base.

At Level 2 PA 2.2. Work product management attribute, the gap can cause unpredictable quality of reports, parallel entries and inconsistent documentation, increased rework cost, consolidation problems. E.g. Old versions of policies and procedures are also in use; identified exceptions are not communicated; internal communication is not filed in a systematic way.

At Level 3 PA 3.1 Process definition gap, the consequences are that best practices and learnt lessons are not taken into account during revision of policies and procedures or the outcomes of the related control processes are not identical in the operational procedures. E.g. Missing or formal description of internal communication procedures withhold staff members to use alternative reporting lines informing oversight board about material weaknesses or improvement suggestions.

At Level 3, the PA 3.2 Process deployment gap can cause inconsistent applications of financial controls built into the operational procedures. Identified opportunities are lost due to inefficient deployment effort. E.g. The oversight board does not take the internal auditor's consultative role and efforts seriously; the financial statement assertions are not properly linked to the business processes during risk assessment; information technology controls do not reflect adequately to the complexity of the IT environment.

At Level 4 PA 4.1 Process measurement gap, the consequences are that the key controls are not properly identified, designed or operating in order to achieve process performance objectives and business goals or detect performance problems early. E.g. the resolution of key control exceptions is not covered in risk assessment.

At Level 4 PA 4.2 Process control gap, the consequences are that the quantitative performance objectives and the defined business goals do not meet. E.g. Short monthly/yearly closing deadline can cause unpredictable materiality of accruals, management estimates and reserves.

3.3 Reasons for internal financial control process improvement

As presented in the previous part, internal control process related risk evaluation is based on the gaps between the target and the assessed process attribute ratings. Setting lower target capability for internal financial control processes is theoretically explainable if the inherent risk of the financial reporting activities and the related business administration processes is measured at very low level or the inherent risk is acceptable to fulfil regulatory compliance requirements. Otherwise Level 2 capability target is the adequate minimum requirement to assess control procedures against reliability objectives of financial reporting.

In more complex environment (featured by business type, size, sectoral regulations, etc.) the continual improvement of business administration processes is desirable. Integration of financial controls with business operations is necessary, when not only the reliability, accuracy and availability of the financial information are critical, but the effectiveness of the related operational activities is also required. Assessing internal financial controls, together with the business processes where they are embedded, against up to Level 3 process attributes is reasonable for the big or multinational organizations, publicly listed companies under SOX regulation, financial institutes, and specific public service companies managing public funds.

3.4 Process Capability Determination

The purpose of process capability determination (PCD) is to identify the strengths, weaknesses and process related risks associated with selected processes with respect to *a particular specified requirement*.

The terminology of particular specified requirement originally meant supplier selection criteria, however the new standard approach is more generalized. The PCD assessment is somehow an extended compliance audit or review, where the specified compliance criteria are translated into target capability profiles of the selected processes. The difference from process improvement (PI) approach is that the PCD main goal is to identify the alterations and to determine the potential risks coming from alteration comparing to the pre-defined requirements.

Hereby some practical examples of different PCD sponsorship cases:

- *Financial Statement Audit.* External financial auditor can use PCD results as sufficient competent evidential matter to design the nature and timing of the necessary substantive tests. Also the Audit Committee, which is responsible to engage and determine compensation of the external audit firm, can utilize PCD results to effectively negotiate the necessary audit effort and fee.

- *Evaluation of Internal Control Systems By Bank Supervisory Authorities.* State Supervisory Authorities responsible for finance sector has to set up evaluation methods applicable for different types of banking organizations.

- *Managing and monitoring EU Structural Funds.* Although the Structural Funds are part of the Community budget, the way in which they are spent is based on a system of shared responsibility between the European Commission and Member State governments. Verification of (operational and financial) control systems can be done by the Commission and/or by the State. PCD concept can be applicable for both.

- "*Single audit model*". The single audit approach is based on sharing results and prioritising cost-benefit principles in order to minimise the duplication of control work, and maximise the level of control, which can be achieved with a given level of resources. Sharing well-defined and documented control information can permit reliance on controls at each level in the chain. A formalised assessment of costs and benefits at each level will enable the demonstration that the controls in place have optimised the residual risk of error in the underlying transactions.

4. Using Capability Advisor

For this project a portal has been configured to support process capability assessments based on the COSO process reference model for financial control and the capability dimension outlined in the part 2 of ISO 15504.

The Capability Adviser portal system represents an online assessment portal supporting assessors in performing assessments, generating reports, and storing in a database all comments from all assessors. There are different user levels in the system:

- **Administrators.** They administer different service organisations or divisions of a large corporation or network.
- **Content Providers.** They maintain the portal content through an easy to use interface for entering new skills models or process assessment models.
- Organisations. They administer an unlimited number of projects and can create assessments for projects, which creates so called project assessment workspaces.
- **Participants.** The participants can do self-assessments, gather notes, print profiles and assessment records. In a formal-assessment they gather evidences electronically and assign

them to processes. To extract improvement recommendations from a formal-assessment the participant can view or print assessor comments connected to certain processes.

- **Assessor Pool.** Organisations can maintain their own assessor pool. Assessors are assigned to assessments of projects and have their own online interface, which is also organised in form of an assessor workbench.

In an assessment assessors rate specific base practices (Level 1) and generic practices (levels 2 – 5) related to the financial control processes. See Figure 5 .

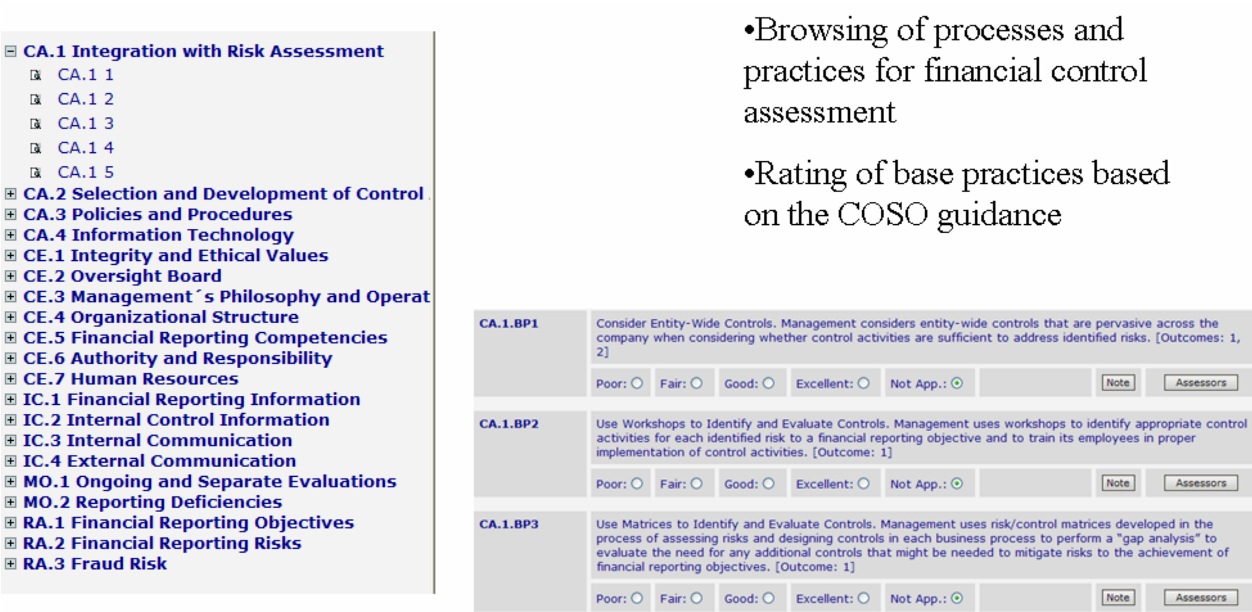

Figure 5: ISO 15504 capability levels and COSO objective categories

Each practice is rated (see ISO 15504 standard) with F (Fully Adequate, L (Largely Adequate), P (Partially Adequate), and N (Not Adequate). The system then generates process attribute rating for the process attributes described in Figure 2 of this paper.

Unit	self assessment	Attributes								
		1	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2
CA.1 Integration with Risk Assessment	Organic Assessor									
	self assessment	FA		PA						
CA.2 Selection and Development of Control Activities	Organic Assessor									
	self assessment	FA	FA	FA						
CA.3 Policies and Procedures	Organic Assessor									
	self assessment	PA		NA						
CA.4 Information Technology	Organic Assessor									
	self assessment	LA								
CE.1 Integrity and Ethical Values	Organic Assessor									
	self assessment									
CE.2 Oversight Board	Organic Assessor									
	self assessment									

Figure 6: ISO 15504 based Process Attribute Rating Profile for Financial Control Processes

The ISO 15504 standard describes in part 2 how the capability levels are calculated based on the attribute rating profiles. A specific level is achieved, if all process attributes on that specific level (e.g.

2.1 performance management and 2.2. work product management for level 2) have been rated by largely or fully, and if all process attributes rating on lower levels were rated fully.

Unit	self assessment	Capability Level 1 2 3 4 5	Note
CA.1 Integration with Risk Assessment	Organic Assessor		Too less assessed PCs
	self assessment	1.5	Not all PCs are assessed
CA.2 Selection and Development of Control Activities	Organic Assessor		Too less assessed PCs
	self assessment	2	Too less assessed PCs
CA.3 Policies and Procedures	Organic Assessor		Too less assessed PCs
	self assessment	0.25	Not all PCs are assessed
CA.4 Information Technology	Organic Assessor		Too less assessed PCs
	self assessment	1	Not all PCs are assessed
CE.1 Integrity and Ethical Values	Organic Assessor		Too less assessed PCs
	self assessment		Too less assessed PCs
CE.2 Oversight Board	Organic Assessor		Too less assessed PCs
	self assessment		Too less assessed PCs

Figure 7: Capability Level Profile for the above process attribute rating

5. Outlook

The COSO based process assessment principles presented in this paper are used for development of the Skill Card and the related training materials of the "Certified European Internal Financial Control Assessor" programme including adaptation of the Principles, Attributes and Approaches of the COSO Small Business Guidance as agreed with the COSO Board for Spanish, German, Romanian and Hungarian translations. This project (Project number: HU/B/05/B/F/PP-170013) is carried out with the financial support of the Commission of the European Communities under the LEONARDO DA VINCI Programme. By utilizing the final results of the pilot project, Europe-wide training providers will offer the certification and training programme accredited by the European Certificates Association (http://www.eu-certificates.org/) from September 2007. Working groups of SAI, IIA, ISACA and ISO 15504 communities are invited for future cooperation. See more details at http://www.ia-manager.org/ or contact to ivanyos@memolux.hu.

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7. Authors' biographies

János Ivanyos is one of the founders of Memolux Ltd. and the managing director responsible for Information Technology support and development since 1989. He was graduated as an economist at Karl Marx University of Economics, Budapest in 1984. He has managed several IT and accounting outsourcing projects (e.g. Unilever Hungary, Heating Works of Budapest, National Employment Office, Ministry of Finance, Nokia Hungary, Accenture, etc.)

He was the project coordinator of the PASS Esprit project during the period of 1997-1999 and the MEDIA-ISF (IST-2000-29651) project (2000-2002). He is participating in running Leonardo da Vinci pilot training projects. He has been the IT section leader of the Hungarian Institute of Internal Auditors (IIA Hungary) since 2003. He is a key trainer of the internal audit training programmes of IIA Hungary.

János Ivanyos has more than 20 years experience in IT, and he has successfully managed many technically complex, international (Europe-wide) projects. He is the co-author of several conference papers and proceedings. The following key articles are published by Wiley:

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Improving SME trust into IT consultancy: a network of certified consultants case study

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Abstract. On behalf of a network of certified ICT consultants (named CASSIS network), we report in this case study an on-going initiative started in 2001. This initiative started with the set-up of a community of skilled and trustable consultants in Commercials Off The Shelf (COTS) software selection for SMEs. Currently the community is spreading in Europe, in particular through the European Quality Network (EQN) association. The paper presents the context of the initiative including the identified market need for certified consultants, the proposed approach regarding the selection of COTS for SMEs, the development of a network of skilled and certified consultants in Luxembourg, and the spreading of the method and the certification at a European scale. It concludes with further issues regarding certification and accreditation.

Keywords: COTS selection methodology, SME, consultants network, skills development, skills certification, trust improvement, CASSIS certificate and network.

Introduction

IT opportunities for SMEs: the context of the COTS software market

As in many other European countries the Luxembourg economy is characterized by a large number of SMEs (Small and medium enterprises less than 250 employees), and, in particular, of VSEs (Very Small Enterprises less than 10 employees). More and more the vitality and even the survival of these companies are heavily depending on the way according to which they can accommodate opportunities that IT can offer to their business and the possible innovation and payback that can be associated with.

COTS (Commercial Off The Shelf) software packages acquisition is one of the most important IT-related activities in a SME. Two main reasons explain the previous assumption: COTS software packages have often a shorter time to market than developed software solutions and due to their business problematic SMEs have generally non trivial needs that a specialized COTS software package has already experienced and therefore can fulfill more easily than a development. From our empirical experience in the covered regions (23 projects of software selection in SME in Luxembourg, Belgium and France between 2001 and 2007), the highest demand is for the following types of COTS software solutions:

- ERP (Enterprise Resource Planning) (50 % of the demand)
- CMS (Content Management System) (13 %)

– CRM (Customer Relationship Management) (9 %)
– DMS (Document Management System) (9 %)

Other types of COTS software solutions where a minor demand has been identified are Human Resources Management Systems, Project Management Systems and Accounting Management Systems.

These COTS software solutions offer IT opportunities for SMEs by supporting logistics, customers' management, providers' relations, and projects and businesses management.

A need for external consultancy

However we can observe that if SMEs managers are excellent in their domain of business, SME management is often suffering from the lack of competences in the IT domain. As a consequence SMEs managers under-estimate needs and miss opportunities related to them.

In addition, the offer for COTS solution is dense. In most cases, the most effective solution for solving SMEs problems exists. Still the challenge is to find the right one ! The right one means the solution that suits best each SME specific context and needs. This is where important issues arise:

– Business issues: the functionalities offered by COTS should be aligned with the support required by the business. In other words the goals and the requirements from the business should be fully understood in order to select the COTS that better fit these requirements.
– Organizational issues: most of the COTS assume a certain organizational context in relation with business processes and information flows. Again this one should be known from the SME and a check is needed if the existing business processes are flexible enough so that they can be adapted.
– Technical issues: most of the COTS assume a certain technical interoperability with other tools. This requires understanding the nature of these protocols and interactions, and checking if bridges can be built with technical solutions already in place.

Understanding and analyzing all these issues are not easy tasks and require skills and experience. Since it is clear that SME management seldom have the required level of skills and experience, there is a real need of external skilled consultants.

A need for neutral consultancy

Active and available COTS consultants are numerous on the market. However even if there are skilled and expert consultants in the field of COTS selection, most of them propose high costs and complex COTS selection methods. That means that in practice they often work for large companies. In addition so-called "COTS consultants for SME" are, in many cases, sales representative selling the COTS that they know without really taking care of the issues rose above. This is probably one of the major explanations why the number of failures is so high in the introduction of COTS in SMEs. For example, a recent study [1] shows that more than 30% of ERP projects are abandoned before the end of the project, 20% of the remaining projects exceed budgets, and more than 20% do not keep the project deadlines.

We clearly identified that a key factor for making SME more trusting in IT is to develop neutral (i.e.: third part and independent from COTS editors) consultancy for helping and advising SME in IT investment.

The CASSIS Initiative

From the observations related in the previous paragraph, the CRP Henri Tudor[1] identified two actions to be undertaken: to make SMEs sensitive to the importance of IT opportunities and to provide neutral consultancy to SMEs for helping them to set-up their IT infrastructure and organization.

[1] CRP Henri Tudor is a public Research Centre in Luxembourg (non-profit organization), dedicated to innovation and technology transfer.

The CASSIS initiative that started in 2001 at CRP Henri Tudor aims at covering these two aspects [2]. In particular, we will detail the specific action in regards to the role of IT consultants experts in the selection of COTS software solution for SMEs.
Regarding COTS software selection, the goal was to find an approach which allows the consultants to minimize their time spent in their mission while focusing on the key issues described before, which optimize the satisfaction of SMEs in terms of the selected COTS with a limited consultancy cost and which establish trust between SMEs and Consultants, which in most case do not know each other.

The answer to these three questions has been proposed in terms of an effective methodology and supporting tool enhancing the performance (i.e. reducing time) of the consultant in its COTS selection mission, a skills certification scheme to improve trust in certified consultancy and the development and spreading of a trusted network of IT consultants for SME. Two R&D projects have been launched: the first one in 2003 to define the methodology and the supporting material (guides, templates, tools, and trainings) and the second one in 2005 to develop the certification scheme and the network of IT consultants.

In this sub-section we briefly introduce the COTS selection methodology and accompanying tool. In the next sub-section we describe the certification scheme itself and the way it is managed. Eventually, we present the development of the network.

COTS selection methodology

So, a COTS selection methodology has been developed as well as a software tool. The method details principles; the experiences from using it have been described in [3] and the tool is presented in [4]. To sum up, common practices of software selection methods (goals oriented: COTS Based Requirements Engineering CRE [5], templates based: Procurement Oriented Requirements Engineering PORE [6], based on the definition of evaluation criteria: Off The Shelf Option OTSO [7], and others like SHERPA [8]) were collected and classified in combination with capitalization of empirical practices of a tenth of software selection projects that were carried out by the CRP Henri Tudor between 2001 and 2003. The practices were then analyzed and adapted to be used in a SME context (where people have low competencies in IT and project management and where the time to market constraint is often very short). Finally the method has been put online and detailed with guides and templates to help its use in software selection projects.

The COTS selection methodology, summarized on the figure 1, is divided in six main steps.

1. **Project Kick Off:** During this first step, scope, time, organization and activities related to the COTS selection project are defined. More precisely users groups that will take part in the requirements definition process are identified.
2. **Business model and requirements specification**: The requirements specification phase enables the elicitation of the functional and organizational needs of each user groups within the company. The analysis of the existing solution helps revealing the strengths and weaknesses of the system in place. Functional and non-functional constraints are thus identified in order to transcribe them into the future specifications. At the same time, the analysis of the company's business processes gets each user group to rate the priority of their requirements in order to describe the scope of the future project.
3. **Market exploration:** Market exploration is concerned with the identification of software packages and potential integrators. Indeed both software and suppliers are pre-selected on the basis of criteria corresponding to the five to eight requirements considered as having highest priority (functional and non-functional such as technical or budgetary aspects).
4. **Call for tenders:** during this phase the requirement book compiling all the requirements (SRS) is written and derived into a questionnaire so as to help suppliers to propose a bid that exactly matches the requirement book. Next the call for tender literature is sent to the selected providers. At the end of the call for tender time, bids are collected.
5. **Supplier Selection:** The supplier's offers, namely answers to the questionnaire, are then analyzed using an evaluation grid, structured on the basis of the requirements weighting. At the conclusion of this selection phase, two or three better solutions are retained for a check of the actual fitness with the initial needs. The final selection is based on an in-depth evaluation of the product during a

hands-off demonstration of the solution. This demonstration helps identifying strengths and weaknesses through business oriented scenarios depending on high rated requirements.

6. **Contract:** This last step consists in negotiating the clauses of the service contract and confirming the commitments in terms of lead times, budget and schedule. This ultimate step closes the study and selection phase carried out by the consultant. The consultant helps the SME to negotiate the clauses of the contract, to confirm the commitments, and to put into the contract all the commitments made during the call for tenders (specifications, supplier's offer, etc.). He/she oversees the installation and commissioning requirement, he/she supervises the transfer of ownership clauses, definitions of the conformity checking phases, modalities of temporary acceptance and final acceptance, and finally he/she oversees compliance with the lead times and the definition of a payments schedule linked to actual progress and delivery phases.

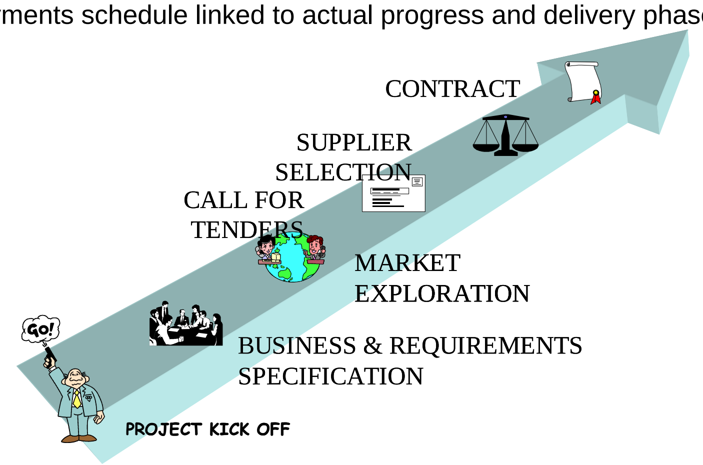

Fig. 1. The COTS selection methodology

The tool[2] developed to support the methodology offers a number of features that help the consultant in performing an efficient mission by:

- Supporting the whole methodology described above, in particular bids analysis
- Making possible the publishing of legal documents (RFP) and reports
- Making possible the storage of the produced requirements documents in a repository system that make possible their reuse and customization in the context of new missions.

Experimentations done by consultants up to now indicate that the use of the tool reduce the consultancy workload by nearly 20% compared with an identical mission without a specific tool, as detailed in [4]. Therefore it is clear that the use of the tool enables to better satisfy the financial constraints of consultancy offers among SMEs while ensuring the process's quality.

Thus the COTS selection methodology converges with characteristics fostered by the Mexican standard for software processes (MoProSoft), reused by the ISO/IEC JTC1 SC7/WG24 [13]: easiness of understanding, of applying, and economical use. Meeting those requirements facilitates the adoption of the method within SMEs context.

However, since the consultant comes with its own method, the ability to assess “in house” software processes has not been developed in the COTS selection method. But a certification scheme for the assessment of the consultant’s skills and practices was the starter of the development of the CASSIS network.

The CASSIS network: certified IT consultants for SMEs

To have a more effective method deployment, an accompanying tool is far from being enough for gaining the interest and the trust of SMEs. To cope with this issue the CRP Henri Tudor has developed and promoted a certificate called “CASSIS” that certified consultants must use for

[2] More about the tool and a demo are provided at: http://www.cassis.lu/cms/cassis/publishingfr.nsf/646184f03288e928c1257035004f3542/e30561d2b01a60b3c12571730053d4bf!OpenDocument

promoting and guaranteeing the quality of their activities. The overall initiative is also promoted through the Internet portal www.cassis.lu [2] that helps in the brokering of SME and certified Consultants. Regular activities are organized in order to foster the network and to encourage consultants to exchange experiences and practices. This includes working groups, conferences, thematic meetings… [9]

A consultant can use the CASSIS certification and methodology if three conditions are fulfilled:
1. The consultant has to follow a one-day training regarding the use of the selection methodology and a second one-day training to learn how to use the supporting tools and materials (guides, templates). At the end of these training sessions, he/she has to successfully pass an exam.
2. During her/his first COTS selection mission, an expert of the CASSIS network board coaches the consultant. At the end of this first coached mission, in case of success, the consultant can officially use the CASSIS certification.
3. Every three years the certification of the consultant is renewed on the basis of the analysis by the CASSIS network board of his activities and associated produced reports.

To do so, a specific training course on the method and the supporting materials has been developed. In addition, a multiple choice questionnaire exam has been written in order to help the trainer evaluate the skills of the consultants at the end of the training session.

To support the coaching part, a set of 56 requirements a certified consultant must comply with has been defined. The requirement definition took place during four workshops sessions in collaboration with IT consultants and IT suppliers (integrators, software houses…) from Luxembourg, Belgium (Walloon region) and France (Lorraine region). Based on these requirements, coaches of the CASSIS network were able to assess capabilities of new consultants to perform software selection in the particular context of SME with respect to quality standards.

After three years of method definition, training and coaching we can conclude that there is a large interest of consultants for this kind of method and certification in French speaking countries (Luxembourg, Belgium, France) where contacts had been established. Indeed, till 2005, 27 consultants from the three countries have followed the training sessions and passed the exam. A dozen of COTS selection missions have been carried out meeting the CASSIS certificate requirements and a few more out of the certification criteria (that means without coaching). We now consider that the CASSIS network has reached its critical mass in terms of number of consultants. Anyway from now on, business and functioning have to be promoted [10].

A board made up of certified consultants and researchers from the CRP Henri Tudor now drives the network. However for the present time, the only experts that coach newly trained consultants are researchers of the CRP Henri Tudor that have developed the methodology. But with the increasing interest of some certified consultants, their commitment in the network board and the experience they gathered during the COTS selection missions they carried out, we can clearly consider that they will be in charge of the future coaching in a near future.

Thus the CRP Henri Tudor would only take part in the network as a trust authority in monitoring the respect of the certifying rules.

Development of the network beyond the Luxembourg area

The EQN project and association

After the success of such a network in Luxembourg and the surrounding French Speaking regions, the CRP Henri Tudor targeted the spreading of this organization at a European scale, throughout a European Network. This was aiming at enhancing the value of the CASSIS certificate by joining a European accredited network, following a standardized modular course architecture [11], and sharing throughout Europe the “IT consultant for SMEs – Software selection” method. Therefore, the principles of the COTS selection method and the CASSIS skills certificate have been presented and accepted as a Job Role in the EQN (European Quality Network) project[3].

The EQN project aims at defining a European association to develop and promote innovation and quality management in the IT certificates and job descriptions (job roles) about over the whole Europe. The EQN project also developed criteria that a job role must match in order to be recognized in a European association [12] (EQN association). As for example, some of the criteria are: spreading over at least two European countries, having training material in at least one other language than English and being reviewed by a cross national team. On top of that, so as to share the knowledge over Europe, job roles must be described following the same structure, using a skill card. Then the “IT consultant for SMEs - Software selection” training courses follow a modular standardized architecture (according to the Bologna process on Education and Training).

Some of the criteria directly matched with the CASSIS network initiative (spreading, reviewing…). We worked to fulfill the remaining criteria.

Thus we characterized the work of the consultant in COTS selection, into a specific skill card based on the skills definition proposed by the Department of Trade and Industry [11] in the United Kingdom for the NVQ (National Vocational Qualification) standards [4].

Using the terminology outlined in the skills definition model, the skills hierarchy for the job role is IT Consultant for SMEs - Software (COTS) selection has been designed. On the following figure is presented the general organization of the skilled card.

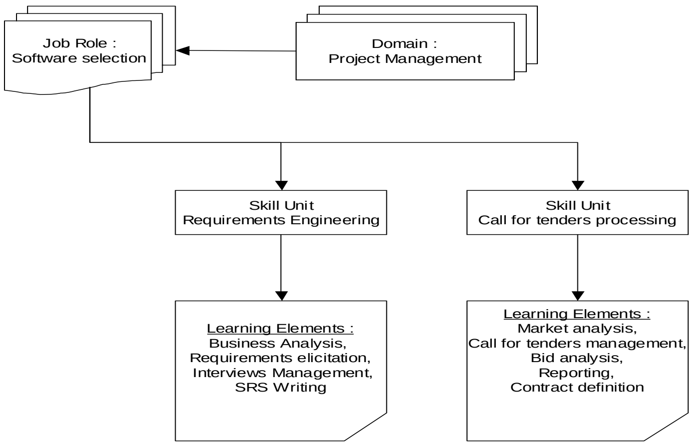

Fig. 2. The Skills Card for the “ IT Consultant for SMEs - Software (COTS) selection” job role

The development of the complete skills card has been done in the context of the EQN project. The skills card is used for the systematic training and assessment of consultants. Thus software selection and acquisition practices of an IT consultant can now be assessed the same way in European countries thanks to the skill card model and EQN certification scheme. This will hopefully lead to improving IT processes within SME.

In addition the multiple choice questionnaire exam has been redesigned so as to match the EQN requirements and the structure of the skill card. Eventually the training literature has been adapted from a local Luxembourg’s context to a European context. However, the remaining supporting materials (guides and templates) could still be adapted and translated in order to propose the full range of supporting material to the European Community, via the English language. By doing so we expect to develop the training and the certification of IT consultants. The newly skilled consultants would be able to work with SMEs for helping them improving their business processes through the renewal of their information system.

[3] EQN is a project carried out with the financial support of the Commission of the European Communities under the Leonardo da Vinci Programme (Project number: A/05/B/F/NT-158.234)

[4] DTI - Department of Trade and Industry UK, British Standards for Occupational Qualification, National Vocational Qualification Standards and Levels

Perspectives

It is clear that the creation of a certification is important in establishing trust between consultants and SMEs at a European scale. However to be really effective it has to be promoted by entities that usually are considered as partners by the SMEs as well as by Consultants. This is the typical role that can be played by Chambers of Commerce and of Craft. In Luxembourg both are today mobilized around the promotion of the CASSIS certification.

We are now looking forward to pursue both the improvement and the spreading of the network. Improving the network means: providing new methodologies and certifications, and continuously improving the current methods and services.

Spreading the network is considered on many axes: developing new targets for the services (small administrations and associations for example) and enlightening methods and services over new countries out of the European context (Russia, Switzerland and Quebec in Canada are potential further development steps).

Conclusion

In this paper, on behalf of an IT certified consultants for SMEs network (CASSIS network initiated in Luxembourg and spreading around in French speaking areas), we have reported on on-going efforts regarding the development and promotion of certified consultants in the domain of COTS selection for SMEs. We have explained the importance of certification in the context of the establishment of trust between SMEs and IT consultants. Now SMEs in Luxembourg and surrounding areas of border countries can benefit from skilled and trustable consultants for helping them in selecting the COTS software that fit best their business needs and improve their business processes.

Today this approach is also followed regarding the certification of other consultants' services that are relevant for SMEs: consultancy in the definition of ICT-based business strategy, an IT maturity assessment (based on ITIL) and the set-up of an ICT resources sharing model between SMEs, and security risk management. We can imagine that these other services could become new job roles in the EQN association.

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IT Security – A skills based elaboration of the IT Security Standards

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Abstract: At the moment the IT Security Management is part of the ITIL (IT Infrastructure Library) process framework. The description in ITIL is process oriented (planning risks, defining security level, etc.) and is not going into too much detail of specific threats on the technical level. ITIL helps to install defined processes to manage the security issues, to analyse risks and threats and refers most often to the ISO 17799 standard for Information Security.

When it comes to the real threats the staff implementing this ITIL process area must always keep up-to-date with the actual risks and threats.

In an EU project under Leonardo da Vinci the EU financed the development of skills required by such an ITIL specific manager responsible for the IT Security area. The strategic background behind that is that European firms in future need a secure basis for a South-Eastern collaboration inside Europe (outsourcing partnership establishments).

In this paper we describe the contents of this education which relates to the ITIL IT Security process area. We also should mention that we did not call it an IT Security Manager but an ***e-security manager***.

The project is being funded under the Leonardo da Vinci Program (SI/05/B/F/PP -176.008).

1. The Demand for Security Management

In this age of continuous innovations and technological changes, the European expansion, and the movement of Europe into an e-Europe in the next few years, the topics of e-Security became an important issue on the European agenda.
The strategy for an e-Europe will only turn to a success if at the same time the e-Security issues in the national laws and European businesses are adapted to this new form of business and the networked society. In the prosperity of an SME the knowledge and the intellectual property plays more and more important role. The competitors and mainly the big companies do not spend on own developments so much and try to get the excellent products from the SMEs just buying the whole company. To help to get advantage on the market for the SME it is very important to keep the secrets of a company. Nowadays most of the information is stored electronically, so the managers of SMEs need to know about e-security.
With the establishment of the e-business special threats were developed to harm the users of the internet. Cyber criminals, or hackers at the beginning, were just showing their power and did not intend to gain money or to do great harm. They just wanted to show, that they are cleverer, than the person, who is using that special computer or the person who developed that piece of code. The hackers broke the code of web pages and put their own comments on the web page or spread

computer viruses using e-mails. They did not target a particular enterprise, just injured where they reached vulnerability. Of course these attacks could lead to a bad reputation or a financial loss for a company, just take into account the time detecting a virus and removing it. Nowadays the cyber-crime evolved to more profit targeted, destroying the image of a company, getting the sensual, personal data of the customers, gaining bank account data for future use and revealing the business secrets and confidential information of a company, these all are part of the activities of the cyber criminals. Figure 1 shows the evolution of cyber-crime. [11].
So all the enterprises, not only the big ones have to protect themselves against electronic threats as well not only physical threats.

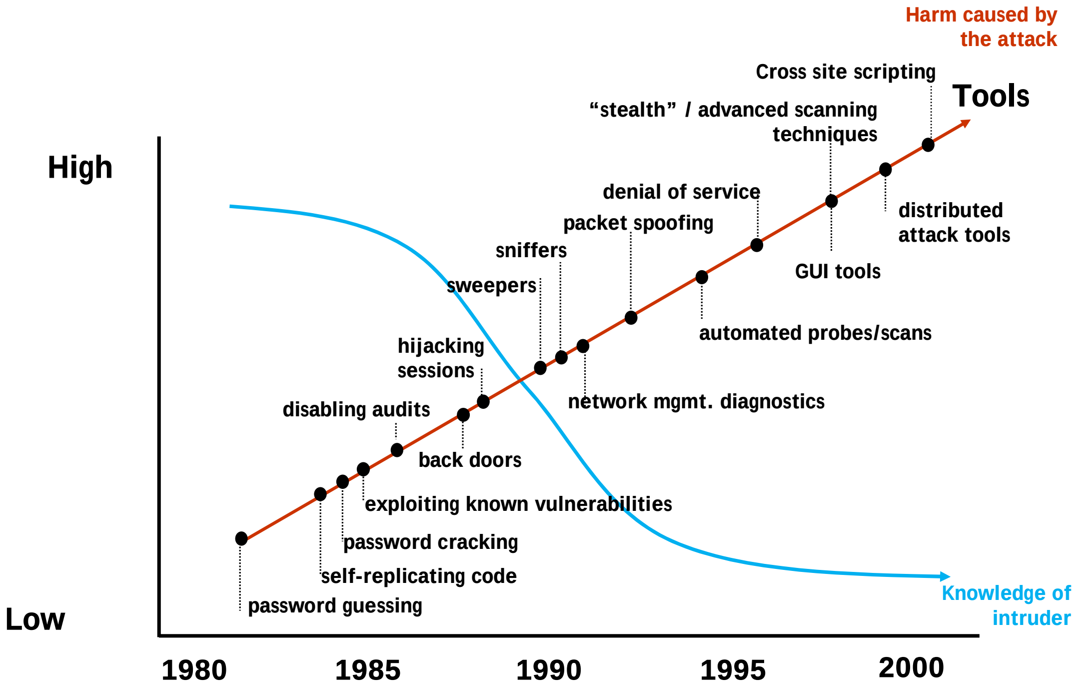

Figure 1: The Evolution of Threats

2. The Relationship with Process Improvement

In ISO 15504 on capability level 3 a standardised infrastructure for managing and controlling he processes is required. Once this Intranet system has been set up and all processes have been configured onto it, all projects start collecting data and information in a standardised way and store it in central repositories (configuration management systems).

Thus all organisations who achieved a capability level 3 have established such infrastructures and achieve huge potentials (re-use of knowledge) as well as they become vulnerable to threats.

Imagine that 5000 employees in a segment of the firm use the same project planning processes inside a joint central infrastructure of the firm. Imagine further that this infrastructure is hit by a virus which slows down the operation and each document check-in now takes 1 minute more. Then you waste 5000 * 1 * number of documents minutes per day.

This is the reason why experienced level 3 and 4 organisations of SPICE started regarding e-security and infrastructure as one of the processes to be considered in the improvement programs.

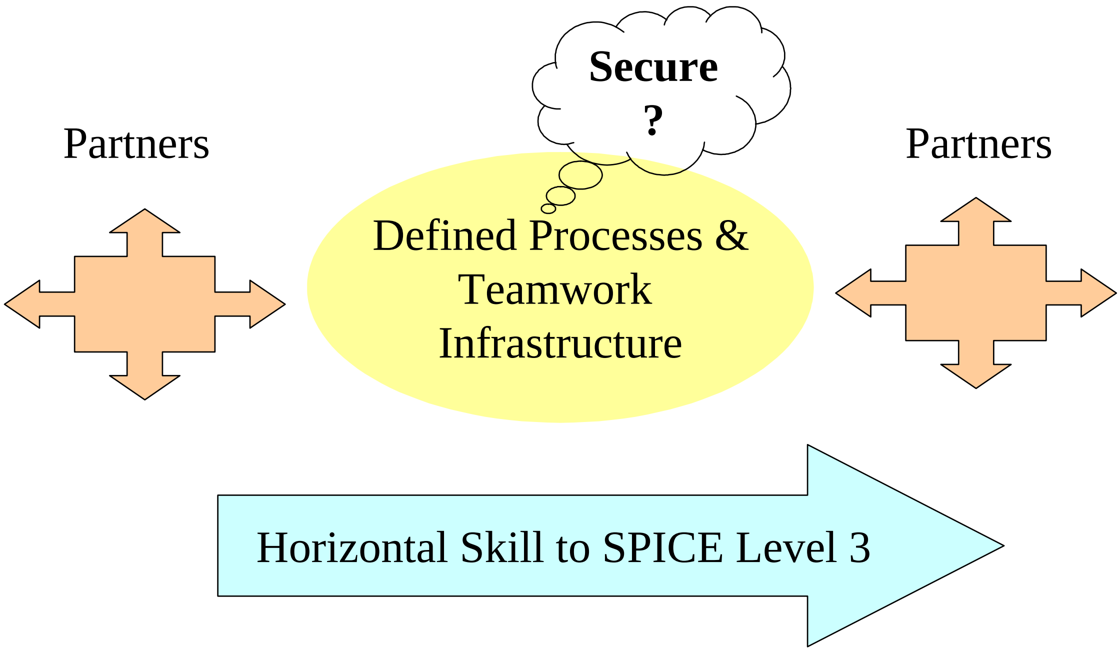

Figure 2: The Defined Level 3 Requires a Standardised Infrastructure

3. The underlying standards to be considered

2.1 EU Directives

Europe is developing towards an e-Europe with growing opportunities but at the same time with growing threats. Since 1999 the EU releases directives to attack these issues such as

- Directive 2000/31/EC of the European Parliament and of the Council of 8 June 2000 on certain legal aspects of information society services, in particular electronic commerce, in the Internal Market ("Directive on electronic commerce") [1]
- Directive 1999/93/EC of the European Parliament and of the Council of 13 December 1999 on a Community framework for electronic signatures [2]
- Official Journal L 013 , 19/01/2000 p. 0012 – 0020 [3]
- European Security Strategy endorsed by the European Council, December 2003, it is general security, but IT security is a part of that. [4]
- Etc.

While releasing such directives it is left open for each national state to implement the directive, resulting in different security strategy implementations in Slovenia, Hungary, Ireland, Austria, and Bulgaria (as well as in other countries). Austria released more detailed laws while in Germany and the UK a whole IT security guidebook was developed.

When looking at the political strategies and the different national educational programs in this area, one of the major problems is that the scope of an e-security manager education differs from country to country. Thus the e-security manager project developed a first version of a cross-national set of skills and learning objectives [5], [12] which all European training institutions should cover to address a similar scope of skills. A full training program has been developed based on the agreed skills set.

2.2 ITIL – IT Infrastructure Library

The ITIL (IT Infrastructure Library) [13], [14] contains 6 process groups, such as

- Service Support
- Service Delivery

- Planning to Implement Service Management
- ICT Infrastructure Management
- Applications Management
- The Business Perspective.

Within these a variable number of very specific disciplines are described.

ITIL has been developed to support the establishment of professional processes in the IT departments of large organisations and networks. In this way the ITIL approach is also quite useful when implementing the outsourcing partnerships between Western and Eastern Europe (see above EU goals).

The handling of security and risks is understood as a fundamental part of service management to be valid in each of the ITIL processes. The ITIL there references the ISO 17799 standard for Information security.

2.3 ISO 17799 Information Security Standard

ISO 17799 is described as a code of practice for information security. It describes 130 best practices to be covered and groups them into 36 control objectives. The objectives are grouped into 11 process areas:

1. Risk Assessment and Treatment
2. System Policy
1. a.)To provide management direction and support for information security

2. Organizing Information Security
    a) To manage information security within the organization
    b) Maintain the security of information and processing facilities with respect to external parties.
3. Asset Management
    a) Achieve and maintain appropriate protection of organizational assets.
    b) Ensure that information receives an appropriate level of protection.
4. Human Resources Security
    a) Ensure that employees, contractors and third parties are suitable for the jobs they are considered for, understand their responsibilities, and to reduce the risk of abuse (theft, misuse, etc).
    b) Ensure that the above are aware of IS threats and their responsibilities, and able to support the organization's security policies
    c) Ensure that the above exit the organization in an orderly and controlled manner.
5. Physical and Environmental Security
    a) Prevent unauthorized physical access, interference and damage to the organization's information and premises.
    b) Prevent loss, theft and damage of assets
    c) Prevent interruption to the organization's activities.
6. Communications and Operations Management
7. Objectives:
    a) Ensure the secure operation of information processing facilities
    b) Maintain the appropriate level of information security and service delivery, aligned with 3rd party agreements
    c) Minimize the risk of systems failures
    d) Protect the integrity of information and software
    e) Maintain the availability and integrity of information and processing facilities
    f) Ensure the protection of information in networks and of the supporting infrastructure
    g) Prevent unauthorized disclosure, modification, removal or destruction of assets.
    h) Prevent unauthorized disruption of business activities.
    i) Maintain the security of information and/or software exchanged internally and externally.

   j) Ensure the security of e-commerce services
   k) Detect unauthorized information processing activities
8. Access Control
   a) Control access to information
   b) Ensure authorized user access
   c) Prevent unauthorized access to information systems
   d) Prevent unauthorized user access and compromise of information and processing facilities
   e) Prevent unauthorized access to networked services
   f) Prevent unauthorized access to operating systems
   g) Prevent unauthorized access to information within application systems
   h) Ensure information security with respect to mobile computing and teleworking facilities
9. Information Systems Acquisition, Development and Maintenance
   a) Ensure that security is an integral part of information systems
   b) Prevent loss, errors or unauthorized modification/use of information within applications
   c) Protect the confidentiality, integrity or authenticity of information via cryptography
   d) Ensure the security of system files
   e) Maintain the security of application system information and software
   f) Reduce/manage risks resulting from exploitation of publiched vulnerabilities

10. Information Security Incident Management
   a) Ensure that security information is communicated in a manner allowing corrective action to be taken in a timely fashion
   b) Ensure a consistent and effective approach is applied to the management of IS issues
11. Business Continuity Management
   a) Counteract interruptions to business activities and protect critical processes from the effects of major failures/disasters
   b) Ensure timely resumption of the above

4. From the Process View to the Skills Dimension

Figure 3 shows the relationship between process establishment and human resources management. Actual people will take the ownership of defined roles and thus will require to achieve a certain skills profile, and the achievement of the human resources skills is equally important than achieving a defined process in technical terms.

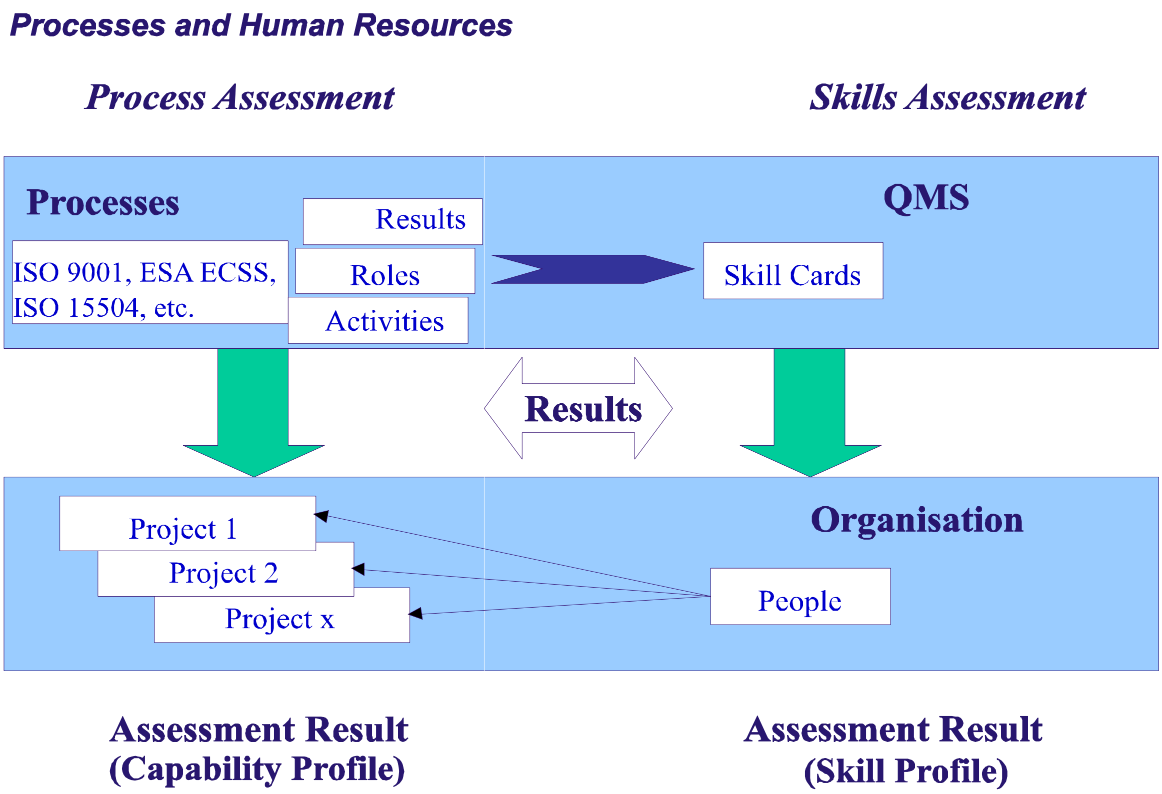

Figure 3: Combination of Process and Skills Related Management

This means that once we have established good practices and defined processes for IT Service Management including security aspects we need to upgrade the skills of staff continuously in the security management area to keep the data safe and protected.

The EU Leonardo da Vinci Program financed the development of the skills of such an IT Security Manager.

5. The E-Security Manager Skills Set

The job role of an e-security manager (see Figure 4) therefore is a specific position in an organisation who understands all these factors: Management and Policy (Management Awareness and Control, Security Policy Establishment, Education, Personal Security, EU and national standards and laws, physical security), System Administration (Antivirus and Content Filters, Updates, Authentication and Authorisation, Availability, Backup, Application Related Security) , Network Security (Firewalls and IDS/IPS Systems, Cryptography).

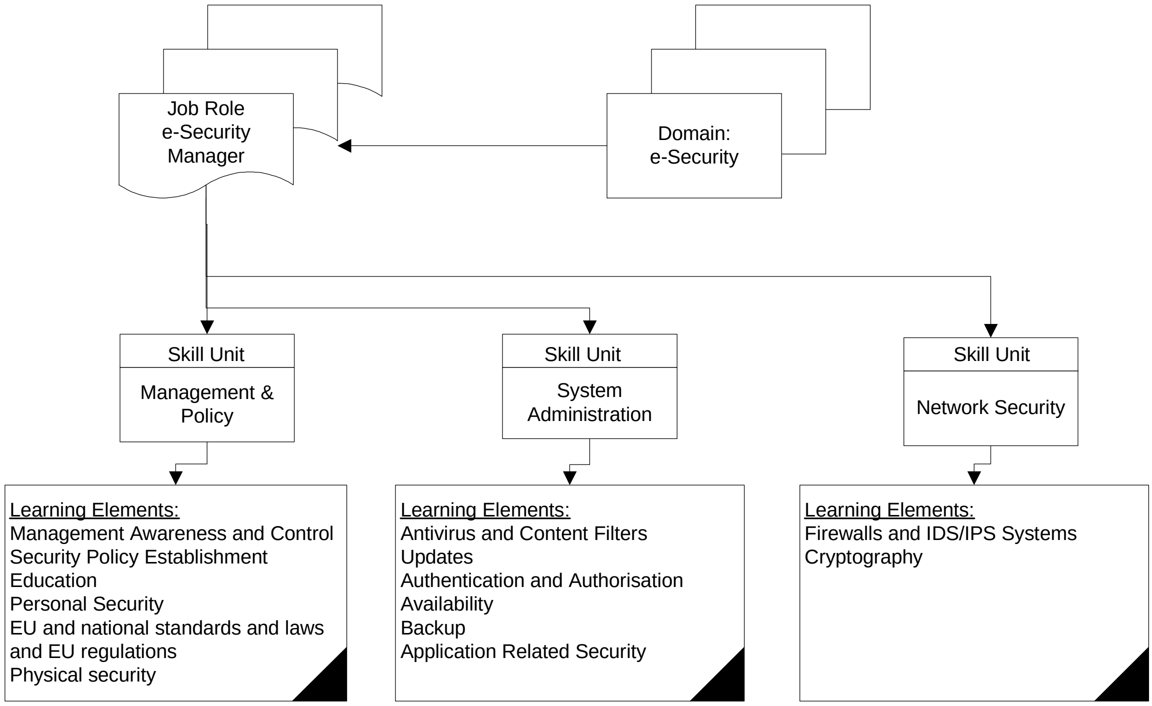

Figure 4: The E-Security Manager Skills Set

For each of the skills elements a training course has been developed in a European partnership.

4.1 Management Awareness and Control

In this element the students learn competencies regarding importance of management awareness of security issues in IT systems

This comprises:

- understanding the importance of involving management in IT security practices
- understanding the principles of communication with management over IT security issues
- understanding the importance of renewing IT security practices with management

4.2 Management Awareness and Control

In this element the students learn competencies regarding security policy establishment.

This comprises:

- understanding the importance of security policy
- understanding relevance of security policy updates
- planning security policy
- understanding security risk analysis and risk management

4.3 Education

In this element the students learn competencies regarding aspect of education in field of IT security.

This comprises:

- understanding the importance of security education (management, employees…)
- understanding relevance of continuous refreshment of security knowledge of management, employees…

4.4 Personal Security

In this element the students learn competencies regarding personal vulnerability and personal intrusion. The personal computers of personnel who work at an enterprise may be targets of different threats and attacks. The student should learn how to prevent these and to build a trustful environment.

4.5 EU and national Standards and laws and EU regulations

In this element the students learn knowledge about e-commerce and e-security laws and regulations, which have been issued by the EU and have been implemented by the member states.

4.6 Physical security

An important part of e-security is the physical security. The physical security means the protection of hardware. The computers, which store important information and data, have been shielded against the physical effects. These physical effects are:

- Incompetent accesses (e.g. unauthorized people)
- The climate of the computer room
- Natural physical effects, such as outdoor-electro-magnetic field
- Unexpected natural or terror disasters

4.7 Antivirus and Content Filters

In this element the students learn competencies regarding antivirus and content management solutions planning, implementation and administration.

This comprises:

- understanding the importance of a antivirus and content management
- understanding relevance of up-to-date updates
- knowing various threads that viruses, trojans, phishing… present
- Identifying the damage that can occur due to virus, trojans, phishing… threads (information leakage, data destruction, industrial espionage, using resources of attacked computer, keyboard sniffing etc.)
- understanding cost of lost man/hours due to users exploiting internet access
- planning antivirus/content management strategy
- managing and monitoring solutions in place

4.8 Updates

In this element the students learn competencies on how to implement a security update, patch and bug fix strategy, analyze and prioritize security updates by potential risks and vulnerabilities, test and track updates.

4.9 Authentication and Authorization

In this element the students learn competencies regarding authentication and authorization systems on application/OS layer and network layer.

This comprises:

- understanding the importance of authentication and authorization on application/OS layer and network layer
- understanding meaning of authentication and authorization on application/OS layer and network layer
- understanding principles of authentication and authorization systems
- understanding what authentication and authorization systems provide on application/OS layer in terms of auditing

4.10 Availability

In the IT community, the metric used to measure availability is the percentage of time that a system is capable of serving its intended function. As it relates to messaging systems, availability is the percentage of time that the messaging service is up and running. The following formula is used to calculate availability levels:

Percentage of availability = (total elapsed time – sum of downtime)/total elapsed time

Availability is typically measured in "nines". For example, a solution with an availability level of "three nines" is capable of supporting its intended function 99.9 percent of the time. The availability is a very important thing in services that store critical folder data.

4.11 Backup

In this element the students learn competencies regarding disaster recovery planning and backup strategies, media and types.

This comprises:

- Understanding the importance of a disaster recovery plan
- Knowing various different backup medias and types
- Identifying the various risks of losing data (Hardware Failure, Software Failure, File System Corruption etc.)
- Planning the backup scheduling and knowing the media rotation methods.
- Testing the restore

4.12 Application Related Security

In this element the students learn competencies regarding Application Related Security covering method of attacks understood, monitoring of possible application vulnerabilities, web application security, secure design architectures, secure distributed architectures, etc. The student must be able to design Secure Web Applications and Secure Network Distributed Applications. The student must have knowledge for various attacks regarding web applications like Cross-Site Scripting (XSS), Cross site request forgery (CSRF), SQL Injection, Command Injection, and vulnerabilities regarding buffer overflow, invalidated parameters, Broken Access Control and Broken Account and Session Management.

4.13 Firewalls and IDS/IPS Systems

In this element the students learn competencies regarding firewalls and Intrusion Detection / Intrusion Prevention Systems IDS/IPS systems.

This comprises:

- understanding the role and importance of firewalls and IDS/IPS systems
- understanding different kind of firewalls

– understanding difference between IDS and IPS system
– planning firewall, IDS/IPS deployment
– understanding security risks of firewalls and how to prevent them with IDS/IPS
– understanding firewall, IDS/IPS feedback (monitoring, auditing etc.)

4.14 Cryptography

In this element the student must show competencies regarding encryption algorithms and functions, encryption programs, firewalls, https secure connection set up, encryption of database content (built in functions or external programs), email en- and decryption.

6. The E-Security Manager Certificate

In collaboration with EU initiatives we apply an online learning platform system and European computer based exam portals. This allows us to send course attendees to exams and to issue European certificates. (See www.eu-certificates.org)

Moodle – This is a web based learning management system which is public domain available. (www.moodle.com)

Capability Adviser – This is a web based assessment portal system with a defined interface database to connect the systems. (http://www.iscn.com/projects/piconew/) [12]

NQA – Network Quality Assurance – This is a web based team working tool which was developed in the EU IST 2000 28162 project. [7]

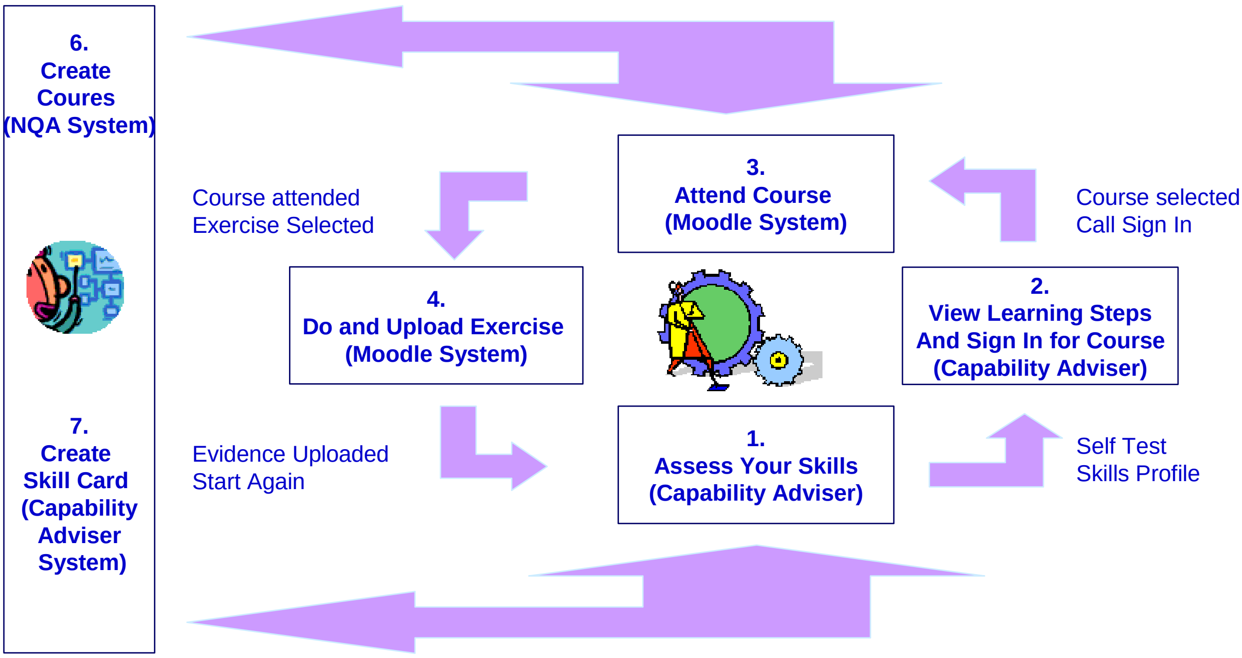

Figure 5: The E-Learning System

1. Participants (Learners) log into the Capability Adviser, browse the skills tree, assess their skills against performance criteria, upload evidences to prove their skills, and print a skills profile.

2. Participants (Learners) select the "Learning Steps" option the Capability Adviser, access recommended learning references, and can call "Sign In" to log into courses on the Moodle web based training server system.
3. Users (Learners) on the Moodle System attend the courses , perform exercises, upload results of their homework, and receive feedback from the trainer.
4. Users (Learners) switch to the Capability Adviser window (if you did all in one session) or log into Capability adviser as participant and upload their homework results as evidence into the system to prove their competence.

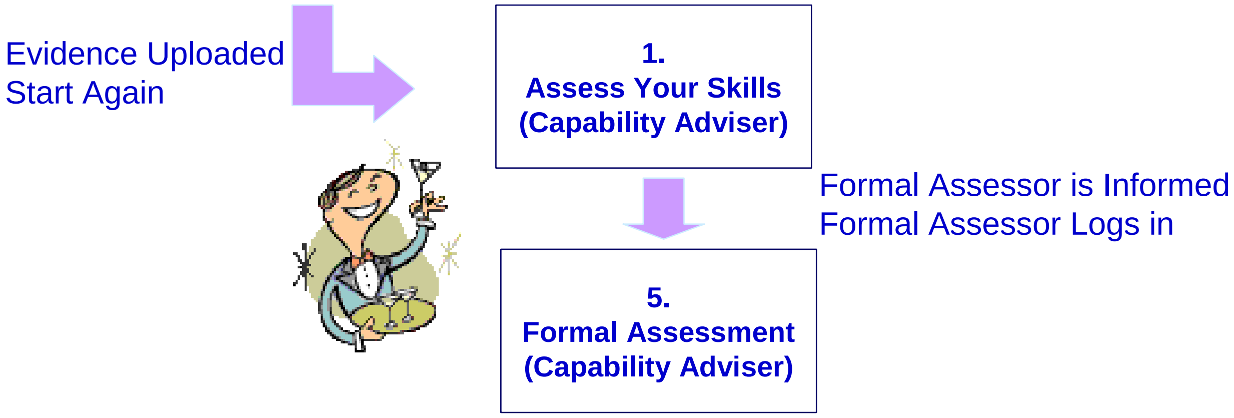

Figure 6: The Formal Assessment and Exam

7. Outlook

The e-security manager board will join the IT Security Manager board in autumn 2007. In this group different major IT security initiatives supported by national governments and EU projects will join forces to establish the Certified IT Security Manager. Two certificates will be made available:

- Basic Level IT Security Manager
- Advanced level IT Security Manager

Keep in mind that a successful operation of a firm on a high capability level requires a smoothly working infrastructure supporting the processes. And this infrastructure contains then a lot of your IPR related materials and a slow down of it has an impact on the overall organization.

So we recommend that you include the "Infrastructure" process in your improvement programs.

8. Acknowledgements

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Ten factors that impede improvement of verification and validation processes in software intensive organizations

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Abstract

In spite of the potential benefits that the correct application of software verification and validation processes, techniques and tools can provide, their institutionalized use in the software industry does not reach the minimum capability levels required gain these benefits. Moreover, this circumstance is aggravated in the small and medium software intensive organizations by the lack of available human and economic resources.

In this paper, 10 of the most important factors that prevent the correct institutionalization of the software verification and validation efficient practices are presented. These factors are obtained from the authors' experience in several software process improvement initiatives in software verification and validation processes.

Keywords

Verification Process, Validation Process, Software Testing Process, Process Improvement, Change Management

1 Introduction

There are many studies on the important benefits that software organizations obtain from the deployment of verification and validation formal processes [1]. These benefits are:

- Increase in client satisfaction through the use of software with fewer defects rates.
- Increase in the software development processes efficiency.
- Facilitation of definition and fulfillment of quality objectives.
- Increase in software developers' satisfaction because the organization provides the right tools and resources to work efficiently.

In addition, participating organizations in these studies have reported economic gains from software verification and validation process improvement activities:

- The defect rate in software delivered to clients was reduced by 20% (BKIN Software).
- The software test effort decreased from 25% to 20% of the total project effort (BKIN Software).

- The number of defects detected during acceptance tests is lower than the 12% of the defects detected during integration tests. The previous value was 37%. (BKIN Software).
- The defects reported by the client/users have decreased by 77% (Archetypon).
- Reduction of 30% in development costs (IMB SEMEA SUD).
- Reduction in delivery time and increase of test efficiency. (Nokia – Network Management Systems).

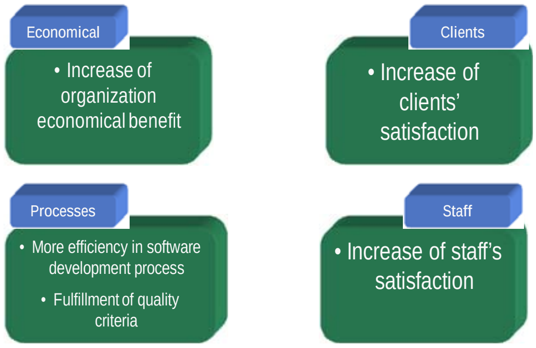

Figure 1: Benefits by means of the improvement of verification and validation processes.

However, in spite of the benefits of an institutionalized software verification and validation processes application, according to the world-wide maturity profile of Software Intensive Organizations (SIOs) elaborated by the Software Engineering Institute (SEI) [2], not all the Verification and Validation process criteria the CMMI (Continuous Representation) established for Level 2 were fully satisfied. In 2006, 402 organizations evaluated their Verification and Validation processes with respect to the criteria established by CMMI (Continuous Representation) for Level 2 of Capacity; and it was found that only 2.98% of the organizations (12) fully satisfied all the Level 2 criteria, whereas 7.96% of the organizations (32) partially satisfied this criteria.

On the other hand, 45 organizations evaluated their Verification and Validation processes with respect to the criteria established in CMMI (Continuous Representation) for Level 1 of Capacity; and it was found that only 8.88% of the organizations (4) fully satisfied all the Level 1 criteria, whereas 40% of the organizations (18) partially satisfied the mentioned criteria (not all the criteria were fully satisfied).

Considering these numbers, it is necessary to analyze the factors which hinder the effective introduction, understanding and institutionalized application of verification and validation of efficient practices in software intensive organizations.

2 Description of Software Intensive Organizations Considered in the Scope of this Work

The factors, that prevent the improvement of software verification and validation processes presented in this paper, have been identified from the lessons learned, gathered along the execution of 10 process improvement projects related to software verification and validation processes. In all the cases, the authors participated in the activities performed by the improvement team. Table 1 shows the main characteristics that determine the typology of the organizations included in the scope of this work.

3 A Reference model to classify the factors that impede the continuous improvement of verification and validation processes

Table 1: Characteristics of the software intensive organizations considered that have initiated improvement activities related to software verification and validation processes

	SIO[1,2] 1	SIO 2	SIO 3	SIO 4	SIO 5
Staff size	≈ 30 people	≈ 50 people	≈ 25 people	≈ 10 people	≈ 35 people
Type of software developed	Information management systems in web and Windows (client/server)	Information management systems in web and Windows (client/server)	Embedded software for measurement purposes	Software designed in the scope of ICT research projects	Information management systems in host environments with web interfaces
Type of jobs performed (New projects, maintenance activities, etc.)	New solutions development and their maintenance related works	New solutions development and their maintenance related works	New solutions development and their maintenance related works	Development of reusable software components	New solutions development and their maintenance related works
Base technologies used	Windows, NET y SQLServer	Windows, PLSQL, Java y Oracle	Windows, Linux, Java, .NET	Windows, Linux, Java, .NET, RFID, SQLServer, Oracle, etc.	AS/400, PDM, Java, WASAD y DB2
Testing tools used	Internal defects management tool and NUnit	Internal defects management tool and JUnit	JUnit and NUnit	JUnit, Nunit Project specific defects management tools	Without specific tools
Rotation in the working groups composition	Low – Stable working groups	Low – Stable working groups	Low – Stable working groups	High –changing each semester	Very Low – Stable working groups
Process Improvement Motivation	Deployment of an efficient process with adaptation guides per type of work	Deployment of an efficient process with adaptation guides per type of work	Deployment of an efficient process with adaptation guides per type of work	Deployment of an efficient process with adaptation guides per type of work	Achievement of ISO 9001:2000 certification for software development

	SIO 6	SIO 7	SIO 8	SIO 9	SIO 10
Staff size	≈ 100 people	≈ 100 people	≈ 100 people	≈ 100 people	≈ 100 people
Type of software developed	ERPs deployment and customization	Development of commercial solutions for knowledge management	eCommerce systems deployment and customiza-tion	Deployment and customization of CASE tools	Development and customization of logistics management information systems
Type of jobs performed (New projects, maintenance activities, etc.)	Customization of commercial off the shelf tools	Customization of commercial off the shelf tools	Customization of commercial off the shelf tools	Customization of commercial off the shelf tools	Customization of commercial off the shelf tools
Base technologies used	Windows, Linux, Java, .NET, other specific languages	Windows, Linux, Java, .NET, other specific languages	Windows, Linux, Java, .NET, other specific languages	Windows, Linux, Java, .NET, other specific languages	Windows, Linux, Java, .NET, other specific languages
Testing tools used	JUnit and Nunit	JUnit and Nunit	JUnit and Nunit	JUnit and Nunit	JUnit and Nunit
Rotation in the working groups composition	Very High – Different per project	Very High – Different per project	Very High – Different per project	Very High – Different per project	Very High – Different per project
Process Improvement Motivation	Achievement of CMM Level 2 of capacity in dev. and management processes	Achievement of CMM Level 2 of capacity in dev. and management processes	Achievement of CMM Level 2 of capacity in dev. and management processes	Achievement of CMM Level 2 of capacity in development and management processes	Achievement of CMM Level 2 of capacity in development and management processes

[1] Software Intensive Organization
[2] Due to contractual obligations, we are not authorized to mention the real names of the company related to this case study. Currently, we are negotiating the permission to mention them explicitly in the final version of this paper. All the data provided are real.

Although the IDEAL model [3] is especially oriented to managing process improvement in software intensive organizations, the principal goal for this model, like other approaches to manage the introduction of process improvements in technological or industrial organizations (i.e. Plan-Do-Check-Act, PDCA), is to establish mechanisms to carry out continuous improvement programs in organizations. IDEAL and other improvement models define the following steps to carry out a process improvement program:

1. **Obtain the required commitment**: this consists of defining the continuous improvement program, in this case, the verification and validation processes; elaborating an improvement action plan; and obtaining the commitment required in terms of objectives, activities, schedule and available resources for the improvement program.
2. **Diagnosis:** the main purpose is to establish the existing efficient practices in the organization and to identify specific improvement needs and opportunities, in this case, relating to the improvement of software verification and validation processes.
3. **Definition**: the purpose is to define the process and all the guides that allow adapting the defined general process to each type of work related to software development and maintenance that are carried out by the organization.
4. **Implementation**: the main purpose is the institutionalized use of the improved processes and techniques established during the definition phase.
5. **Results analysis**: this phase quantifies the benefits derived from the process improvement activities and determines the new process improvement goals. Effective results analysis activities and the factors that impede them are addressed when the improvement objectives are well stated, they are translated into measurement objectives and indicators and, finally, an institutionalized verification and validation processes are being used properly.

On the other hand, in order to apply any of the existing improvement models properly, it is necessary to apply a software process reference model that establishes the main goals, activities and tasks of the verification and validation processes. There are several reference models that are useful for verification and validation process improvement: ISO 12207 [5], CMMI [6], IEEE1074 [7] and TMM [10].

Throughout the execution of several process improvement programs, the authors have identified several factors that impede software verification and validation processes improvement. These factors have been classified according to the IDEAL model phase, whenever they arise. For each factor, its identification (through a brief sentence), detailed description and the solution authors propose (and applied) are presented. It should be noted that problems are not in order of importance.

4 Description of Software Intensive Organizations Considered in the Scope of this Work

In the following subsections, the factors identified are presented, bearing in mind that they are not ordered by degree of importance or relevance.

A) Factors related to software process reference models

Nowadays, there are different software process reference models (ISO 12207 [5], CMMI [6], IEE1074 [7] and TMM [10]) which describe verification and validation processes to be executed during the development of software projects, their goals and efficient practices. However, these models present problems in identifying current efficient practices; needs; and improvement opportunities during the improvement diagnosis stage, and as a guide to software improvement in an organization.

FACTOR 1	
Statement	**Reference models, which define verification and validation activities, are not easy to use.**
Detailed Description	It is generally assumed that software process reference models are difficult to use because: ▪ Their terminology, in many cases, it is not known and/or understood by the organization's personnel. ▪ The terminology employed in a specific SIO is not known and/or understood by the supporting

FACTOR 1	
	consultants that help the organization improve its verification and validation processes. ▪ Software Process reference models are very dense documents that present, in a few pages, many concepts and ideas using very condensed phrases, making them difficult to understand.
Solution proposed / applied	Improvement teams should be composed of personnel with different profiles: ▪ Experts in the reference model selected to guide the improvement activities ▪ Experts in testing, verification and validation techniques. ▪ Project managers with a global vision of all the types of jobs to be performed in the scope of SIO activity. ▪ Personnel with a great deal of experience in the development of each different final and intermediate product considered in the SIO life cycle (analysis, design, programming and integration).
FACTOR 2	
Statement	**Reference models do not provide the required integration among verification and validation processes with the rest of engineering process[3] considered during development of software projects.**
Detailed Description	The reference models considered provide a detailed description of the activities in each verification and validation process. However, these activities must be executed in a synchronized way with other engineering and project management activities. ▪ Reference models do not describe these interactions in detail; ▪ If they (the process models) are described, it is only with reference to the process it must interact with, without describing how they should synchronize nor the information that must be provided /used in each of the synchronized process. It is therefore necessary to carry out important additional work to permit efficient synchronization between verification and validation activities and engineering activities.
Solution proposed / applied	Along the improvement programs, the authors have defined developed two types of solutions: ▪ Synchronization maps that enrich the information provided by software process reference models with reference to information on: profiles of participants in each activity; the activities (belonging to the same or other processes) to be enacted before, during and after the activity in question; and the information to be interchanged between them. ▪ Customized guides for each organization's role participating in the development process, including a specific section on the verification and validation and other tasks to be performed as a consequence of the execution of each engineering or management activity.

Table 2: Factors related to software process reference models

B) Obtaining the commitment required to initiate process improvement activities

One of the principal difficulties of any improvement program is to obtain senior management support and sponsorship, as well as the necessary commitment to improvement objectives, available resources and assigned schedule. The problems increase when the improvement objectives are related to software testing, verification and validation. The most important problems are shown in table 3.

FACTOR 3	
Statement	**It is very difficult to estimate the expected ROI on the improvement of software verification and validation processes. Moreover, the estimations have a low degree of reliability**
Detailed Description	When senior management analyse the convenience, need and opportunity to begin a software process improvement program centred on software verification and validation activities, they need to estimate the expected Return on Investment (ROI). In order to do so, they have: ▪ To estimate the effort and costs the improvement activities require. These types of estimation can be made using expert judgement-based techniques [8]. ▪ To estimate the benefits (decreasing costs or increasing income) that can be achieved as a consequence of the application of the improved process and verification and validation techniques. There are no well-tested techniques to perform this type of estimation.
Solution proposed / applied	The solution proposed by the authors is based on the calculation of quality and non quality costs, but using a linear model based on: ▪ The cost associated with each error or non-conformity detected during the project and delay with respect to the commencement of the project. A multiplication factor is assigned; it becomes higher as the project execution time advances; and is distinct in each organization where the method is applied.

[3] The concept "engineering process" is used to refer to of requisite specification analysis, design, programming, deployment and information system maintenance processes.

FACTOR 3	
	▪ The cost required to perform the technical reviews and tests registered in the project control and monitoring tool used in the organization. Currently, this model is under research and the results obtained from this application are partially correct. Moreover, the authors are beginning to compile and standardize a set of case studies and a framework that permit the application of benchmarking techniques to compare the characteristics of an organization that wants to initiate an improvement program, related to verification and validation, with other improvement programs previously executed in the same process areas.
FACTOR 4	
Statement	**The estimated cost of improvement activities related to verification and validation process improvement is very high. Thus, although the expected benefits might be very significant, the organization cannot afford it.**
Detailed Description	The cost of improving verification and validation processes includes the economic value of the time that internal staff participating in the improvement program dedicates to these processes; the cost of external consultants who usually guide the improvement process; and the cost associated with the acquisition of CASE tools to manage and automate the new process defined. This initial investment for a software improvement program can be so high for small and medium development settings, that although the potential benefit is considerable, these organizations will not be able to gain from them.
Solution proposed / applied	The solution proposed by the authors is based on: ▪ The definition of Verification and Validation Process Patterns [9]. These patterns, researched by the staff of the Software Engineering Lab at Carlos III University, are pre-defined solutions to apply the software verification and validation principle in different organizational contexts. These patterns provide information on: Initial Context, Final Context, Problem, Solution, Inputs and Outputs. ▪ Training resources and electronic process guides that provide the procedures and technical instructions on the use of Verification and Validation Process Patterns with a set of specific CASE tools. ▪ Business models that permit the publication and trading of process patterns and electronic process guides so that several organizations can use and share the costs of developing process patterns and electronic process guides These solutions reduce the initial investment required to initiate software process improvement programs, enabling small and medium software development settings to initiate these types of activities.

Table 3: Factors related to obtaining senior management commitment

C) Current situation Diagnosis

Once the commitment required to initiate an improvement program is obtained, it is necessary to determine the current situation of the company in relation to the testing, verification and validation activities. These activities are not usually well considered by the organization's personnel, especially those who are taking part in software process improvement activities for the first time.

FACTOR 5	
Statement	**The activities dedicated to diagnosing the current practice in relation to the verification and validation process improvement activities are considered a waste of time and money.**
Detailed Description	Normally, the main purpose of the diagnosing phase is to detect some deficiencies in the current verification and validation practices and to identify the process improvement areas. This information is not recognized as valuable by most of the organization's staff, so the improvement activities can be perceived very negatively.
Solution proposed / applied	The solution proposed by the authors is to describe the verification and validation processes currently in use, after efficient practices are detected, enriched with other forms of existing bibliography, and compiled in terms of process patterns. This action plan to compose these process patterns should include activities of the following types: ▪ Process pattern creation ▪ Adaptation of existing process patterns ▪ Creation of templates with the structure of products created/updated/used during the process pattern use. ▪ Creation of specific instructions to use the process pattern ▪ Acquisition and/or creation of examples of process pattern application and the products required by each process pattern. ▪ Execution of support activities to help personnel learn how to use the patterns, guides and templates defined. ▪ Monitoring of the use of the process patterns defined.

FACTOR 5	
	▪ Process pattern deployment activities to institutionalize the process patterns defined. This strategy, in addition to a reduction of effort in future activities supposes that the organization's staff there will be more motivated and involved in the improvement activities, a critical success factor in all types of improvement programs in an organization.

Table 4: Factors related to the current situation diagnosis

D) Definition of efficient and optimized processes

Defining a new verification and validation process, as well as elaborating adaptation guidelines is one of the most problematic stages of the process improvement due to the lengthy discussions and arguments that arise among the task force. In the verification and validation process, the main problems identified are shown in table 5.

FACTOR 6	
Statement	**What comes first: the new testing process or the acquisition of the testing tools for automation purposes?**
Detailed Description	In several organizations, the acquisition of an expensive software testing tool initiates software testing in process improvement activities. This means that the improvements defined are restricted to activities that the tool in question provides, which limits its improvement capacity.
Solution proposed / applied	Firstly, the objectives, inputs and outputs of the verification and validation processes must be defined. Then, the tools to manage and automate the process defined must be selected. Subsequently, and in collaboration with the tools and testing process experts, the procedures and technical instructions that detail the testing process are elaborated. Guidelines on the use of the tool for the process defined must be provided. The most common verification and validation processes tools are those related to defects and errors management. Moreover, in most organizations considered, free testing tools were implemented for the automation of unit testing (NUnit and/or JUnit). In none of the organizations considered, was a tool for tool for performance or system functional testing for institutionalized use purchased.
FACTOR 7	
Statement	**The establishment of specific review techniques, by pairs or through formal inspections, is perceived as an unnecessary work overload that cannot be assumed.**
Detailed Description	Design and code reviews (performed formally or by peers) are shown by software developers as an efficient technique from the theoretical point of view, but due to the actual pressure of software development projects, they suppose a work overload that developers cannot assume.
Solution proposed / applied	The solutions proposed and applied by some of the authors are centred on the following aspects: ▪ Use of pre-defined check lists for design and code technical reviews. The reviewers can use this list as guidelines to determine which issues should be verified, enabling the detection of most common errors. ▪ Use of metrics, based on the effort and efficiency of the review process, using the information provided in the checklists and the evolution of corrective actions proposed. ▪ Use of estimation techniques to determine quality and non quality costs presented in factor 4. ▪ Uses of informal review techniques, peer-review techniques are especially recommended.
FACTOR 8	
Statement	**The definition of test cases is perceived as an unnecessary and bureaucratic activity**
Detailed Description	The detailed definition of test cases (including the identification of the steps to complete the test case) required to perform system tests is usually perceived by software developers as an unproductive task; many times, it is the same person who defines and executes system tests.
Solution proposed / applied	The solution proposed has two sides: ▪ The authors have successfully applied pre-filled templates, including information on the most common steps to be included in a test case definition. Moreover, all the test cases defined in the scope of the development and maintenance projects performed by the organization, was stored in a shared folder. In many cases, advanced information searching services are being used to take full advantage of this folder, ▪ It is necessary to quantify the cost reduction in the execution of regression tests when corrective maintenance projects are developed. This calculation can be performed by means of a small and easy exercise in each company. Moreover, depending on the organizational characteristics of the Software Intensive Organization, personnel rotation initiatives between the roles involved in the verification and validation processes can be applied, but only if skilled personnel is available.

Table 5: Factors related to the definition of an improved verification and validation process

E) Institutionalization of the improved verification and validation processes

The risks do not disappear when an improved verification and validation process, which is efficient and fulfills the organization expectations, is defined. Software engineers have to be provided with the required skills in order to use the defined process properly. Moreover, it is necessary to gain the support of everyone involved to prevent the non application of these types of activities when a project is delayed. These problems are described in Table 6.

FACTOR 9	
Statement	**The practice training of the software engineer in revisions, inspections and software test activities is insufficient.**
Detailed Description	One of the most important problems with proper software related reviews, inspections and test is that many users do not know or remember the theory that is essential for revision of the contents of an analysis or design or a reliable test of a function, type/class, module or software component.
Solution proposed / applied	Training provided to personnel for the execution of improved verification and validation process should not be centred on learning the use of a specific software tool. It must include refresher sessions on, or even introduce, fundamentals of functional and structural testing, checklist to perform technical (design and code) reviews performed in a formal way or between peers. The authors have applied continuous training programs with the following structure: ▪ First, a list of the required skills, related to the institutionalized verification and validation processes, is prepared. ▪ Then, personnel attend training sessions (≈ 20 – 30 hours) to learn how to follow the institutionalized verification and validation processes and the techniques to be used. ▪ Finally, short refresher sessions are planned, in order to reinforce the more problematic, or difficult to apply, issues in the institutionalized verification and validation processes
FACTOR 10	
Statement	**The project delays are proportional to the decrease in time and effort dedicated to verification and validation activities, especially testing activities.**
Detailed Description	Normally, when a software development project is delayed, project management usually decide to increase the programming time and decrease the testing time, assuming all probable and future costs derived from corrective maintenance activities. This phenomenon, besides having a negative impact on the company image, also reduces dramatically staff motivation.
Solution proposed / applied	The only solution to this problem is for senior management to meet their commitment to quality products and take all the corrective actions necessary for the proper verification and validation of software, renegotiating the delivery dates compatible with these commitment.

Table 6: Factors related to the definition of an improved verification and validation process

5 Conclusions

This paper has presented the benefits that the improvement of the verification and validation process may provide a software intensive organization, but this paper presents that there are few organizations which have reached the capability level to obtain all the expected benefits.

As a consequence, this paper presented 10 factors, identified by the authors of this paper, based on their experience in software process improvement programs, which impede the achievement of the previously mentioned benefits. Moreover, this paper presented solutions for solving the problems enumerated. These solutions are based on the authors' practical experience. The progressive solution of the problems related to the factors enumerated in this paper will permit an improvement program which incomes will be translated in the company account in terms of economical benefits, or in the increase of the quality of the developed products or the provision of an effective, efficient and friendly working environment.

In many cases, the solutions mark the beginning of research lines being carried out/developed by the Software Engineering Lab of the Computer Science Department at Carlos III University. These research lines are related to:

- Estimation methods to calculate the ROI expected from the execution of an improvement program centred on verification and validation processes.
- Cost and Effort Estimation methods required by an improvement program centered on verification and validation processes.
- Definition of resources and business models that permit small and medium software intensive organizations to share costs required to initiate an improvement project centered on software verification and validation processes.
- Definition of qualitative and quantitative models that permit the calculation of the added value of each improvement activity performed in the software verification and validation processes.
- Consideration of the impacts of even partially achieved higher maturity levels in small business environment.

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7 Author CVs

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Software Process Improvement in Small Companies: An Experience

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Abstract. Software small companies can make a big profit from the well-known Software Process Improvement Models. Key factors for succeeding in the application of a software improvement program are: a good model, the implication of the company staff and a good method. After developing an ISO/IEC 15504-based model adapted to small companies and a method for its implementation, in this article we summarize the real experience of the application of this method to eight software small companies in the Balearic Islands.

Keywords: Software process improvement, Small Companies, ISO/IEC 15504 (SPICE), ISO 9001:2000, Quality Management System

1 Introduction

Software Process Improvement programs have often been successfully applied to big organizations with high research and investment budgets. However, small companies usually do not have enough economical, temporal and human resources to afford the implementation of an improvement program [1, 2, 3].

To encourage the application of the existent quality standards on software small organizations, the adaptation of a reference model to the particular characteristics of this type of companies could be a point in favor. With this goal in mind we have developed a model for the implementation of a Quality Management System (QMS) for software small companies [4].

The model is an adaptation of the international standard ISO/IEC 15504 which leads the software improvement sector jointly with the Capability Maturity Model.

2 The Method

With the intention of demonstrating that our model was useful, during the year 2002 we contacted software small companies of our nearest environment to help them to start an improvement path. At that time, SPICE was not still released as a standard and, since companies were very interested not only in the improvement path but also in an ISO 9001 certification, we decided to analyze the compatibility of both standards and provided a method [5,6] which allows the implementation of a QMS compliant with the ISO 9001:2000. This method uses our SPICE-based model [4] to improve software processes.

The method covers all the activities for quality management in software small companies (see Table 1 “Summary of QMS activities”) and can be used as a reference framework to assess software processes. It follows the same structure as the Spanish public methodology, MÉTRICA V3, dividing its activities into tasks, and identifying input and output products.

Two different groups of activities are considered in the method.

2.1 QMS Implementation Activities

Once the company has decided to initiate an improvement path of its processes, the first group of activities is aimed at helping in the establishment of the QMS.

Firstly, it is necessary to define the QMS general parameters: the quality policy and the quality plan. At the beginning, it is very important to involve the organization staff in the continuous improvement. Staff motivation and specific education to the quality group in the company are essential activities to begin with in the implementation of the QMS.

Following on from the establishment of the QMS, activities are dedicated to assess and improve the company processes. To perform this task, a second group of activities provide guidance in the identification and analysis of the organization processes, as well as in the calculation of their capability. The objective is to help the company to identify and prioritize a set of processes to improve.

Finally, the method includes audit and improvement activities. This group of activities details all the necessary tasks to obtain the ISO 9001:2000 certification.

2.2 QMS Maintenance Activities

As a good QMS should bet on the continuous improvement, the model also considers a second group of activities which support the maintenance of the implemented system and the process improvement. These activities help the company to control the established improvement plan.

Table 1. Summary of QMS activities

Activity		Input products	Output products	Practices and Techniques	Participants
GC 1	*Establishment of the QMS general parameters*	Strategic plan Quality policy and goals Action plan	Quality policy and goals Quality plan Work standards	Work sessions Plan Cataloguing	Company staff Quality group Project managers
GC 2	*Education*	Quality management plan Quality plan Training material	Motivation course Training courses	Works sessions Presentations	Company staff Quality group Project managers
GC 3	*First SPICE assessment*	ISO/IEC 15504 processes and rating scale Quality plan Assessment Guide Assessment support tools	Assessment plan Companies assessment filled up SPICE assessment report	Plan Work sessions Calculation method	Quality group Project managers Company staff SPICE assessor
GC 4	*Process analysis and documentation*	ISO/IEC 12207 Quality Plan SPICE assessment report	Process catalogue	Work sessions Dataflow diagrams	Quality group
GC 5	*Process improvement*	SPICE assessment report Quality goals Quality plan ISO/IEC 12207 Process catalogue	Improvement plan Process catalogue (processes to improve) Implementation schedule Reviews record	Work sessions Technical reviews Presentations	Quality group Project managers Company staff
GC 6	*ISO*	Proposals from	Certification	Presentations	Company

Activity		Input products	Output products	Practices and Techniques	Partici-pants
	9001:2000 certification	official certification entities QMS Process catalogue	plan Audit report Non-conformities Corrective actions report Certificate	Work sessions Technical reviews	staff Quality group Certification group (external)
GC 7	*Second SPICE assessment*	Process catalogue (improved) Assessment guide Assessment support tools ISO/IEC 15504 processes and rating scale SPICE assessment report	Assessment plan Companies assessment filled up SPICE assessment report	Plan Work sessions Calculation method	Quality group Project managers Company staff SPICE assessor

3 The QuaSAR Project: A Real-case Application of the Model

Motivation on helping software companies of our environment to assess and improve their processes led us to initiate the QuaSAR (*Qualitat de Software baleAR*) project. This investigation project allowed us to study the position of the software companies in the Balearic Islands. The main goal of the project was the creation of a plan for software development businesses to help them to improve their software processes and to certificate against the ISO 9001:2000 standard.

3.1 Participants

Before starting the QuaSAR project, we contacted with the Quality Department of the IDI (*Institut d'Innovació Empresarial de les Illes Balears*), a public organism whose mission is to promote quality in Balearic organizations. This organism acted as coordinator and mediator among all parties taking part in the project.

Part of the success of QuaSAR was thanks to their participants, different entities with very distinct motivations. Besides the investigation group from the University, the project participants were the following:

- The IDI, the before-mentioned public organism, provided logistic support and managed all economical aspects including grant requests through projects financed by the local government.
- An association, GRUPSoftBALEAR, which joins all the enterprises, acted as the "spreading engine" of the best practises among its associates.
- Software development SME which wanted both an ISO 9001 certification and a software process improvement. In the beginning of the project, there were not any ISO 9001-certified software company in the Balearic Islands. QuaSAR was the perfect opportunity for eight software small companies (5-30 employees) to achieve their improvement objectives. These organizations are mainly oriented to the development of applications for the tourist sector which is very widespread in the Balearic economy. Among these companies there was also a public organization.
- A consulting firm with experience on ISO 9001 implementation on software development organizations provided support in the certification process.
- A group of award holders, computer engineering students form the *Universitat de les Illes Balears*, attending the last year or writing a final project about quality, helped the companies with the implementation of the QMS and also with the software process improvement.

3.2 Motivation and Training Phase

Activities at the beginning of the project were dedicated to initiate and involve companies in the continuous improvement. More concretely, activities taken in at this point are GC 1 *Establishment of the QMS general parameters* and GC 2 *Education*.

Each company set up a work group, a quality plan, quality objectives and a quality policy. They also had to identify the information systems that would be the purpose of the quality management.

Then, the training phase started. We considered necessary to motivate company employees and train quality managers and students on software life cycle processes and on the basis of the ISO/IEC 15504.

3.3 Assessment and Improvement Phase

Activities in the assessment and improvement phase are intended to assess and improve company processes, both at management level and software specific processes. At this point, the method proposes three activities: GC 3 *First SPICE assessment*, GC 4 *Process analysis and documentation* and GC 5 *Process Improvement*.

3.3.1 First SPICE Assessment

In order to determine the current position of each company and make the assessments that would be used as a basis to measure progress, the capability of the software lifecycle processes was calculated. To perform this action different work sessions with the companies were planned. The objective was gathering data about the state of all the processes at a global level.

As a result of this first assessment, a report on the state of all processes considered in the ISO/IEC 15504 was elaborated for each one of the assessed companies. These reports show the value and the capability level reached by each company. They also suggest improvement actions for performance indicators (capability 1) with a rating result of less than 50%.

Once the company weaknesses were identified it was possible to define improvement goals, the tasks to perform to reach them and also a plan with identified milestones. At this point, the total collaboration of each company was necessary both to show agreement with the obtained score and to prioritize the improvements to be introduced since it is not realistic to think that all improvements can be simultaneously tackled.

3.3.2 Prioritizing Processes to Improve

Taking the assessment report as a basis each company prioritised three processes for improvement. The coincidence among the eight companies was nearly full and the following five processes were selected for the improvement:

- Testing process. What the companies name in a generic manner “software testing” involves all tests performed during a software project, from unit tests to system tests once the software has been integrated with the hardware and during its maintenance.
- Configuration management process.
- Analysis and design processes.
- Project management process.
- Assessment and improvement process.

3.3.3 Process Analysis and Documentation

In accordance with the ISO 9001:2000, for the implementation of the QMS company processes need to be documented. Therefore, each company defined a process catalogue and a process matrix with a detailed description of the process. At the same time they were introducing short-term improvements in the process description. It is important to notice that this process descriptions would be the ones revised by the certification auditors. Although a process must not show intentions but realities, a company can not be successfully assessed if it does not have well-defined processes.

As certification is much related to process implementation, companies decided to start working in this sense. This implementation in the company real projects was the costliest part of the QuaSAR project.

3.3.4 Improving Processes

Due to time limitations it was considered convenient to focus the improvement on only three processes. Therefore, companies voted among the five processes previously considered. The results of this vote were the following:

1. The testing process. Seven of the eight companies were interested on improving this process.
2. The assessment and improvement process obtained 6 votes in favour.
3. The configuration management process was the third process to improve with 4 votes in favour.

Then, from the University three process improvement sessions were planned and carried out. The main goal of these sessions was to transmit to the companies the necessary knowledge for the improvement and also to offer a practical vision of the implementation of the processes: how other companies had done it, support software applications in the market, etc. Each company decided to assist or not to the different sessions that were conducted by professionals.

Therefore, at the same time the companies were implementing the ISO 9001, they were working on the process improvement. At this point, suggestions based on the SPICE assessment and also those stemmed form the improvement sessions done were especially useful. Companies redefined the processes to improve and established an action plan.

3.4 Improvement Audit

The last activities in the project were aimed to check the improvement in the company and to obtain the certification against the ISO 9001:2000 standard. Improvement audit activities proposed by the method are GC 6 *ISO 9001:2000 certification* and GC 7 *Second SPICE assessment*.

For the ISO 9001:2000 certification it was necessary to contract a certification entity. Different certification companies made their offers considering the special case of a service for eight companies. Then, software participating companies, by common consent, selected the certification entity that would certificate them.

All the software companies decided to pass a previous audit before the certification audit. In this previous audit usually the auditor revises the QMS documentation, audits a software project, and meets the company staff to introduce the audit team and also to check the involvement of the company staff, a requirement of the Normative. By doing this, the auditor checks if the company is prepared to pass the audit.

The result of this previous audit was satisfactory in the eight QuaSAR companies. The auditor only detected some non-conformities and gave the approval for the final audit. As the first audit is not considered as a formal one, the auditor could act as a consultant and propose some solutions to the detected problems.

3.4.1 ISO 9001:2000 Certification Audit

A certification audit against the ISO 9001:2000 checks the fulfilment of the Normative. Then, in subsequent maintenance audits it is not necessary to review all aspects. However, there are some points that must be verified in all audits, while the remaining points are only revised if the auditor considers it convenient. The first task to do in order to perform an audit is a planning. The auditor meets the quality manager of the company to establish the date to audit each point of the Normative and also to identify the company employees that will be affected.

In average, the audit was done in three days per company. Usually the duration of an audit is in direct proportion to the number of employees affected by the QMS.

The first audit day consisted in a meeting between the auditor and the quality manager to determine the schedule. This day the auditor also checked the fulfilment of the general requirements of the Normative and also if the staff had carried out with the implementation of the QMS.

During the second day, the auditor revised five company projects. These projects were selected form the different company departments. For each project, the auditor interviewed the project manager to check those aspects that would demonstrate that some products had been realised in accord with the Normative. More concretely the following aspects were revised:

- Project requirements. The auditor checked if requirements were well specified and also if requirements changes had been controlled.
- Project management and configuration management processes.
- Requirements verification.

Finally, during the last audit day, the auditor concentrated his work on the assessment and improvement aspects. Firstly, he revised customer satisfaction using questionnaires. He also analysed the improvement actions the company had considered. During this day, the auditor also drew up an audit report and proceeded to read it in a meeting with the company staff and quality managers. The result, in general, was very satisfactory. The auditor only detected some minor non-conformities among the different departments of the audited companies.

Once the audit had finished and the report had been delivered, the certification company gave a two-month term to the companies to make the proposed changes and to send a report of performed actions. In this report, each company had to inform about taken actions to solve the detected non-conformities. In case of serious non-conformities, this report must include all the necessary documents to prove that they have been corrected.

To finish with the certification process, software companies solved all detected non-conformities and delivered the necessary documentation to the certification entity. Then, the certification committee analysed the reports. Finally, all QuaSAR companies were awarded with the ISO 9001:2000 certification.

3.5 End Results

Once the QuaSAR project has finished the results of the SPICE assessment in the eight participant companies can be analysed. In this section, some conclusions about the maturity level of the assessed processes are presented.

Some processes have reached a score greater than 85%. In accordance with SPICE this means that these processes would be candidates for a level 2 assessment (see Table 2 “Candidates for a Level 2 SPICE assessment”). As the evaluation guidance used in the first SPICE assessment only facilitates the computation of the capability level 1, we decide to postpone the evaluation of the next capability levels to the second assessment.

Table 2. Candidates for a Level 2 SPICE assessment

Company processes		E1	E2	E3	E4	E5
CUS.1.1	*Acquisition preparation process*				X	X
CUS.1.2	*Supplier Selection process*					X
CUS.1.4	*Customer Acceptance process*	X				
CUS.2	*Supply process*		X	X		X
CUS.3	*Requirements Elicitation process*	X				X
ENG.1.1	*System requirements analysis and design process*					X
ENG.1.2	*Software requirements and analysis process*					X
ENG.2	*System and software maintenance process*					X
SUP.1	*Documentation process*					X
SUP.2	*Configuration Management process*					X

The two processes with greater score were the *Supply process* and the *Requirements Elicitation process* (see Figure 1 “Score average”). The purpose of the first one is to provide software to the customer that meets the agreed requirements. The purpose of the requirements process is to gather, process, and track evolving customer needs and requirements throughout the life of the software product and/or service so as to establish a requirements baseline that serves as the basis for defining the needed software work. Since the main goal of any enterprise is customer satisfaction, it is not strange that these processes, which directly involve the customer, were considered essential and, as a consequence obtained greater ratings in respect of the other processes.

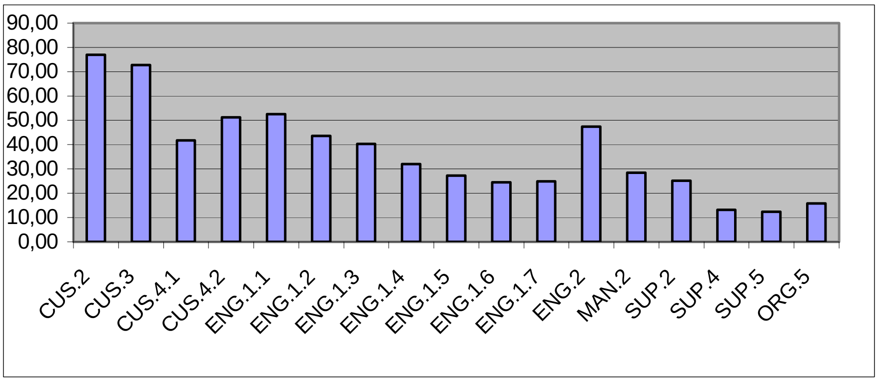

Fig. 1. Score average

3.6 Benefits

The QuaSAR project has been successful for all participating companies and all the initial objectives have been fulfilled:

- Software companies have implemented a QMS and have been awarded with the ISO 9001:2000 certification. This fact has resulted on a short-term improvement of some of their processes, as well as on the identification and planning of future improvements.
- The *Institut d'Innovació Empresarial de les Illes Balears* has met its goal by promoting quality in the specific sector of software development, starting a first experience we hope it will be used as a model for future collaborations.
- The consulting firm has taking part in an innovative project in Spain and has opened up market on the Islands.
- Students had the opportunity of learning about quality management and living the business reality. Some of them have continued working as employees in the company.
- From the UIB, investigation has been applied to a real case. It has been very useful in order to polish the results and adapt them to the reality of the small companies.

As it was expected, from the detailed analysis of the ISO 9001:2000 and the ISO/IEC 15504, it can be confirmed that a good capability level of the lifecycle processes facilitates, in all senses, the implementation of a QMS compliant with the ISO 9001:2000.

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Improving Software Delivery through Early Involvement of Testers

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Abstract

Software Process Improvement (SPI) initiatives in large commercial banking organisations are often constrained by the control mechanisms implemented by the organisation to protect it from financial loss. As such, any changes to the software development process must maintain the required level of independent quality control. However, commercial pressures from customers and competition dictate that high quality software systems are delivered within shorter timeframes. In order to meet these increasing demands, whilst maintaining the desired level of quality, one option is for organisations to make more effective use of the Quality Assurance (QA) team during the software development process. This paper reports on current research which is examining the impact on software delivery of involving testers earlier in the development lifecycle.

Keywords

Software Process Improvement, Testing, Methodology, Project Management, Action Research

1 Introduction

More recent collaborative software development approaches such as agile methods advocate “working” software as the primary measure and encourage developers and business people to work together to ensure that what is being delivered will add business value. There is however little or no mention of the traditional QA function as quality is assumed to be “built in” through practices like test first development, pair programming and continuous integration [1]. However, some authors [2,3,4] believe that programmers cast a less than critical eye on their own work or that psychologically, they do not want to ‘destroy’ their own work and as such are not best placed to provide assurance over code that they have developed.

Due to nature of the business, with many of its software systems supporting high volumes of financial transactions, Halifax Bank of Scotland (HBOS) still maintain an in-house QA function to provide quality assurance independent of the development team. This is seen as an essential control mechanism in the delivery of software projects and as such any software process improvement must fit within this model. As with traditional waterfall-based software development processes however, this independent QA team do not typically get involved until late in the lifecycle, usually after functional specifications have been completed and build is well underway or even complete. Subsequently, the focus is on detection of defects as part of a post build phase. The term defect can take on different meanings in different contexts depending on the success criteria of the actual quality assurance activities. For the purposes of this study, a defect refers to a scenario in which the application does not conform to its functional and/or technical specification. The activity of identifying the presence of these defects is referred to as System Testing. This paper outlines ongoing research examining how the eCommerce team within HBOS proposes to improve its software delivery by involving its independent QA team earlier in the development process.

The paper is structured as follows. Section 2 details the existing process and associated constraints. Section 3 describes the proposed changes to the existing process and the implementation approach being taken. Section 4 contains a discussion on perceived benefits of making the changes and finally section 5 provides a brief concluding summary of the paper.

2 Background

The software team involved in this research is part of a major UK bank and is responsible for the development of eCommerce applications supporting customer servicing requirements identified by each of the bank's business divisions. The team was established in 2001 but has now grown to more than sixty people including one of the authors. They have successfully delivered a number of large projects since their inception and as such believe that they are doing some things well and should continue with or enhance these practices. Each project attempts to learn from previous projects by carrying out end of project reviews and determining changes required to working conventions for the next project. All team members come from a technical background but focus on one of analysis, development, testing or project management disciplines.

2.1 Current Software Development Process

The diagram in Figure 1 illustrates the current process followed by the development team.

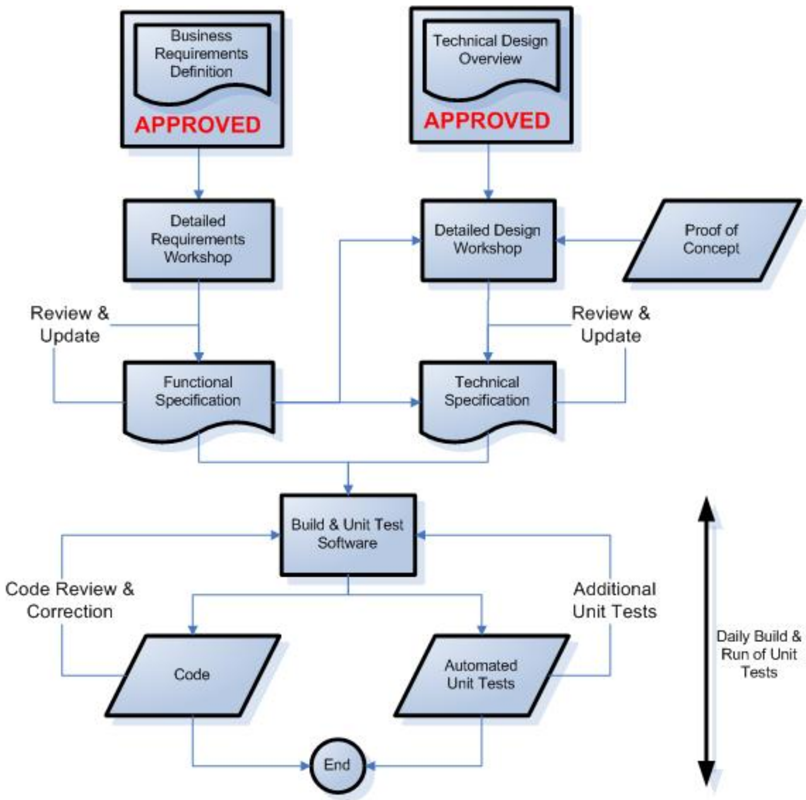

Figure 1: Current development process

The flows represent a typical iteration which involves taking a functional area (or cluster of use cases) and developing all the artefacts associated with that functional area, from specifications through to code and unit tests. Note that multiple iterations can be run in parallel.

The current approach to testing is based on the traditional V-Model [5] which, although by definition does not rule out early involvement of the QA team, the implementation of the model typically leads to a "phased" testing model as described by Gelperin and Hetzel [6] which focuses on test execution as the primary testing activity and views (system) testing as a separate lifecycle phase. The testing process is currently not iterative or incremental and system test execution only commences when the entire application is available to test.

2.2 Constraints of the Current Process

Whilst the current process has been in place for a number of years and is well understood, project retrospectives [7] have identified a number of constraints or areas which could be improved. A key observation was that the developers and testers work primarily as separate teams, joining up during system test execution when both teams have the common objective of getting an application production-ready. Table 1 categorises and describes the identified constraints as well as listing the impact of each.

Table 1: Constraints of the current process

Constraint Type	Constraint	Impact
Requirements Stability	The Requirements Definitions along with Functional and Technical Specifications must be 'signed-off' before the process of defining test conditions can commence.	No opportunity for the QA team to influence the specifications in terms of testability or completeness.
		The QA team are playing catch-up as all other project members have a good understanding of the project by the time the QA team join the project.
Requirements Interpretation	Development and testing teams may adopt different interpretations of a requirement of specification.	Misunderstandings or ambiguities are not detected until defects are raised during system test execution.
		Conflict between QA and development teams during system test execution.
Technical Complexity	The QA team may not comprehend the level of technical complexity associated with a particular piece of functionality.	Testing is not focussed on the areas with the greatest risk.
Waterfall Model	System testing execution is a single phase carried out after the complete application has been built.	All testing is on critical path and there is no early independent assessment of quality.

3 Proposed SPI Initiative

Figure 2 illustrates the proposed changes to the process, by integrating the QA team into the iterative process adopted by the development team. It is proposed that integration will be achieved by the introduction of a number of review points (A-D) as shown in the diagram.

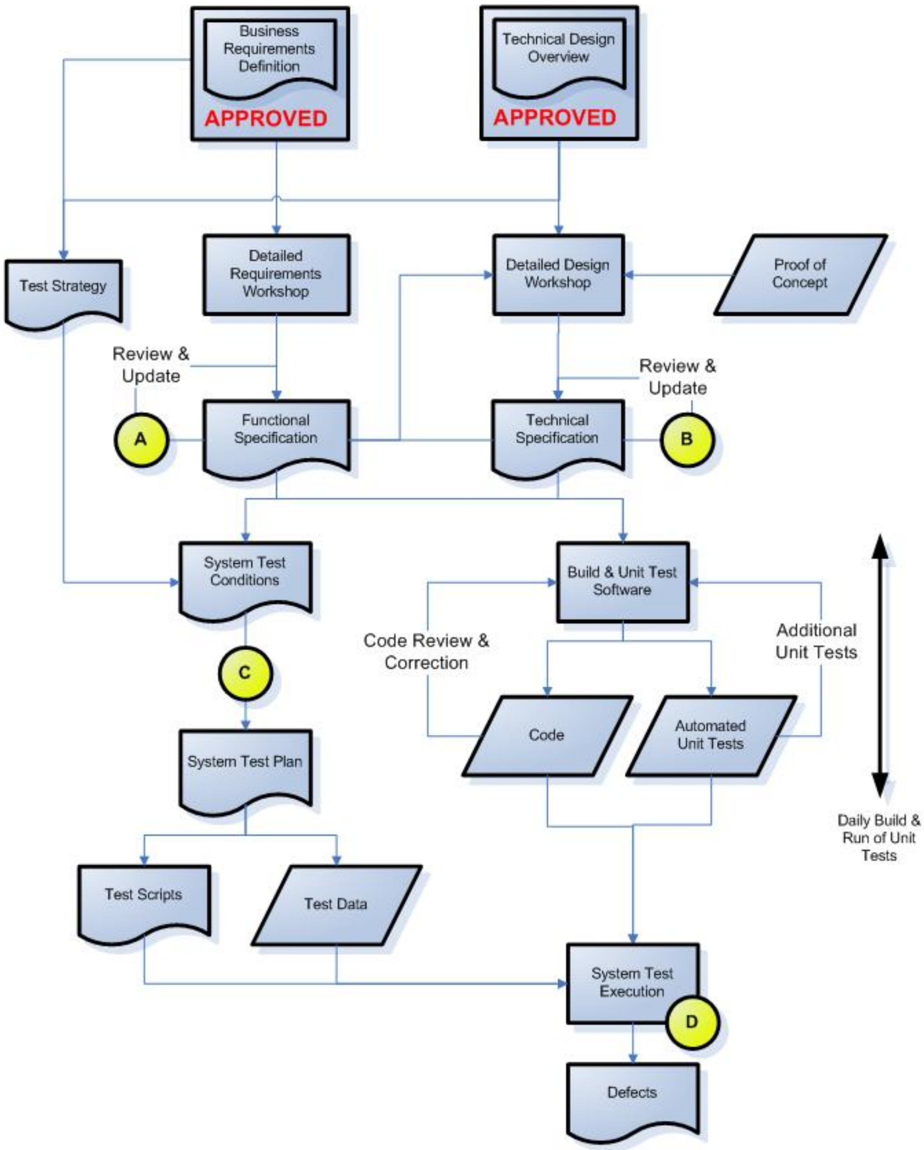

Figure 2: Proposed Collaborative Process

Review points A and B refer to the evaluation of the Functional and Technical Specifications respectively by the QA team before they are baselined. Review point C refers to the evaluation by the development team of the test conditions and scenarios produced by the QA team. Finally, review point D refers to "mission" based testing which focuses on exploring the parts of the application which have already been developed. This is achieved by analysing the application in greater detail which is not possible from written specifications and enhances overall application knowledge. The iteration testing therefore has a specific set of objectives or mission, which is not necessarily to execute all documented test conditions.

3.1 Implementation Approach

The implementation of these changes will be achieved by building the new review points into the project quality plan and giving the development and test team leaders responsibility for ensuring these are incorporated into the schedule. The changes are being made on one project initially and the experience with the new review points will be analysed at the end of the system testing phase of this pilot project. The changes to the process have been agreed with the project team and the project is currently being run using the refined approach. The development and test teams were participants in the post implementation reviews from previous projects which helped identify the constraints detailed previously. This is an important part of the software process improvement as it helps to get "buy-in" and commitment from the individuals who will ultimately have responsibility for making the changes. This commitment is based on the belief by the individuals that these changes will make things better, thus creating a willingness to try out the revised working conventions.

Tom DeMarco, a consultant and metrics expert, has said "if you don't measure, then you're left with only one reason to believe you are still in control: hysterical optimism" [8]. We must be able to use data that is readily available from previous projects if we want to be able to assess the impact either positive or negative of the proposed changes. The research to date has gathered system test defect data as well as effort data from a number of projects previously delivered using the approach outlined in Section 2. The following key characteristics of these projects are sufficiently similar to be able analyse the metrics together.

- Development Team – many of the same team have worked on most or all of the projects
- Test (QA) Team – many of the same team have worked on most or all of the projects
- Technology – the technology and platform is similar in all projects
- Customer – All projects were delivered for the same organisational division

The primary variables on the different projects were therefore effort and number of defects. As such, the metrics outlined in Table 2 will be collated and analysed during this study both for historical projects, in order to get a baseline, and for current/future projects after the proposed changes have been introduced.

Table 2: Project Effort and Defect Metrics

Metric	Description	Source
Test Execution Effort	Number of days effort expended by the QA team on execution of previously defined test scripts.	Time Recording System – time booked against Test Execution tasks.
Development Support Effort	Number of days effort expended by the development team on defect investigation and resolution during the System Test period.	Time Recording System – time booked against Testing Support tasks.
System Test Defects	Number of defects identified during the System Test phase along with an indicator determining if the defect was rejected by the development team. A rejected defect suggests that there is a different understanding between development and QA team on what the requirement is.	Test Management tool – count of defects recorded with "System Test" in the "Phase Detected" field.
Development Effort	Number of days effort expended by the development team on design and build, up to release of the software to System Test.	Time Recording System – time booked against Design & Build tasks.

Whilst the study is focusing on test execution metrics and development team effort associated with supporting this test execution, application design and build effort is included in order to give an indication of size and complexity for each project and to enable relative comparisons.

The reliability of this data depends on the accuracy with which it is recorded and there is a heavy reliance on individuals to appropriately record effort and defect data in the respective time recording and defect management tools. All timesheets are authorised by the project manager providing an opportunity to challenge and correct incorrect entries. Similarly, all defects are reviewed by the project manager providing an opportunity to review details before assigning to developers for resolution.

The organisation currently records the number of Severity 1 and 2 defects detected in production in the month following implementation. Severity 1 and 2 defects are defined as those which result in significant loss of service to multiple customers or any kind of financial loss. Analysis of these metrics has indicated that the existing pre-release testing is effective resulting in acceptable post release quality. As such, the changes being proposed as part of this research are not trying to change the current end result of pre-release testing and are instead concerned with how that end result is achieved.

4 Discussion

Our belief in carrying out this study is that earlier and more frequent inspection of specifications (both functional and technical) and working code by the QA team, as well as developer review of test conditions, will result in improved software delivery. We anticipate that improved delivery will be evidenced through realising a number of benefits.

4.1 Increased Developer/Tester Understanding

This approach is consistent with Lifecycle Testing Models [6], which views testing as a parallel track affecting software requirements and designs, strongly interacting with development activities from the beginning of a project. It is expected that the introduction of these changes will result in an increased shared understanding between development and test teams and a qualitative approach will be used to assess this. Development and QA personnel who have been involved in projects before and after changes have been implemented will be interviewed by the researcher, with questions grouped in relation to the constraints identified in Table 1. One metric that will be considered, but not in isolation, is the number of defects rejected, as this indicates that there is not a common understanding between development and QA teams in relation to specific requirements.

4.2 Earlier Defect Detection

Whilst the number of overall cumulative defects discovered by the QA team during System Testing may not necessarily decrease with the introduction of the changes, the timing of the detection of defects in relation to application build will change. This will be evident by analysing the date which defects were detected in relation to the application build timeline.

4.3 Reduced Testing Support Effort

The principle of Defect Cost Increase (DCI) [1] claims that the sooner you find a defect, the cheaper it is to fix and as such any approach which puts testing at the end of the process will be expensive. This is supported by other evidence, including a study of US defence contractors [9]. Given that, test execution and defect identification will now happen earlier in the process, the literature related to the principle of DCI provides evidence that defect repair costs will be reduced. We also believe that some of the defects that will be found in the testing of the initial incremental releases could be classified as fundamental and will actually result in avoidance of similar defects in subsequent increments. If it takes less time to fix defects and/or there are fewer defects (as a result of avoidance) then there will be less effort required from developers on testing support activities. One potential issue is that the development team are busy delivering the next increment and do not have sufficient time to diagnose and resolve the defects that are being raised against the previous increment. Ideally, development resource would be allocated to provide dedicated testing support for each release, but this could result in inefficient use of development resource. The development and test team leaders will work together to understand the nature of each defect that is raised, determining the appropriate priority. This means that if a defect is holding up a significant number of test scripts being executed, or if it represents a "fundamental" defect, then it will be assigned to a developer for immediate resolution.

4.4 Improved Resource Management

With the current approach, there are often resource "spikes" during system test execution in order to meet target implementation dates. These are as a result of delays in completion of the build in addition to a large numbers of defects in the early parts of the system test phase given that it is the first time the code has been exposed to any kind of independent testing. Based on the net effect of each of the previously detailed benefits, we believe that the approach outlined in this paper will enable improved scheduling of both QA and development resources on test execution and testing support activities. From early in the software development process (after release of each increment), there will be an accurate assessment of software quality available, providing an understanding of what to expect on the subsequent and final increments. Analysis of the resource profile (effort against time) across projects before and after introduction of the changes, looking specifically at the QA and Development team effort during the test execution phase, will provide evidence as to the realisation of this benefit.

4.5 Reduced Time To Market

By the time the development team complete the build of all required functionality, the QA team will already have had an opportunity to execute some level of testing on the functionality delivered in each increment except the last one. As such, it is anticipated that a certain percentage of the defects will have already been detected and resolved, resulting in a higher quality application entering the final system test phase. If this is true, then it is expected that the effort and elapsed time required to execute this final system test phase will be less than with the current waterfall-type approach. One important factor to consider is how much new or changed code is in the final release from the development team as this will have a significant impact on residual effort required. In order to manage this, the release cycles are being restricted such that there will be no more than four weeks between releases to the QA team. If releases are too frequent however, the QA team may spend an excessive amount of time "shaking down" releases as opposed to testing new or amended functionality. It is also important that the QA team understand what is available to test in each release and this will be managed through detailed release notes and release meetings between development and QA team leaders. We plan to use the test execution and testing support effort data as well as elapsed time across projects, before and after introduction of the changes, to determine realisation of this benefit. This is the most important benefit from a business perspective as it may result in a shortened critical path and a reduced time to market for software releases.

5 Conclusion

The challenges in introducing Software Process Improvement (SPI) into a commercial banking organisation are many and varied. This research is looking at a how a simple but fundamental change to the working conventions could have a positive impact on team collaboration and resource management, in addition to achieving potentially significant benefits of reduced cost and quicker time to market for software releases.

The changes are currently being implemented on a specific project and on completion of that project we will carry out analysis of the results. Based on this analysis, the working conventions may be revised further before rolling out this SPI initiative across the organisation.

6 Literature

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7 Author CVs

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Fergal graduated from the University of Ulster at Coleraine with a BSc Hons in Computing. He currently works as a Project Manager in the Halifax Bank of Scotland (HBOS) eCommerce Centre of Excellence where he has responsibility for delivery of internet based software applications supporting HBOS customers. Fergal is currently pursuing his Masters by research part-time in the area of Software Process Improvement.

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SPI from the Customers View

- Experiences from an EUR 6 Mio Tender –

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Abstract. Since 1986, the start of the CMM project, the software industry faces a more than 20 years discussion about process maturity. Does this mean that a customer can trust in the capability of his suppliers? During the RFI of a EUR 6 Mio tender the customer agreed to set up some criteria related to process maturity. The result is disillusioning. Common models like ISO 15504 (SPICE) or CMMi are unknown to about 50% of the suppliers in the market. Even if there are some processes and some procedure models (i.e. RuP) in place, most of the suppliers failed when asked to concretize their model relating to the tendered project. The same problem raises up, when suppliers where asked to describe how their SDE supports their procedure model. This paper addresses some areas with an ongoing and substantial improvement during the last 20 years and describes a lot of work still to be done. The basic data result from a tender with 12 bidders, some big companies and some sme.. As a result of this tender companies should invest more in knowledge and culture, less in paper ware and companies should improve the knowledge of their sales people.

The Study

This study is a post mortem analysis of a Tender. A logistic company, situated in northern Germany is running a project to modernize its IT infrastructure. This Project is divided in several parts of which each has been tendered separately. The author worked as external procurement expert in one of this tenders. While the business requirements where clearly stated and easy to understand, critical issues rose with nonfunctional aspects like availability, performance and maintainability. Because of this the bidders where asked to describe their solution in terms of ISO 9126.

At the other hand the project was extreme time critical, so the ability of the bidder to run projects and processes was crucial. As a result of this analysis a catalogue of criteria was derived from ISO 9126, ISO 15504 (SPICE) and some aspects of methods procedure models and defining, assembling and usage of SDE.

Knowing that marketing and sales departments normally have standard text parts where they describe a proper façade of process maturity bidders where asked to describe how their process model fits to the challenges of the project. The aim of these questions where to distinct between marketing and real capability.

The whole catalogue was divided in 2 parts one small part with basic questions used in the RFI and a greater catalogue with more elaborated questions used in the RFP. Goal was to find the best bidder with the best solution for the technical and project issues.

The catalogue was not derived to support research purposes but the results –in the opinion of the author- create a flashlight on the real improvement of process maturity in the IT market. So this study is an ex post analysis of this tender.

The Underlying Tender: Aspects of Process Maturity and Product Quality

The tender team developed a criteria catalogue. Each criteria was represented by an open question tp prevent simple yes/no answers.
Each criterion was weighted due to its relevance for the project success. The weight of these criteria is not in the focus of this study because it compares the bidders by each criterion.
It was predefined that the answers where rated by a simple scale depending if thy where not, partially, largely or fully satisfying the expectations of the tender team.
There where several aspects of process maturity and product quality in the criteria catalogues all criteria addressed process existence which means that there where no criteria to address SPICE or CMMi Level 2 or higher. The bidders where asked to give short and concrete answers. The following analysis concentrates on the most interesting aspects of the catalogue as there are:

- Used procedure model (V-Model, XP, RuP …)
- Usage of the model in the project
- Support of the model by an adequate SDE
- Quality management
- Project management
- Risk Management
- Test in general
- Regression test
- Support of the test process by an adequate STE
- Requirements Management
- Configuration Management
- Tool support for configuration management
- Ability to integrate the tendered project into the whole project (Support of organizational, technical and management interfaces)
- Experience with ISO15504 / CMMI
- Certification of staff.

There where additional questions in which the bidders where asked to transfer their general knowledge of procedure and process models into the context of the bid. The procurement team wanted to proof the ability of the bidders to handle the pitfalls of the project.
There where other criteria which addressed more commercial aspects but these questions are not in the scope of this paper.

The Analysis of the Results and the Creation of the Database

During the analysis of the bids the results where stored in a database which contained

- The Bidder
- The Criteria
- The analysis result in terms of
    - An unambiguous rating of fulfillment
        - Fully
        - Largely
        - Partially
        - Not
    - A clear reason for the rating

This database allowed to analyze the data and to group the bidders for each analyzed criteria to the rating of fulfillment.

Theses work allows now to calculate the percentage of each rating(F,L,P,N) for each criteria (i.E Criteria = Project Planning Result = {F=20% ; L = 33 % P = 42% N = 5%})

To have a better understanding of the data the bidders where departed into big companies and SME's. This allows to analyze if the process maturity of SME is (or is not) different from big bidders.

The results in general

As a result of these analysis several lacks where identified each of these lacks creates –in a midterm sight- a risk for the ability of the German software industry to compete with near- and offshore companies.

- Lack of ability to distinguish between product and process characteristics and to provide answers valid in the product or process context of a question.
- Lack of ability to transfer theoretical process knowledge to recommendations for practical project pitfalls
- Lack of quality culture (may be that there is a quality culture in the technical teams but this culture did not really reach management and sales people)
- A lack of attention to cost and project performance
- A lack of attention to test which means not only unit, functional or non functional (i. e. performance) testing but also the ability to create testable and especially regression testable software.
- An overkill in the usage of standard text parts
- A lack of process procedure and product integration.

As a further result it could be said that SME urgently need an adequate model for process maturity with an international accepted process model easy enough to create first substantial progress to process maturity product quality and project efficiency. And they need a measurement framework delivering a plausible roadmap able to support planning of focused investments. May be that the CETIC Micro Evaluation Framework is a starting point for a suitable approach [Laporte 2005] or an enhanced tapestry approach [Kuvaja 1999].

As far as big companies failed to meet the expectations, the question is: "why is a level 5 company not able to answer even simple questions". One possible assumption is that process capability or organizational maturity is a matter of some showcases but not a matter of culture. It might be that tenders are mainly processed by sales people using standard text parts without deeper knowledge about their meaning.

The results in detail

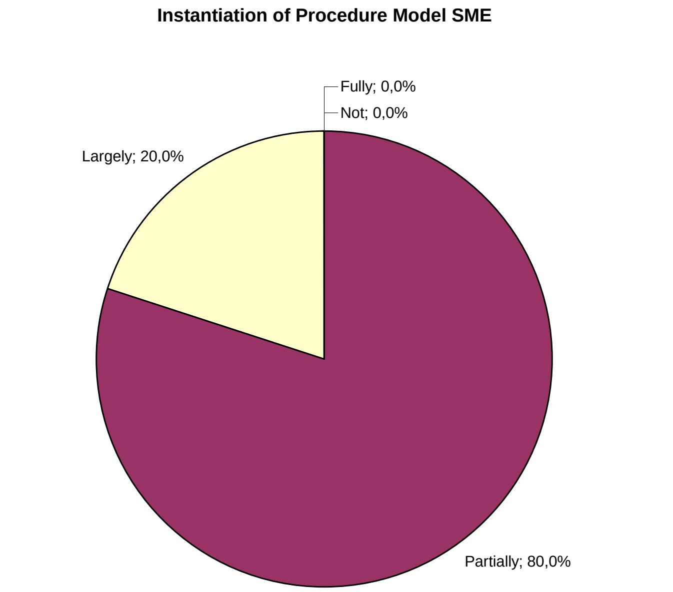
In the following section some detailed results are provided:

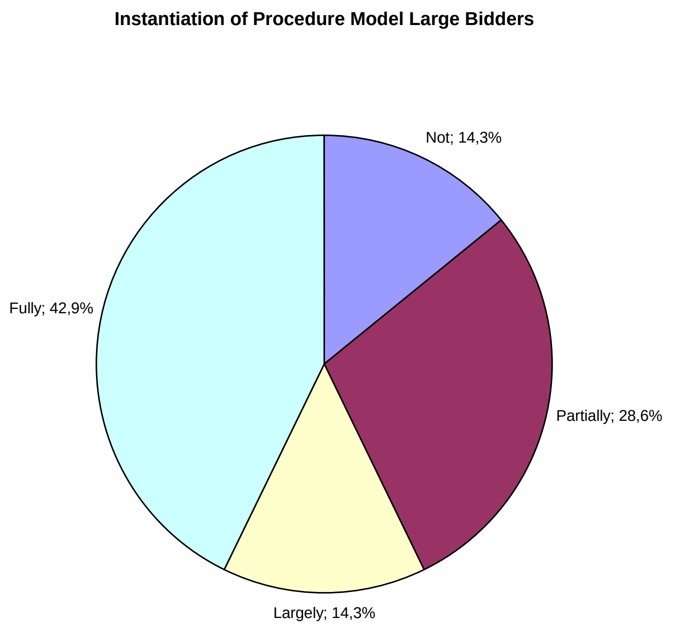
Used procedure model (V-Model, XP, RuP …)

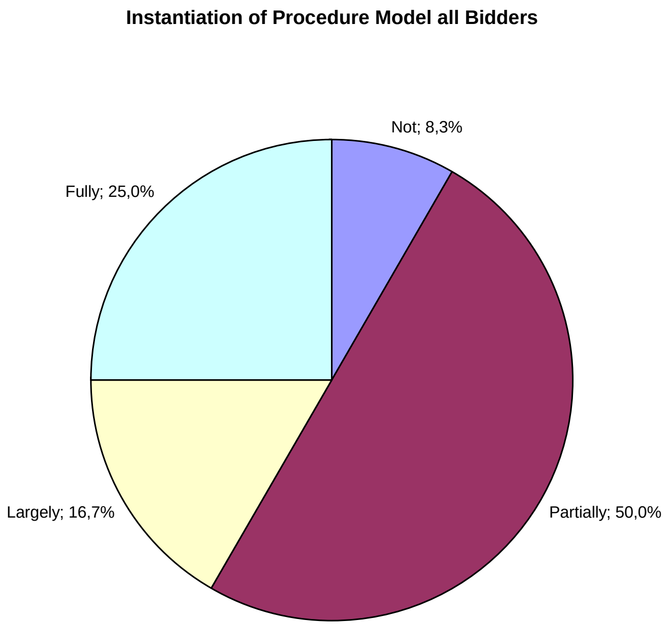
Most of the bidders have a procedure model in place

Usage of the model in the project

Many bidders are not able to instantiate their procedure model for a concrete project context


Instantiation of Procedure Model SME
Fully; 0,0%
Not; 0,0%
Largely; 20,0%
Partially; 80,0%

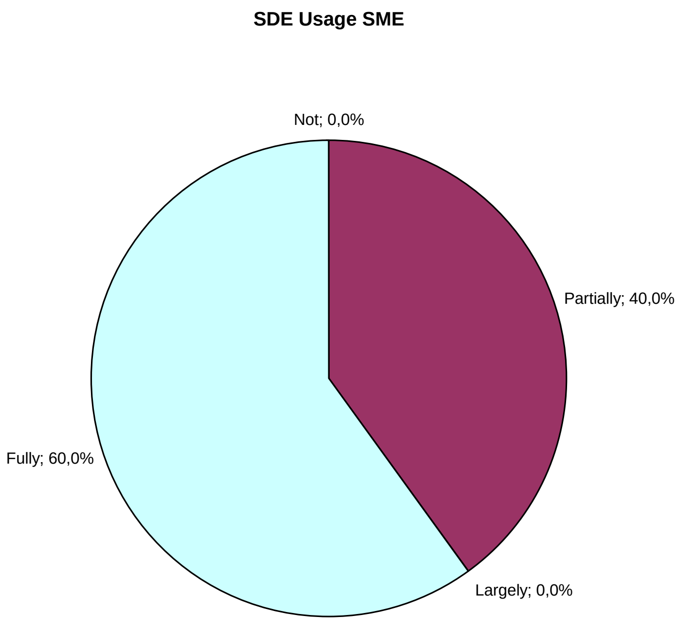

Instantiation of Procedure Model Large Bidders
Not; 14,3%
Fully; 42,9%
Partially; 28,6%
Largely; 14,3%

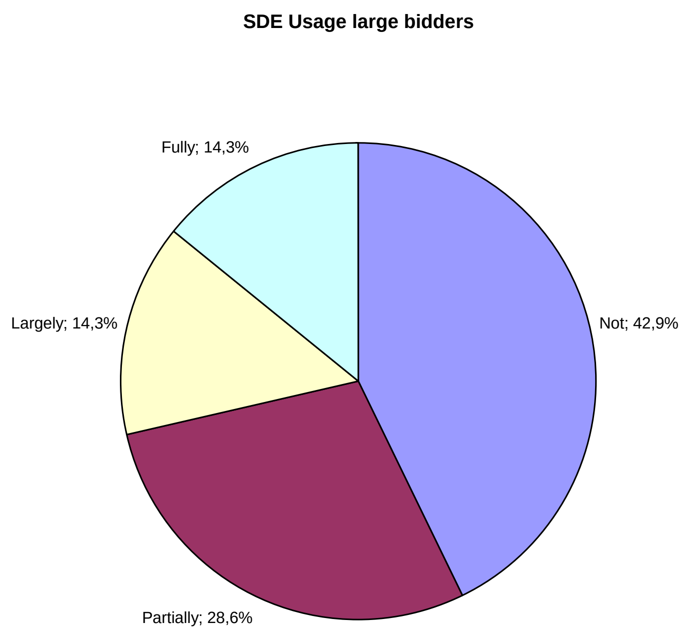


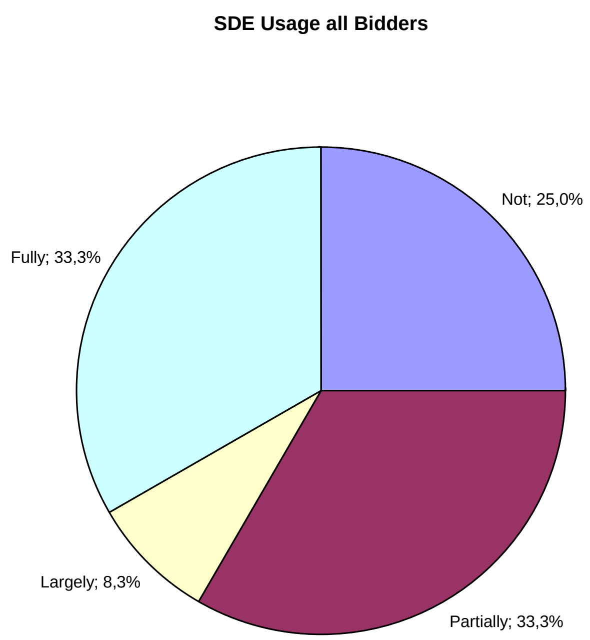
This means that procedure models are not part of the company culture. This creates a risk for the customer side. If a supplier is not able his procedure model properly there might be no adequate response to the main project challenges.

Support of the model by an adequate SDE

Most of the bidders were not able to explain how their SDE supports their procedure model.



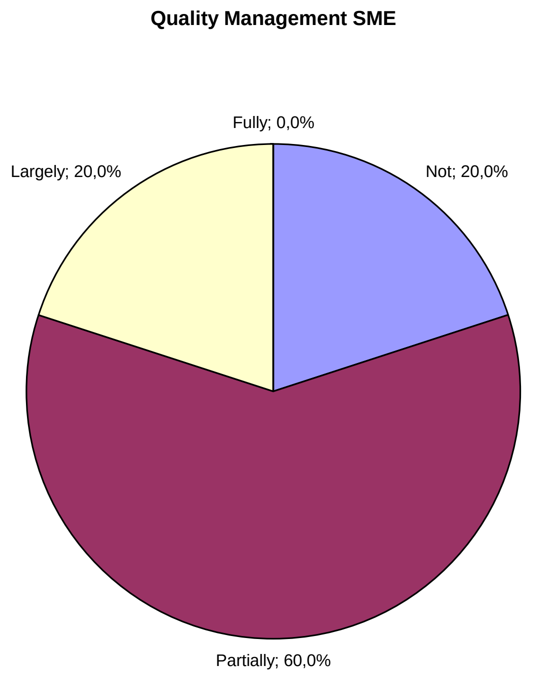


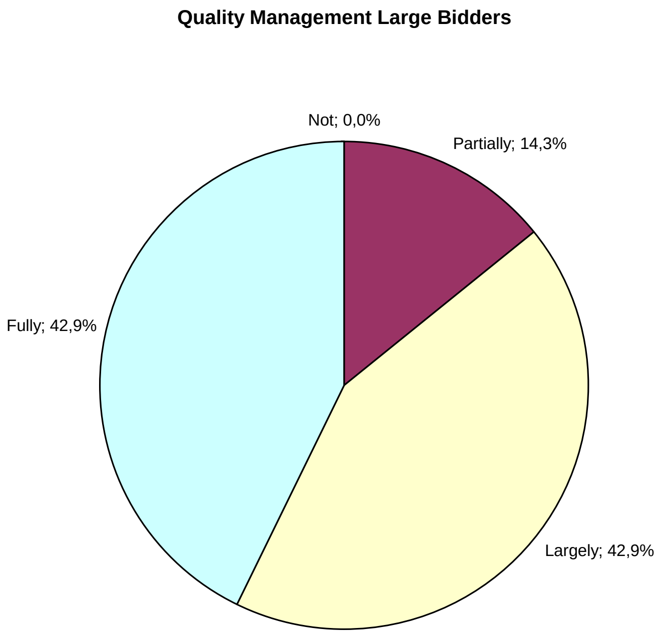


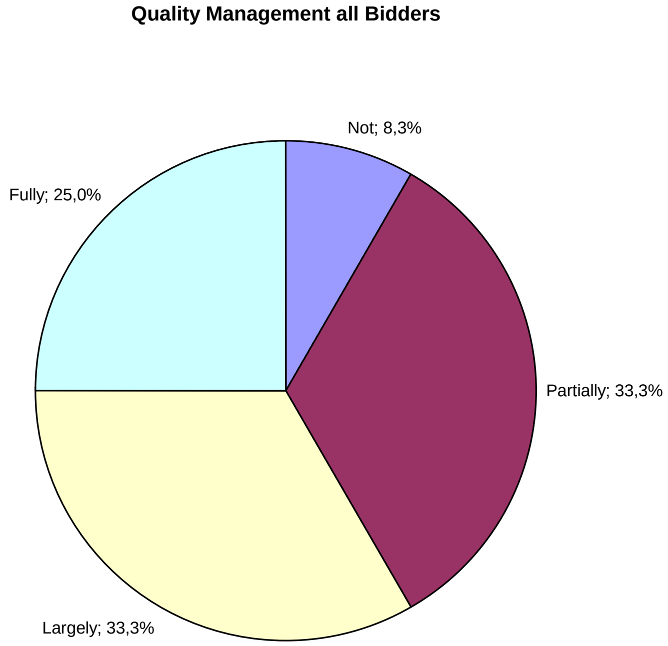
From a customer perspective it is unsatisfactory that a supplier don't know how to his SDE to support his procedure model. If SDE and procedure model are not consistent, cost might rise and additional risk might occur.

Quality management

Many bidders had a quality management in place but the benefits of these processes where not clear.


Quality Management SME
Fully; 0,0%
Largely; 20,0%
Not; 20,0%
Partially; 60,0%

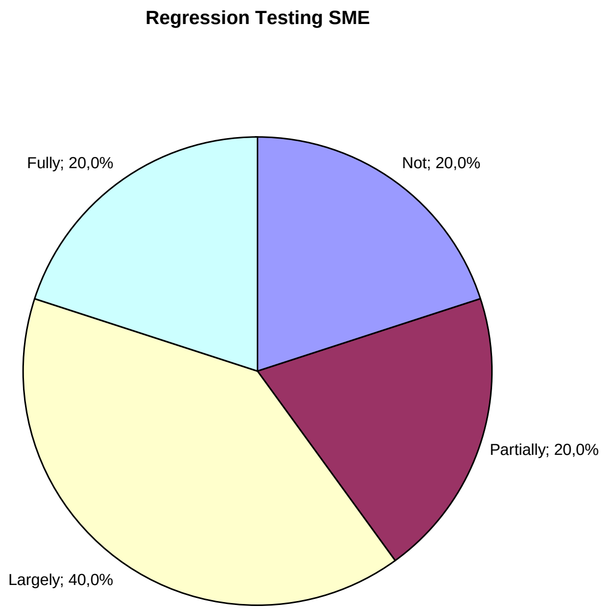

Quality Management Large Bidders
Not; 0,0%
Partially; 14,3%
Fully; 42,9%
Largely; 42,9%

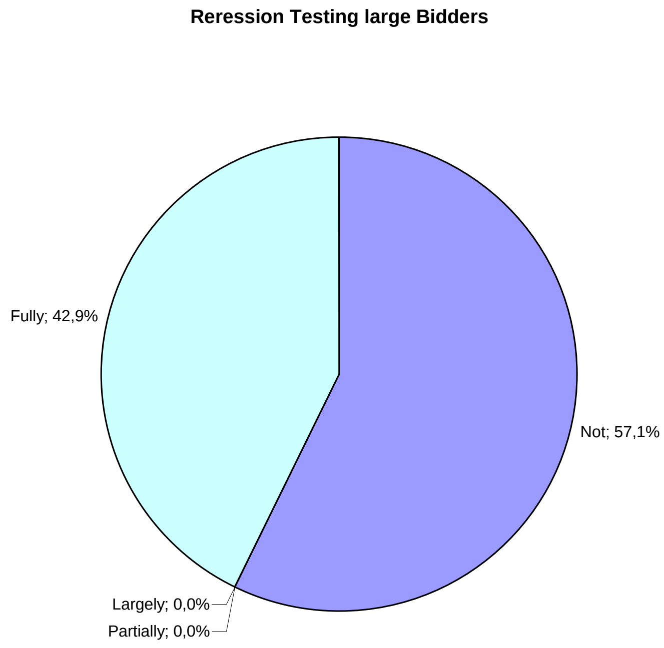


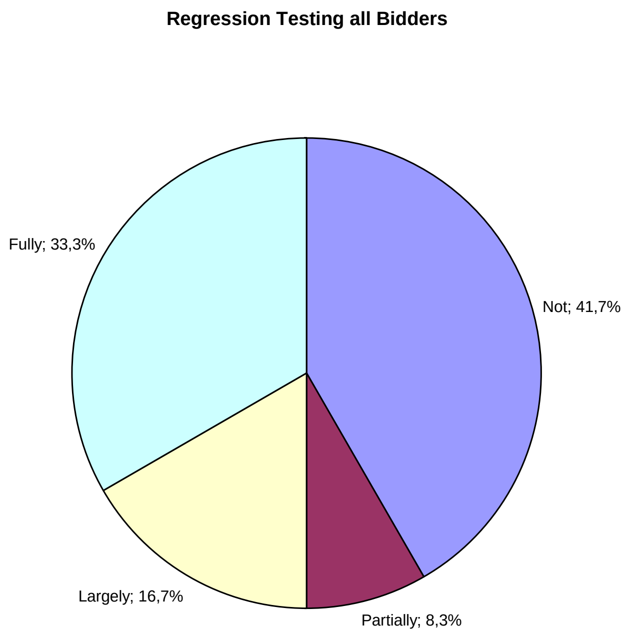
A customer normally can expect that a bidder is able to explain his quality management, its responses to the project challenges and its benefits for the intended project.

Regression test

Most of the bidders have neither an idea of regression testing nor an idea of the iso 9126 quality goal "Testability"



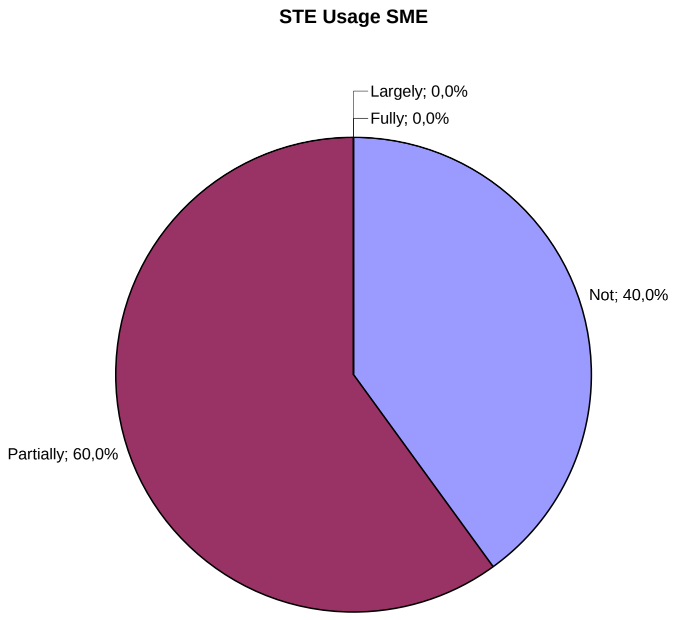


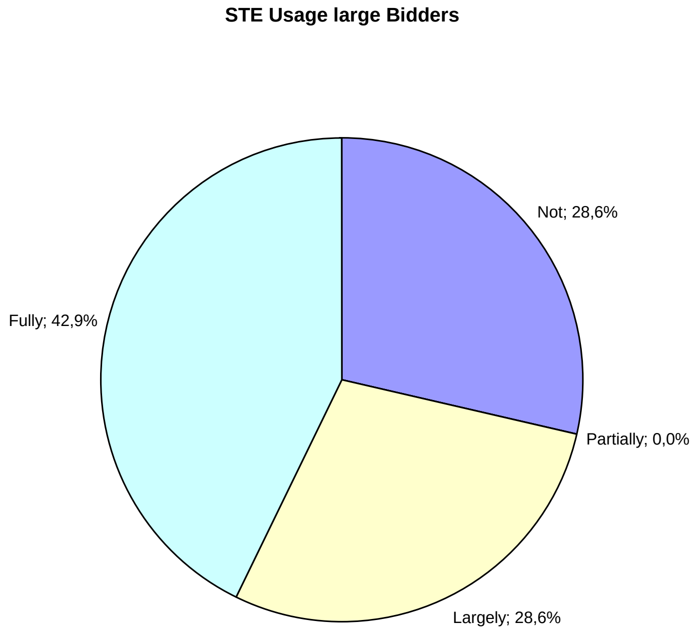


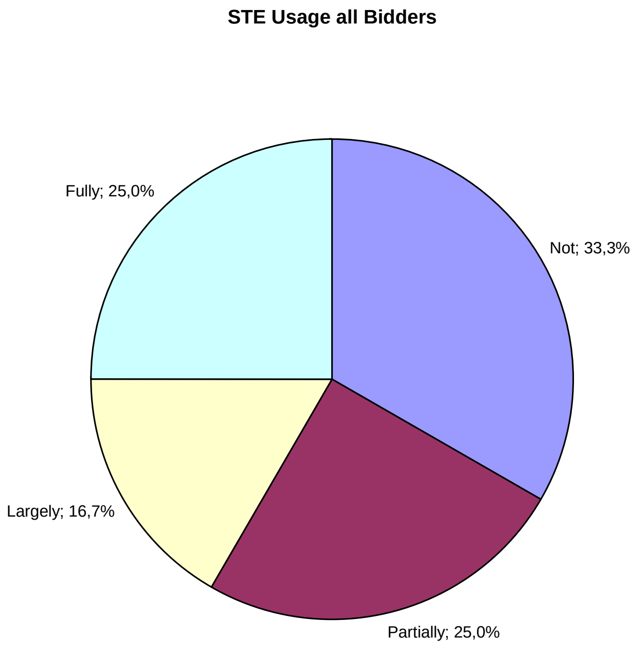
From a customer perspective this is a real pitfall. Testing is a big part of every project budget. If a supplier has no procedure to ensure testability and regression test in place, cost of system and acceptance testing will surely overrun the budget and the lack of ability creates a risk for the schedule.

Support of the test process by an adequate STE

Only a few bidders had an idea about the requirements for a well designed STE.


STE Usage SME
Largely; 0,0%
Fully; 0,0%
Not; 40,0%
Partially; 60,0%

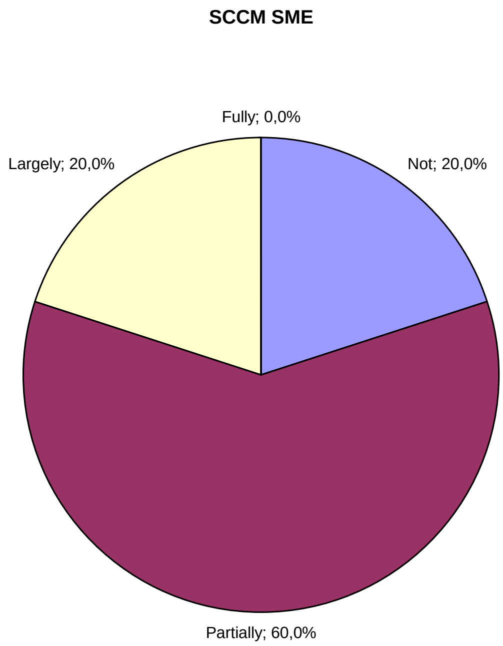

STE Usage large Bidders
Not; 28,6%
Fully; 42,9%
Partially; 0,0%
Largely; 28,6%

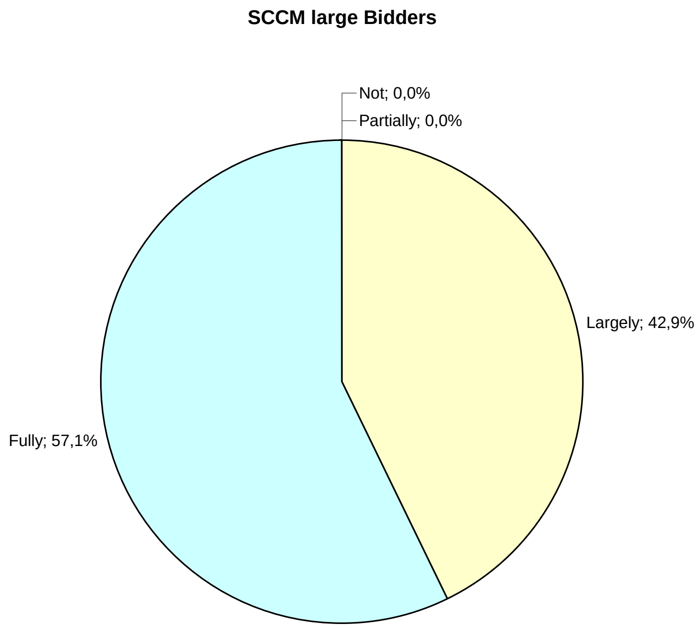


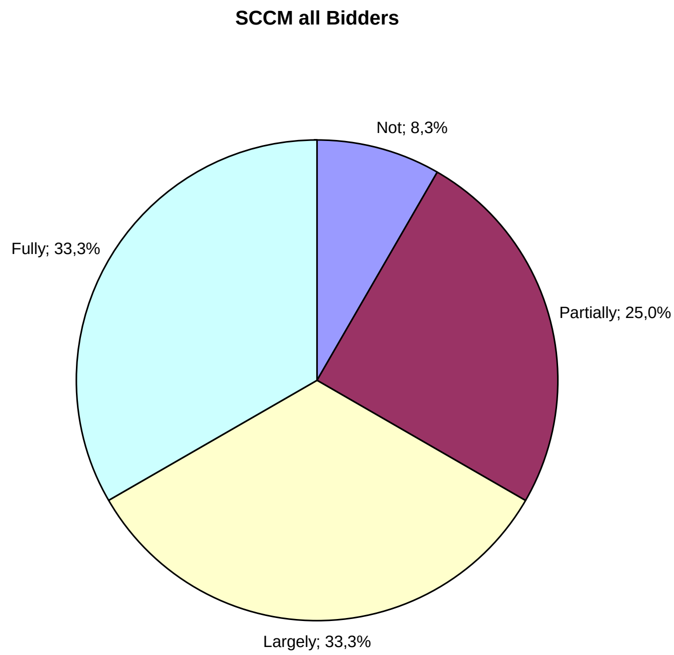
This means that their projects have insufficient support for software testing. From a customer perspective this means a substantial risk for budget and schedule.

Configuration Management

Configuration Management is either not in place or it is reduced to code control. Mostly there is no configuration management for documentation and testing in place.



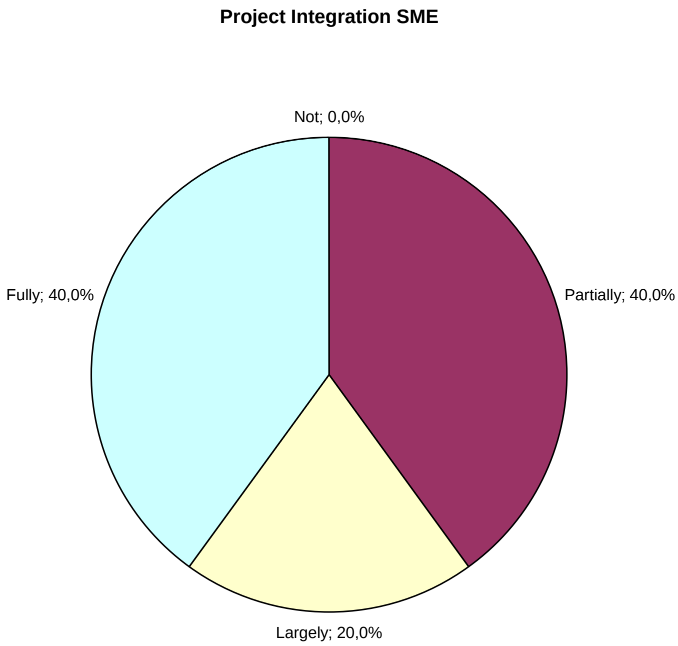


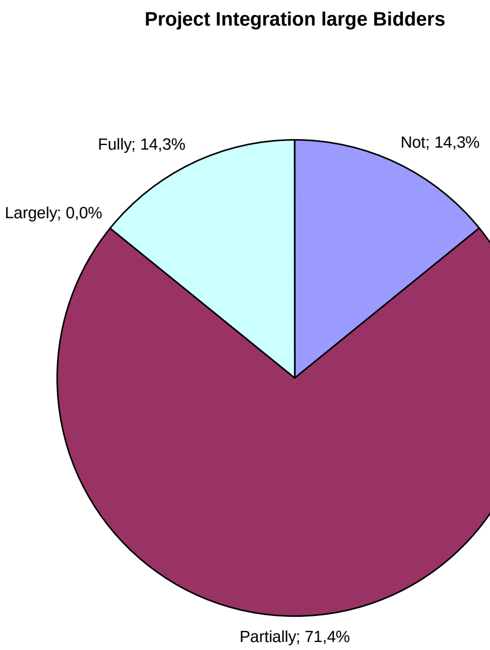


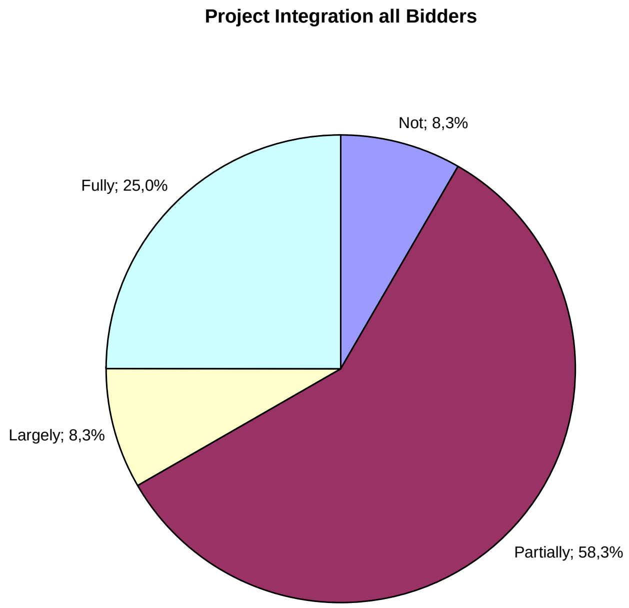
From a customer perspective this approach (Only to control source code) creates a risk for the control and consistency of deliverables. This might harm acceptance testing, operational use and maintenance.

Ability to integrate the tendered project into the whole project (Support of organizational, technical and management interfaces)

This is a problem for all type of bidder


Project Integration SME
Not; 0,0%
Fully; 40,0%
Partially; 40,0%
Largely; 20,0%

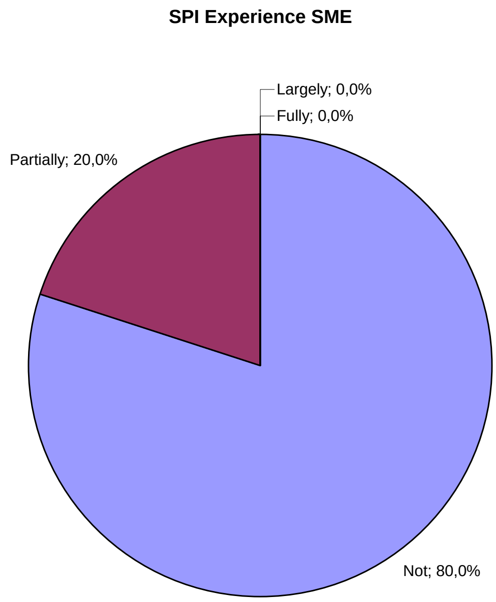

Project Integration large Bidders
Fully; 14,3%
Not; 14,3%
Largely; 0,0%
Partially; 71,4%

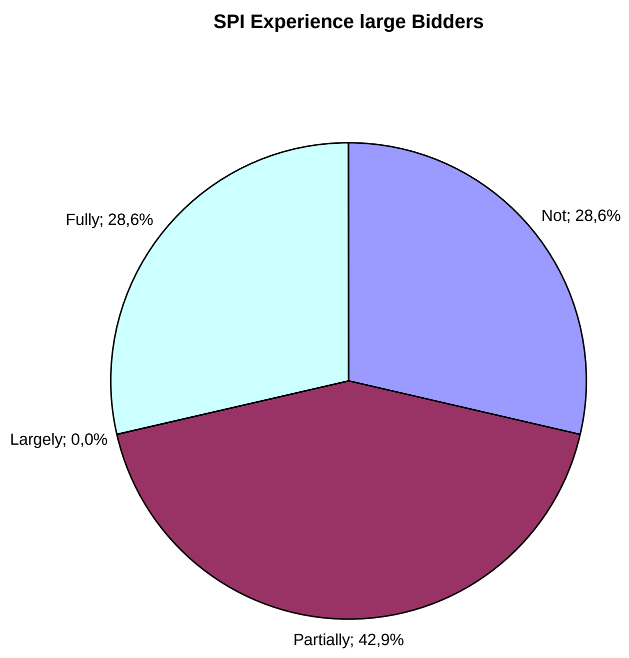


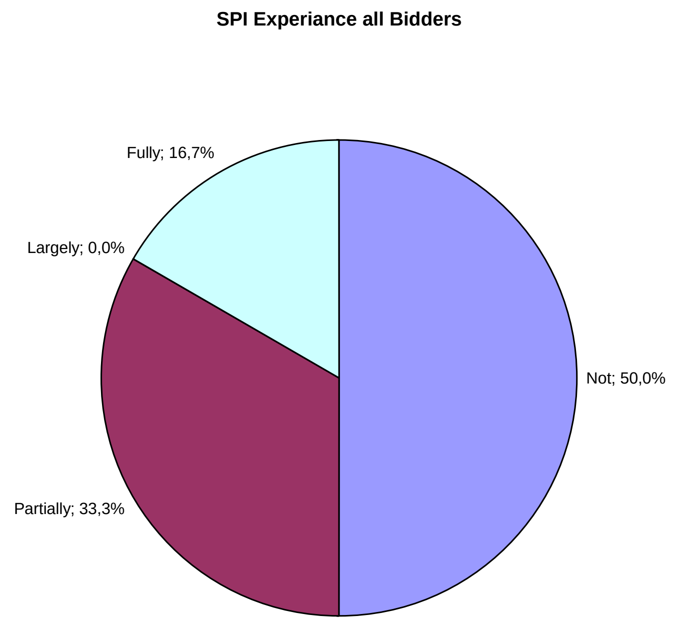
From a customer perspective collaboration between the projects inside of big programs is necessary. If a development project fails to collaborate with a migration project substantial risks for the operational use are in place.

Experience with ISO15504 / CMMI

There is experience with ISO 15504 or CMMi even in SME







It might be a surprise that only a few large bidders have substantial experience with maturity models. But as a fact large bidders use CMMi or SPICE or they did only some first steps (Planning). More than 20% of the large bidders do not use capability or maturity models.

Summary

The data was derived from a tender which was addressed to a couple of companies which seems to be representative for the whole market in terms of staff number, revenue, usage of procedure models and technologies. It might not be representative in a scientific and statistical approach. It is not completely sure that other tenders would produce the same result. But looking at the results of other not analyzed tenders I think it is very probable that other tenders with a partly different group of bidders will produce similar results. If this can be proved, a critical review of SPI is necessary. No doubt, procedure descriptions and templates are useful. But they are only a first step in al long struggle for product quality, process culture and project efficiency.

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QFD4SPI: A Technique to Monitor and Control Software Process Improvement Programs

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Abstract

Software Process Improvement Programs provide many benefits to the companies investing in this type of activities. Visibility of the technical advance of this type of programs is provided at the end of appraisal and implementation phases. Sometimes the technical advance information is reduced between those two milestones. This paper presents a technique named QFD4SPI, to monitor and control the technical advance of SPI programs. Moreover, the results, obtained from its application in a improvement program initiated by a small software development company, are provided.

Keywords

Software Process Improvement, QFD, Improvement Monitoring, ISO 15504, CMMI.

1 Introduction

The knowledge area of this paper is Software Process Improvement (SPI) Project Management. According to [14] the Project Management is the application of knowledge, abilities, tools and techniques to the project activities in order to satisfy projects requirements. It is indicated that SPI implementation objective [13], is to assist practitioners in effectively implementing SPI Project Requirements. The SPI implementation process is essential and necessary for the success of project [21], it could be said that: If the implementation process fails then SPI will fail.

One problem identified is the monitoring of SPI implementation, the Software Engineering Institute developed IDEAL model [12] for initiating, planning and guiding improvement action. However, this model is explicitly linked to the CMM and is not generic enough to be useful for designing SPI implementation programmes using other SPI roadmaps or initiatives [13]. The problem is that the IDEAL model doesn't provide proper approaches for monitoring the SPI objectives [9].

Following with the problem of SPI project monitoring, the success of this kind of project depends so much on the monitoring of actual results against planned results. According to [4] is necessary to demonstrate periodically the consecution of shorts and long time goals to managers, even the SPI responsible must be capable to answer question likes: ¿Where are we now?, ¿ Where do we want to be?, ¿ How will we know when we get there?. So, the proposal should facilitate the monitoring of SPI implementation.

Another problem identified is the lack of aligning between SPI Projects and the business objective, [5] considers that situation as a serious fail in strategy of SPI implementation. According to [11] CMMI and other SPI models do not connect maturity levels and business objectives of the organization. So, the proposal should try to find a technique that aligns the SPI objectives with the business objectives

Once have been identified all those problems and being used some proposals from [11], [9], [6] and [15], and taking some of theirs points, it is going to be proposed a technique using QFD, named QFD4SPI, that facilitates the implementing of those "Whats" associated to SPI based on ISO 15504 or CMMI recommendations. The idea use using QFD as a technique for implementing a Model or Methodology has been previously used for TQM [8], [18] and GQM [16].

Based on before and the little empirical evidences, is believed that:

- If we have one objective monitoring technique then we can determine the actual and planned state of SPI program at different levels.
- If we can align objectively the Business objective and Software Project Improvement objectives, we can calculate the actual value returned by an SPI program at a specific moment

The rest of the paper is structured as follow: Section 2 present a review of the state of art on Quality Function Deployment (QFD) and its previous application to SPI programs monitoring; Section 3 presents the proposed technique (QFD4SPI); Section 4 presents a case study of QFD4SPI application in a small software development company and; finally, section 5 presents the conclusions of this research work.

2 State of the Art

2.1 Quality Function Deployment (QFD)

QFD is a proven technique that permits "listen the customer's voices" and systematically translates it through each phase of the product development stage [19]. For that reason QFD uses charts or matrices to discover interrelationships between customers and/or users needs, product performance characteristics and design and implementation methods. [16].

QFD is formed by a model named "House of Quality" (HoQ), that is composed by a set of "rooms" that encapsulate the needed processes to develop a completely and satisfactory product specifications.

The QFD is composed by 10 rooms, which are:

- The "Whats" room (1): This room contains the customer expectation as they were expressed. Normally these expectations are so many, but using an affinity diagram technique, this amount is condensed in the 20 or 30 most important requirements.
- The "Customer Competitive Assessment" (CCA) (2) and "Customer importance" room (3): When QFD is used, the market research must be designed conforms the expectation to be implemented. The market research provides information about the customer expressed requirements, ("Customer importance" room) and about the existing product fortress or weakness.
- The "Hows" room (4): During the phase of "Hows", metrics are developed or components are associated to determine the degree of success related to "Whats". Each "What" requires at least one (ore more) "How".
- The "Relationship matrix" room (5): In this room, is defined or checked the relationship of each What with each How. This evaluation can be objective or subjective evaluation, neither any value.
- The "Absolute Score" room (6) or "Relative Score" room (7): At the first room was created one model or hypothesis that contributes to the user satisfaction, the Relationship matrix and the Customer Importance Rating are used to classify distinct measure by the importance given by the client. The "Relative Score" room measure or determine the grade of completion of TV or hypothesis.

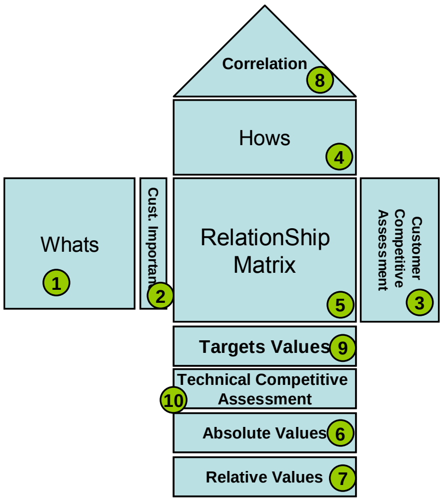

Fig. 1.House Of Quality

- The “Correlation Matrix” room (8): The Correlation Matrix room is where they can be resolved. The correlations are established by comparing each “How” with every other “How” in order to detect conflicts.
- The “Target Values” room (9): At this point, the requirements have been identified, evaluated and tested in the preceding rooms. The final set of recommended specifications is placed in the Target Values room.
- The “Technical Competitive Assessment” (TCA) room (10): This room is where Metric testing are developed and applied.

2.2 QFD Proposals applied to control SPI

A) Hu’s Proposal

Hu [9] proposes to use a QFD to capture, evaluate, and monitoring the customer requirements, as it effective implementation. His propose include a voice of the customer (VOC), one House of Quality, and two matrices, one for practices evaluation and other for implementation evaluation. The first matrix relates process areas and specific practices. The implementation matrix allows monitoring the Process Areas with the needing products for it implementation. This proposal demonstrates that is possible to ingrate models like CMMI, IDEAL and QFD. This proposal does not demonstrate the research work initial hypothesis, because:

- The author declare as a weaknesses, the grade of subjectivity of his solution, his solution allow to know the actual situation but not planned.
- He align Customer Requirement and Process Areas, but not Business Objective and Improvement Objectives.

B) Liu’s Proposal

Liu [9] proposes a framework using Quality Function Deployment (QFD) to deal with the problem of no connection between Business objectives and SPI maturity levels. This framework has three fundamental objectives: (i) establish a connection between requirements from the business and Key Process Areas (KPAs) in CMM; (ii) propose a methodology for the priority assessment of requirements from multiple perspectives; and (iii) it helps identify a set of software process improvement actions based on business requirements and KPAs. His proposal uses 4 different matrices:

- Requirements Impact Matrix (Business Requirements vs. Quality Requirements)
- Requirements-goals Impact Matrix (Business Requirements vs. Key Process Areas)

- Goals-practices Impact Matrix (Key Process Area vs. Specific Practices)
- House of Quality (Specific Practices and Activities)
- Although this proposal demonstrates that is possible to align Business Objectives and SPI Objectives, this proposal does not solve the problem of subjectivity, because:
- It does not consider Process Areas values for actual value, neither for planned values
- The way to determine the values associated to the relationship matrix depends on observation of actions; it doesn't search for direct and documented evidences.

3 QFD4SPI Description

The QFD's HoQ is a technique that permits to manage and monitor the SPI. This tool must permit to priories and to plan the SPI implementation. The proposal (QFD4SPI) consists of a QFD deployed in 4 phases, is formed by 4 matrices that allows monitoring the SPI completely, since Business Objects to the CMMI's specific practices, The 4 matrices are (see figure 2): House of Quality (HoQ) (M1), Improvement Matrix (M2), Practice Evaluation Matrix (M3) and Institutionalization Matrix (M4). The HoQ contains the aligning rate between Business Objects (BO) and SPI objectives (SPIO). The selection of the BO's are taken from [5], this process is similar to the process for getting the Voice of Customer (VOC).

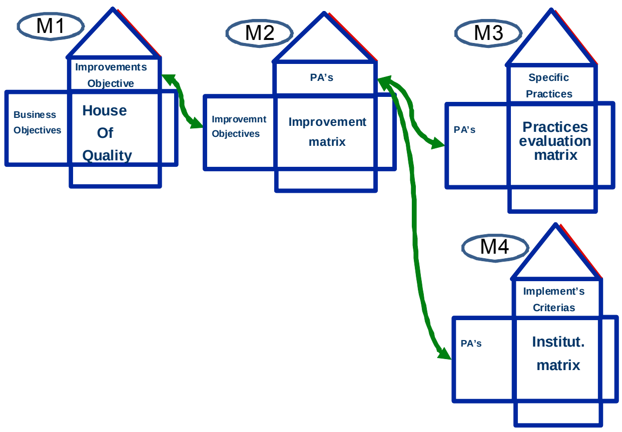

Fig. 2. QFD 4's Phases Model

[8] propose the following Business Objectives (BO):
- BO1: Reduce Time To Market
- BO2: Find and Fix reported problems once
- BO3: Fix systems errors that were found by customer and final user.
- BO4: Improve estimation of delivering time
- BO5: Increase products quality
- BO6: Always work with the correct module version or product life cycle
- BO7: Increase market share

Related to these business objectives, it has been identified and proposed the following SPI Objectives:
- SPIO1.1: Have completely visibility of resource assigning activities
- SPIO1.2: Have completely visibility of projects activities
- SPIO1.3: Work accordance the defined quality standard
- SPIO1.4: Warrants that resources have the needed knowledge, experience and abilities to performance theirs duties
- SPIO1.5: Anticipate to the problems and/or solve them skilfully
- SPIO2.1: Formalize a bidirectional requirement traceability matrix
- SPIO2.2: Control the requirement changes request
- SPIO2.3: Identify potential inconsistencies on requirement change request
- SPIO2.4: Control the elements that form a work product (CM)

- SPIO3.1: Promote management based on metrics as a mechanism of SPI monitoring
- SPIO3.2: Learn from Learned Experiences
- SPIO3.3: Evaluate periodically the organization process against international models/standard
- SPIO3.4: Control Project Risks

Table 1 presents the possible aligning between BO and SPIO:

Business Objectives	SPI Objectives
BO4	SPIO1.1, SPIO1.2
BO6	SPIO1.4,SPIO1.5, SPIO3.4

Table 1. Business Objective mapped to SPI Objectives

The Improvement Matrix permit to evaluate the SPI Objective (SPIO) versus Process Areas (PA), this matrix contains the aligning rate between SPIO and the PA to be implemented; table 2 presents the relationships:

SPI Objectives	Process Area
SPIO1.1	Project Planning (PP), Project Monitoring and Control (PMC)
SPIO1.2	PP,PMC
SPIO1.3	Project and Product Quality Assurance (PPQA)
SPIO1.4	PP
SPIO1.5	PP,PMC
SPIO2.1	Requirements Management (REQM)
SPIO2.2	REQM
SPIO2.3	REQM, Configuration Management (CM)
SPIO2.4	CM

Table 2. SPI Objectives mapped to Process Area

The practices evaluation matrix (figure 2, M2) allows knowing the implementation rate at Process area level and even to specific practice level (figure 2, M3). The practice institutionalisation matrix (figure 2, M4) allows knowing the Organization Process Area grade of Use, it allow knowing if the organization is actually generating evidence of using SPI work products. Whole matrices have the same structure; the only things that change are “Whats” and “Hows”. The next section details how the practice evaluation matrix is conformed. The structure of the Practice Evaluation Matrix (PEM) is (see figure 3):

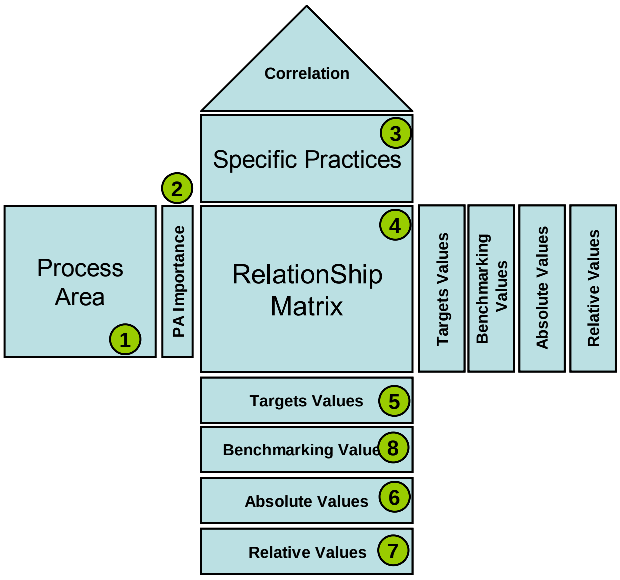

Fig. 3. Practice Evaluation Matrix

- The “Process Area” room (1): This room contains all the process area to be implemented by the SPI.
- The “PA Importance” room (2): this room contains the PA implementation order or the importance of each into the SPI. There is a particularity case when the organization pretends to have an official appraisal based on ISO15504 or SCAMPI [1], in this case all process area will have the same priority.
- The “Specific Practices” room (3): This room will include all the Specific Practices (SP) and generic practices (GP) that are associated to the PA’s existing on the “What” room.
- The “Relationship Matrix” room (4): This room contain the completing rate of each SP respect to its PA. Because each SP is just only associated to one PA, this matrix is orthogonal. The values are determined by the SP deployment grade, the determination is based on question like those presented in [2], but oriented to find physical evidences of Work Product, policy document, process, template, guidance, etc. needed to satisfy the SP. The questionnaire to be used is an adapted version of the Maturity Questionnaire developed by [22].
- The “Target Values” room (5): The target value (TV) is the desired implementation value, so it represent the target to reach by the “What” or “How” components. The original version proposed by Akao, just exist a TV Columns, into the proposal is included a TV row. The TV rows or columns help to determine to completeness rate, by some arithmetical operations. The calculus for each TV is different, for instance:
  - Horizontal TV: This value is obtained by the following formula:

    $$TVHoriz(j,i) = \sum (PA(j) * RM(j,i)) \quad (1)$$

    Where:
    - J is the row to be calculated
    - PA(j) the PA priority
    - RM(j,i) , Relationship Matrix (RM) cell value
  - Column TV: This value is obtained by the following formula,

    $$TVColum(i) = \sum (RM(j,i) * PA(j) \quad (2)$$

    Where:
    - I is the column to be calculated
    - RM(j,i) , RM cell value
    - PA(j) the PA priority
- The “Absolute Score” room (6): These rooms contain the sum of SP or PA’s implementation values.
- The “Relative Score” room (7): These rooms contain depending on the case, the SP o PA implementation grade. This value is result of division of AV into AV
- The “Benchmarking Values” room (8): Its use can be unlimited, due to it let’s to compare SPI performances. It can be done a SPI’s benchmarking by Process Area, or by Specific Practices.

4. Case of Study of monitoring CMMI implementation using QFD

Considering an IT organization that recognized the benefits of implementing CMMI, considering that they already know their fortress, weakness and Business Objectives, considering that has been developed a SPI Project Plan by the SPEG Group and that they were ready to start the SPI program, the project sponsors asked about having some way of monitoring an controlling the technical advance of the SPI program, and knowing in advance their limitation about funding resources. It has been proposed QFD4SPI, in order to perform the planning, implementation and evaluation of a CMMI implementation into the organization. Their organizational scope was limited to Web Development Group, and specifically to a 10 persons group dedicated to new development of Internet Web Portals, the technology used for developing are: Macromedia, Java, JavaScript, etc. This organization chooses to implement CMMI using the continuous model; they selected to improve the Project Planning and Project Monitoring and Control Process Areas. The steps followed to introduce this technique into the organization were:

1. Commitment: Find sponsorship and support by SEPG group
2. Diagnosis: Perform no official SCAMPI appraisal, class B, having as a result of evaluation the known that most of Specific Practices of the Project Management PA's were not implemented.
3. Improvement Definition: Select to improve all Project Management Process Area, beginning by PP and PMC
4. Institutionalization: Institutionalize the quality process into the organization, this step is not performed yet, due to that Processes, Politics, and some of Work Product are still being developed or being in reviewing.

To apply our technique was necessary a few set of steps, the following list resume them, but are going to be explained later:

1. Select Business Objectives
2. Select SPI Implementation Process Area
3. Select Specific Practices and Generic Practices
4. Assign execution priority to Process Area
5. Assign execution priority to SPI Objectives
6. Assign execution priority to Business Objectives
7. Answer Appraisal Questionnaire
8. Show Performance Monitoring QFD

Detailed Steps

Step 1: Select Business Objective

Purpose: Once has been performed the initial appraisal, some relevant BO can be suggested. The objective of this step is to select those BO that are better adapted to the actual needs of business and the organization motivation to perform de SPI.

Process/Outputs: The BO's selected were: BO4: Improve estimation of delivering time; BO6: Always work with the correct module version or product life cycle.

Step 2: Select SPI Implementation Process Area

Purpose: The objective of this step is to select that Process Areas that are into the scope of SPI project and associated to Business Objective previously selected

Process/Outputs: The PA's selected were: PP, Project Planning; PMC, Project Monitoring Control.

Step 3: Select Specific Practices and Generic Practices

Purpose: The objective of this step is to select that Specific Practices (SP) and Generic Practices (GP) associated to Process Area previously selected. In order to simplification just were selected SP's.

Process/Outputs: All SP's defined by CMMI for the PP and PMC were selected.

Step 4: Assign Execution Priority to Process Area

Purpose: The objective of this step is assigning the Process Areas an execution priority. This priority means the order to be implemented during SPI. PA priority values are limited to integer values, in a range of 1 to 7, being seven the heaviest.

Process/Outputs: During the SPI planning, PP was considered more important than PMC, so the assigned execution priority to each PA, were the following values: PP = 7; PMC = 6.These values are used as source for each PA Target Value formula. The resulting operations in our case of study are:

$$TV\_PP = Priority\_PP * Num.\ Practices\ PP = 7 * 14 = 98 \quad (3)$$

$$TV\_PMC = Priority\_PMC * Num.\ Practices\ PMC = 6 * 10 = 60 \quad (4)$$

The value of TV_PP (98) and TV_PMC (60) means the implementation target values for considering that PA's PP and PMC finished respectively.

Step 5: Assign execution priority to SPI objectives

Purpose: The objective of this step is assigning an execution priority to each SPI Objectives. This priority means the order of importance for the SPI objectives. A SPIO priority value is limited to integer values, in a range from 1 to 7 in our case study all SPIO priorities have a value equal to 1.

Process/Outputs: First, it was assigned an implementation priority to each SPIO. All SPIO Priority have a value equal to 1.For executing second task, we will use PA's TV and SPIO's Priorities. Even when SPIO TV's are calculated automatically, the background formulas are the following:

TV_SPIO1.1=Priority_SPIO1.1 * (TV_PP+ TV_PMC) = 1* (98+60) = 158 (5)
TV_SPIO1.2 = Priority_SPIO1.2 * (TV_PP+ TV_PMC) = 1* (98+60) = 158 (6)
TV_SPIO1.4 = Priority_SPIO1.4 * TV_PP = 1* 98 = 98 (7)
TV_SPIO1.5 = Priority_SPIO1.5 * (TV_PP+ TV_PMC) = 1* (98+60) = 158 (8)
TV_SPIO3.4 = Priority_SPIO3.4 * (TV_PP+ TV_PMC) = 1* (98+60) = 158 (9)

The value of TV_SPIOn.n means the implementation target values for considering the SPI objectives reached

Step 6: Assign execution priority to Business Objectives

Purpose: The objective of this step is assigning to each Business Objective its importance priority. This priority means the importance order for the SPI. BO priority values are limited to integer values, in a range of 1 to 7, being seven the heaviest.

Outputs: First, it was assign a priority value for each BO, in our case the value assigned was 1 (BO4=1, BO6=1).Second, using BO priority value and SPI TV values as data, the SPIO TV's were calculated automatically, the background formulas are the following:

TV_BO4=Priority_BO4*(TV_OM1.1+ TV_OM1.2) = 1 * (158+158) =316 (10)
TV_BO6=Priority_BO6*(TV_OM1.4+TV_OM1.5+ TV_OM3.4) = 1 * (90+158+158) = 406 (11)

The value of TV_BO4 (316) and TV_BO6 (406) means the implementation target values for considering the BO4 and BO6 satisfied respectively .

Step 7: Answer Assessment Questionnaire

Purpose: The objective of this step is answering a set of question associated to selected PA's and SP's. This question pretend to identify physical evidences of Work Products, Processes, Template, Guidance, etc., that are needed to satisfy the SP's. The answers are binary, in means that allowed values are (YES/NOT, 1/0, etc.).

Outputs: A monitoring questionnaire filled in by stakeholders. In a more extent paper, the questionnaire used is presented .

Step 8: Use Monitoring Performance QFD

Purpose: The objective of this step is monitoring performance of SPI, using QFD4SPI; it allows knowing the implementation grade of BO, SPIO and PA.

Tasks: No tasks are performed during this step, all operations are automatically, and depend directly on the given answers to the Questionnaire.

Outputs: General monitoring charts were obtained. In a more extent paper, the charts obtained are presented. At that moment of the improvement program, the conclusions taken from these charts were:

- From the Practice Evaluation Matrix, it can be concluded that: PP is 50% completed; PMC is 40% completed; during SPI Implementation, this values have to be interpreted along some values. taken from the SPI Project Plan, in order to know the advance or delay of the definition phase of SPI project
- From the Improvement Matrix, it can be concluded that: PP has satisfied the SPI Objectives in a 54% and PMC in a 40%; SPIO1.4 is the most completed SPI Objective; and the sum of Relative Weight indicates that 47% of SPI Objectives are covered.

- From House of Quality, it can be concluded that: the BO4 is reached in 46% percentage and BO6 in a 48% percentage. This conclusion is based on the assumption that a BO accomplishment is based on the termination of the associated SPIO's

As a general monitoring conclusion, 47% of the improvement definition phase of the SPI project is completed. This ratio must be compared against the planning defined into the SPI Project Plan, in order to know the delay or advance of the program.

5. Conclusions

This paper introduces the QFD4SPI technique in order to monitor the technical degree of advance of a SPI program, specially, during the improvements definition stages.

QFD4SPI has been applied in an actual case, regarding with the Project Planning and Project Monitoring and Control improvement program in a small software development company. Like has been demonstrated in [2], the key factors of using QFD were at the moment of planning, implementing and evaluating a project.

The application of QFD4SPI technique has verified the hypothesis that intend to perform a objective SPI monitoring, because the results are based on physical evidences that try to diminish interpretation issues. The results generated by an initial appraisal, and after that must be updated periodically for be used as SPI performance dashboard that helps to manage and monitor each SPI component, reporting the actual value and planned value degree of implementation.

It has been demonstrated that is possible to align Business Objective and SPI Objectives, along the are article has been presented a set of matrices that permit to trace the BO, from it definition until its respectively implementation, and it also possible to show the contribution of a Work Product to the SPI implementation. The current version of QFD4SPI is being improved in several areas that are:

- Inclusion of new types of charts providing information related to the SPI program historical evolution.
- Inclusion of extended capabilities to compare the actual state with the planned state of a SPI program. These capabilities should include schedule and efforts information.

Moreover, the authors of the paper are applying QFD4SPI in other improvement programs, so a wider assessment of the technique is planned.

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ROI of Software Process Improvement at BL Informática – SPI is Really Worth

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Abstract

In today's global competitive environment, organizations are always trying to improve their practices aiming to achieve higher levels of productivity, quality and competitiveness. Software process improvement is one of the most used approaches to achieve these goals. However, this kind of initiative is not easy, and usually great investments are necessary. Therefore, to determine the return of these investments is very important to justify the investments and keep high level management and project teams motivated for continuous improvement. In this paper, we present quantitative results of return on investment at BL Informática, a Brazilian small-sized organization that is improving its processes since 2003 and is experiencing great success. We present the benefits regarding schedule, costs, productivity, quality, customer satisfaction and also financial benefits. Results show that investments in SPI really can payoff, as happened in BL Informática.

Keywords

Software Process Improvement, Return on Investment, Software Quality

1 Introduction

Software process improvement (SPI) has become the primary approach to improving software quality and reliability, employee and customer satisfaction, and return on investment (ROI). Although the literature acknowledges that SPI implementation faces various problems, most published cases report success, detailing dramatic improvements [1]. Many companies have invested large sums of money in improving their software processes, and several research papers document SPI's effectiveness. SPI aims to create more effective and efficient software development and maintenance by structuring and optimizing processes. SPI assumes that a well-managed organization with a defined engineering process is more likely to produce products that consistently meet the purchaser's requirements within schedule and budget than a poorly managed organization with no such engineering process [2].

BL Informática is a small Brazilian organization founded in 1988 in Rio de Janeiro. Its SPI initiatives have started in 2003 and already brought great benefits [3, 4]. During this period, the company has obtained the ISO 9001:2000 [5] certification, was evaluated on MPS.BR [6] Level F and CMMI [7] Level 3. Obtaining certifications or higher maturity levels is a clear evidence of the success in the investment made. However, these results are not the only possible ways to measure the return on investment of a SPI approach. Business-related aspects are also very important when calculating ROI, and results as costs reduction, better quality of products, increase in productivity, greater costumer satisfaction, among others, can also be considered results from investing in SPI.

Model solutions for implementing a measurement program do not always fit an organization without tailoring. Therefore a Goal-Question-Metric (GQM) measurement program started at BL Informática together with the SPI program. In the first phase, metrics were defined for each process deployed and associated with the business goals. During the next phases of the SPI program, with the deployment of new processes, the organization's measurement plan was carefully adjusted and improved with new metrics. Even before the SPI initiative, the organization had already established a measurement culture collecting basic metrics per team member as: work effort distribution, estimated vs actual task duration and effort and performance index of time and cost for all the projects.

In this paper, we present the results of return on investment obtained so far by BL Informática's SPI initiatives, with regard to: cost and schedule estimates, productivity, density of defects (quality), customer satisfaction, financial benefits and others. Results show that investing in SPI programs is worth and really brings great benefits for software organizations.

This paper is composed by four sections. The next section discusses Software Process Improvement initiatives and their return on investment. Section 3 presents the results obtained so far by BL Informática. Finally, section 4 presents our conclusions and future work.

2 ROI of Software Process Improvement Initiatives

With the amount of attention, literature, and investments focusing on SPI, the question regularly pops up whether these investments are worth their cost. Surprisingly, we find only a limited number of industrial SPI publications that contain cost-benefit numbers and that measure ROI [2].

The ROI of SPI can be considered the amount of money gained from a new and improved software process. That is, the ROI of SPI refers to a new and improved software process which results in more money than is spent to improve it. The ROI of SPI is generally a ratio of benefits to costs for creating a new and improved software process [8]. However, benefits for a new and improved software process are usually increases in product variety, portfolio size, and market share. The benefits also include increases in customer satisfaction, productivity, efficiency, quality, and reliability. Decreases in costs, cycle times, and process complexity are important benefits too [8].

SPI's benefits will strongly depend on why an organization starts SPI in the first place—what are the intended benefits? Literature findings are diverse and distributed among software engineering's numerous business goals. Furthermore, different SPI approaches have different effects. An alternative to calculating pure cash-flow benefits is to ask those involved (for example, management) what a certain improvement is "worth." This means not just measuring the effort of the improvement activities but looking at that improvement's value and taking that value as the benefit [2].

The benefits of SPI come from two basic sources, increased revenue and profits and decreased costs and cost savings. The benefits of SPI originating from increased revenue and profits are primarily due to increased productivity. That is, increased output or work products per unit time. The benefits of SPI originating from decreased costs and cost savings are due to less maintenance, rework, and testing. This often leads to shorter cycle times and faster schedules. Methods for benefit analysis include measurement of productivity, defect density, quality, and defect removal efficiency. Measurements using the defect removal, software effort, and total life cycle cost models are also key methods for benefit analysis. This is by no means an exhaustive list of methods for benefit analysis. However, it is a virtual treasure trove of methods for benefit analysis that can fuel your SPI and ROI of SPI activities for years [8].

Analyzing SPI's ROI is relevant for [2]

- Convincing managers to invest money and effort in improvement, and convincing them that SPI can help solve structural problems.
- Estimating how much effort to invest to solve a certain problem or estimating whether a certain intended benefit is worth its cost.
- Deciding which process improvement to implement first. Many organizations must prioritize due to timing and resource constraints.

- Continuing improvement programs. SPI budgets are assigned and discussed yearly, so benefits must be explicit and organizations must show sufficient ROI, or continuation is at risk.

Given the importance of measuring the benefits of investments on software process improvement, BL Informática analyzed results of more than 3 years improving its processes. Results of this analysis will be presented in the next section.

3 Results from BL Informática's SPI initiatives

BL Informática started its SPI initiative in 2003 motivated by the expected benefits of a quality program and by its customers' needs. The first phase of the SPI program was focused in obtaining the ISO 9001:2000 [5] certification, obtained in December of 2004. Second phase focused in implementing the practices required by the MPS.BR level F. MPS.BR [6] is a Brazilian reference model that is compliant with CMMI [7]. Level F of MPS.BR corresponds to Level 2 of CMMI. Level F was obtained in September of 2005. The third phase aimed to implement the practices required by CMMI level 3, obtained in July of 2006. It is important to notice that some basic metrics were part of the culture of this organization since 2000, before the SPI initiative, what made it easier to evaluate the gains obtained by each one of these initiatives.

We analyzed the benefits of our SPI approach considering different perspectives: cost and schedule estimates, productivity, density of defects (quality), customer satisfaction and financial benefits. Each one of these perspectives will be presented later in this section. First, it is important to characterize the projects that contributed with data for our analysis.

Table 1 – Measured Project's Characteristics

ISO 9001:2000			
Project	**Project Size (PF)**	**Team Size**	**Language**
A	50	2	VB
B	622	5	Java
C	40	2	VB
MPS.BR level F			
Project	**Project Size (PF)**	**Team Size**	**Language**
D	30	2	VB
E	200	2	Delphi
F	452	6	Java
CMMI 3			
Project	**Project Size (PF)**	**Team Size**	**Language**
H	44	3	Java
I	84	3	Java
J	205	4	Java
K	41	3	.NET
After CMMI 3			
Project	**Project Size (PF)**	**Team Size**	**Language**
L	268	8	Java
M	603	7	Java
N	457	3	Java
O	124	5	Java

3.1 Benefits on Costs and Schedule Estimation

To address this kind of benefits, we used techniques of earned value analysis, as defined on PMBOK - Project Cost Management Knowledge Area [9]. This technique was selected since it is the most commonly used method for performance measurement and it helps the project manager to monitor, control the project and predict the real conclusion date of the project considering the actual performance. Two performance indexes are used, the Cost Performance Index (CPI) and the Schedule Performance Index (SPI). The CPI means, when a final or intermediate work product is delivered, how much of the budget approved was saved or exceeded, increasing the confidence about the cost estimating method. If it is 1, you are right on budget. If it is less than 1, you are over budget. If it is greater than 1, you are under budget. The SPI, on the other hand, means, when a final or intermediate work product is delivered, how much of the schedule approved was saved or exceeded, increasing the confidence about the time estimating method. Similarly, if it is 1, you are right on schedule. If it is less than 1, you are behind schedule. If it is greater than 1, you are ahead of schedule.

To calculate CPI and SPI three basic measures are used: 1) The budget (BCWS), part of the approved cost planned to be spent during a period; 2) The actual cost (ACWP), is the total of direct and indirect costs incurred in accomplishing work on the activity during a given period; 3) The earned value (BCWP), is a portion of the total budget equal to the percentage of the work actually completed. The values defined previously can be used to provide measures to show if the work is accomplished as planned. CPI is calculated using the following formula: CPI = BCWP /ACWP, with this index the final cost of the project can be forecasted. In addition, the SPI formula states that: SPI = BCWP / BCWS, it can predict the project completion date.

As shown in Table 2 and Figure 1, there has been an improvement of almost 11% in Schedule Performance Index since the first phase of the improvement initiative. It is the result of using size estimations, like Function Point Analysis. Moreover, the first estimates are always calibrated considering historic data of the organization. There was a minor worsening of this performance index at the end of the second phase, and it is justified by the complexity of one of the projects and the technology used to develop it. With the deployment of the engineering process areas after the second phase, this kind of difficulty was solved by the adoption of design rationale and other software engineering best practices. The improvement in this index means that projects are now being completed 11% earlier than before, which is of great value for the organization, mainly considering time-to-market issues.

Table 2 and Figure 1 also show that already in the first stage of the improvement program there was an improvement of almost 21% in Cost Performance Index. It means that when the project management process areas were implemented (second phase), projects monitoring and control became more efficient. The worsening at the end of the second phase was caused by the same reasons described for schedule performance index. The improvement in CPI means that projects are now costing 54% less than before, which is extremely good for the organization, which is making much better use of available funding.

Table 2. Improvement of the Schedule and Cost Performance Indexes after the SPI phases

Phases of SPI program	Improvement in SPI	Improvement in CPI
Before Process Adoption	-	-
1st Phase – ISO 9001 Process	2,43%	20,83%
2nd Phase – MPS.BR Level F	-1,23%	-20%
3rd Phase – CMMI Level 3	3,57%	41,17%
After Achieving CMMI Level 3	10,63%	54,05%

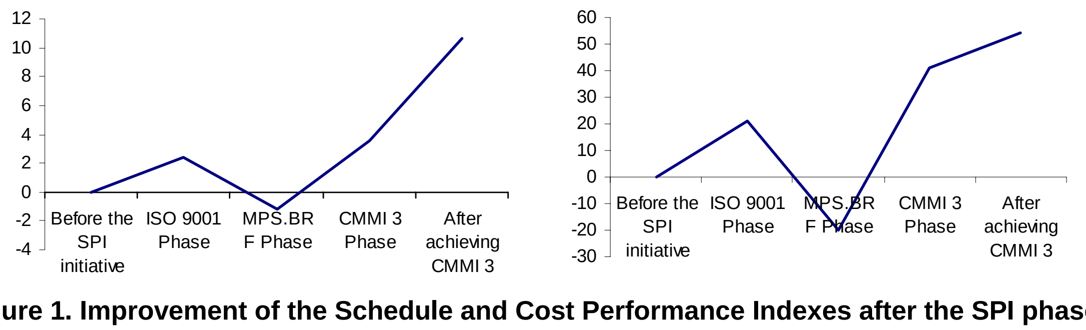


Figure 1. Improvement of the Schedule and Cost Performance Indexes after the SPI phases

3.2 Benefits on Productivity

It's known that in higher maturity level organizations, the gain of productivity is more evident than on the others. Moreover, many factors can influence productivity values, like: language, size of the project, use of tools, technical issues and so on. Thus, in our analysis, all the projects selected use the same language, tools and development environment, so that the influence of external factors will be reduced. We also normalized productivity values by size (function points) in order to be able to select projects of different sizes. Productivity was considered only for programming and testing activities.

As shown in Table 3 and Figure 2, after the first phase of the SPI program, the organization's productivity didn't change. A significant improvement of the productivity only appeared at the end of the third phase, when we were concerned with the entire product's life cycle, not only with monitoring and control activities. Together, all the management and engineering processes are improving our productivity levels. Results shows that people are producing 57% more than before, which corroborates the costs and schedule improvements shown in Section 3.1.

Phases of SPI program	Improvement in Productivity
Before Process Adoption	-
1st Phase – ISO 9001 Process	-
2nd Phase – MPS.BR Level F	-
3rd Phase – CMMI Level 3	9,1%
After Achieving CMMI Level 3	57,14%

Table 3. Gain in productivity after the SPI phases

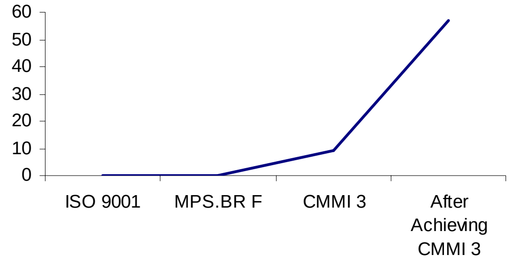


Figure 2. Gain in productivity after the SPI phases

3.3 Benefits on Product Quality (Defect Density)

An important principle to reduce costs is to find and correct defects as early as possible [10]. The costs to detect and remove defects grow dramatically as they are propagated to later phases of the development cycle. Therefore, defects detected in earlier phases are easier to correct and can contribute positively for the project. The relation between Software Quality Activities and rework shows how much the quality activities guarantee less rework during the projects. Quality activities considered in our initiative were: inspection, quality auditing, peer review and metrics collection. In addition, rework is any modification in an artifact approved.

We have gathered data related to defect density (number of defects divided by the number of function points of the project) in each of the phases of improvement, considering three moments of the projects: (i) during development, i.e., any defect detected before the internal acceptance tests; (ii) during internal acceptance tests, i.e., any defect detected in this phase of tests, in which the product is already developed; and (iii) during customer acceptance tests, i.e. validation tests performed by clients in the final phase of the projects.

As shown Figure 3 and Table 4, we can see that there was a great improvement, since defects are now being detected earlier during development, and fewer defects are being left for internal acceptance tests and even less, or almost none to customer acceptance tests. We can also notice that during the third phase there was an initial increase in the defects detected in the internal acceptance tests. It happened due to the learning curve, in which people were still learning how to use the engineering processes. However after stabilizing we can notice that not only we have a descending curve, which means defects are being detected earlier, but we also can notice less defects detected in all phases. It can indicate that people actually learned how to produce better products, which once again is related to better productivity and less costs, as shown in sections 3.2 and 3.1 and in greater costumer satisfaction, as will be presented in section 3.3.

Table 4. Number of defects per point function after each SPI phase

Phases of SPI program	Peer Review	Internal Acceptance	Customer Acceptance Tests
Before Process Adoption	-	-	-
1st Phase – ISO 9001 Process	1,78	2,24	3,67
2nd Phase – MPS.BR Level F	2,13	0,28	0,02

3rd Phase – CMMI Level 3	0,98	1,45	0,03
After Achieving CMMI Level 3	0,48	0,12	0,01

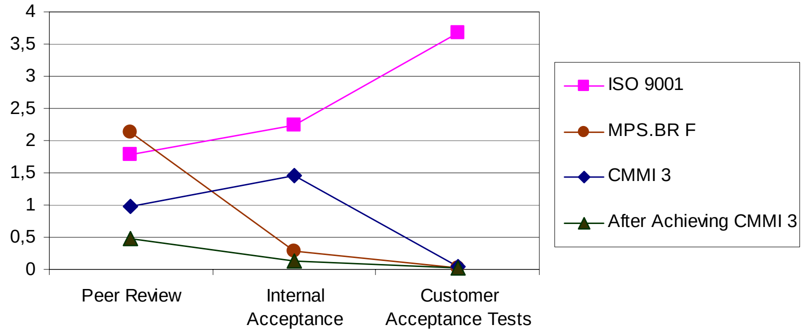


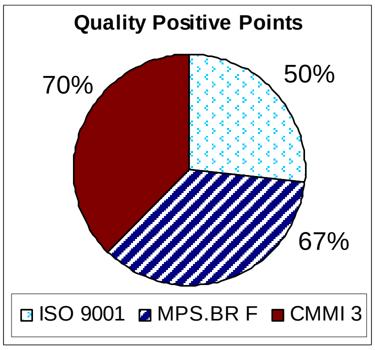
Figure 3. Number of defects per point function after each SPI phase

3.4 Benefits on Customer Satisfaction

The purpose in measuring customer satisfaction is to see where a company stands in this regard in the eyes of its customers, thereby enabling service and product improvements which will lead to higher satisfaction levels. And also, it is necessary to measure if the quality objectives defined were associated with this "customer satisfaction". That's why a satisfaction questionnaire was created since the first phase of the SPI program to verify if the software process improvement program was impacting positively the customer's opinion about the organization. A free question about positive and negative points of the organization is included. The questionnaire was sent to all customers so that they could fill it with no interference. The positive points can measure how SPI program is achieving our customers and, on the other hand, the negative points will result in a plan for improving each identified area. Such plans need to be based on what customers really need, rather than what management believes to be a good goal.

Figure 4 shows that quality points were written by the clients all over the phases of the SPI program. The figure shows that the customers detect more quality points during the SPI program. The quality points pointed by the customers during the SPI program were: Organization, Be on schedule, Software Process Improvement, Quality, Methodology and Integration with Customer's team. In addition, Commitment and Technical Knowledge were mentioned in the questionnaire too.

The percentage of satisfaction during the SPI program is increasing and they are divided between the two higher scales: "Above the Medium" and "Excellent".



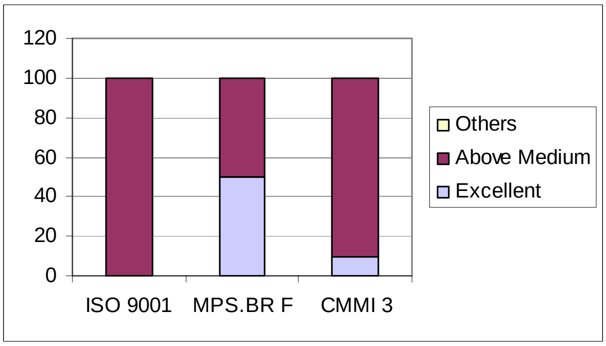


Figure 4. Percentage of Quality Positive points in each SPI phase and Percentage of Satisfaction Rating in each SPI phase

3.5 Financial Benefits

Return on investment is a versatile and simple tool to make a decision of an investment: if it does not have a positive ROI, or if there are other opportunities with a higher ROI, then the investment should be not be undertaken. A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio, by the following formula: ROI = (Gain from investment – Cost of Investment)/Cost of Investment.

To calculate the ROI the following costs were considered: external training, consulting and the value of the evaluations. The costs with internal training and the infra-structure (hardware, software, equipments) were not considered. On the other hand, the only gain considered was the financial credit with the projects developed during the SPI phases. Table 5 and Figure 5 show data regarding investments on the SPI initiatives undertaken by BL Informática. It is very interesting to notice that during the first periods, there is a negative result, i.e. the costs were greater than the revenues. However, all the benefits that SPI bring to the organization rapidly bring financial profits as well. Now, we are experiencing 54% of gains.

Phases of SPI program	ROI
1st Phase – ISO 9001 Process	-75%
2nd Phase – MPS.BR Level F	-3%
3rd Phase – CMMI Level 3	54%

Table 5. Financial Benefits calculated after each SPI phase

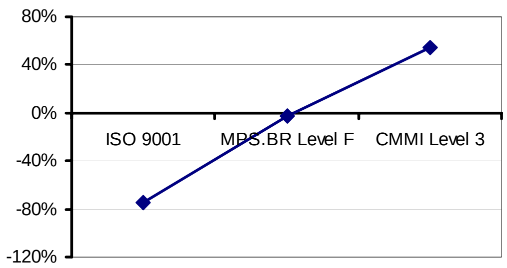


Figure 5. Financial Benefits calculated after each SPI phase

4 Conclusions

In this paper we presented results of return on investment of BL Informática's Software Process Improvement Initiative, comparing data from different phases of the improvement program. The paper shows that the investment in SPI can minimize the effects of classic project issues as schedule delays, budget overrun, poor requirements definition, scope control, risk and configuration management. Moreover, predictable actions are more often. Also, as a direct effect of these achievements we can point customers, high management and collaborators' great satisfaction and significant decrease of people turnover. Therefore, a SPI culture encourages clients to suggest the organization for other clients and contract more projects. Therefore, there is an increase in the number of projects providing great returns on the investment. In its challenge to continuously improve the processes and increase return on investment, BL Informática's SPI initiative next phase will be the achievement of CMMI Level 5 by the end of 2007.

Finally, we have shown time reduction of about 10%, costs reduction of about 54%, productivity gains of over 57%, significant reduction in the defects rates, significant increase in customer satisfaction and a financial gain of 54%. Therefore, we can see that SPI initiatives are really worth and do payoff, bringing benefits for the overall organization, in regard to several different perspectives.

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